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Considering risks in early stage investment planning for emission abatement technologies in large combustion plants

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ABSTRACT

Fossil fuels will continue to be the most important energy source for electricity generation in most parts of the world for the next decades. Therefore emission abatement technologies in large combustion plants are an important measure to reduce the emission of pollutants and to lower the negative effects thereof for humans, animals and the environment. Investment decisions for emission reduction measures are, however, facing various kinds of risks and uncertainties, caused by political, technological, economic and legal influences. The consideration of these risks in early stage investment planning is often complex yet important for investors. This paper investigates the possibilities to consider risks and uncertainties in early stage investment and cost calculation methodologies of different complexity. The real options analysis is presented as well as less complex methods, such as Monte-Carlo or sensitivity analyses that lower the calculation effort. The application of a specifically developed risk portfolio is recommended before quantitatively investigating risks. This portfolio helps to identify the most critical risks and to focus on them, reducing again the calculation effort. The presented approach is not only of interest for investors, but also for policies, especially if data is scarce or uncertainties exist regarding specific plant parameters or cost and price components. The content of this paper is presented using the example of nitrogen oxide emission reduction measures. It is, however, possible, to transfer the results to other pollutants or technologies in a related context.

1. Introduction

The public image of fossil energy generation suffered a lot over the last decades, due to the discussions on limited resources, pollutant emission and climate change. Nevertheless, in most regions of the world, combustion of fossil fuels is and will stay an economic way to meet the energy demand for the next decades (US EIA, 2015a). The statistics of the US Energy Information Administration (US EIA, 2015b) show that while the worldwide electricity consumption has been rising by 40% during the last ten years, the amount of electricity generated from fossil fuels has not only grown in an absolute manner but also in its relative share. In 2002 the worldwide share of fossil electric energy added up to 65%; in 2012 it reached a level of 67%. Yet local discrepancies are huge, for example between OECD and Non-OECD countries. In the OECD region the growth rate of fossil fuelled electricity generation between 2002 and 2012 amounted to 8%, while renewable energy increased by 40% and nuclear power generation declined by 15%. In the rest of the world, fossil generation grew by more than 96%, showing the highest growth rate compared to renewable and nuclear generation (US EIA, 2015b).

To lower the environmental damage of the rising energy demand, air emissions of environmentally critical pollutants need to be reduced. A large amount of fossil fuels is transformed into electricity and heat in Large Combustion Plants (LCP).[1] Therefore, emission reduction measures for these plants are an important instrument for global environmental protection programmes. On the other hand, energy is a very important cost driver for many industries. Emission reduction measures in fossil fuelled LCP are often end-of-pipe-technologies, or so called secondary measures.

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[1] LCP are defined as combustion installations with a rated thermal input exceeding 50 MW (European Commission, 2006).

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These technologies directly influence the production costs and might thus raise the market price of electricity (Schultmann et al., 2001). We focus our work on pollutants that are currently less in scope than the very pervasive CO_2, but still doing severe harm to humans and the environment, such as PM (particulate matter), SO_2 (sulphur dioxide) and NO_X (nitrogen oxide). They are providing a large abatement potential especially in developing countries, where national legislations might not yet cover them appropriately. NO_X abatement technologies will be used as a case study in several of the following chapters.

Investments in this kind of installations are often considered critically by plant operators as they usually have a long term perspective, do not cause positive revenues (at least if external costs are excluded) and the technological options are limited.[2] National legislation, however, forces plant operators to invest in emission abatement technologies by setting up thresholds or other environmental policy instruments. Therefore, plant operators shall be supported in their decision making process. Due to the already mentioned circumstances, we do not focus on classical investment decisions that are based on a "now-or-never" perspective and try to find the techno-economically favourable investment from several alternatives. We rather investigate the question of when is the right time for an investment. Therefore we compare the option of investing now with the option of waiting and investing later in the future or maybe not at all. This question is especially relevant if risks and uncertainties are influencing the investment decision. In Section 2 an overview about our approach and the content of this paper will be provided and the methodology of how we achieved our results will be introduced.

Investment calculations inherently contain various uncertainties due to future political, technological, economic or other kinds of developments. Intensive research is ongoing in the field of risk management and consideration of risks in investment decision making. Many publications can be quoted, starting with the fundamentals from Dixit and Pindyck (1994) to more recent publications. Laurikka and Koljonen (2006), Fuss et al. (2009), Zhou et al. (2010) and Lee (2011) present risk considering modelling approaches in a macroeconomic context. Blyth et al. (2007) and Fuss et al. (2008) analyze risk based investment decisions for CO_2 emission reduction measures on a microeconomic scale. Klessmann et al. (2008) investigate political instruments and the effects and relevant risks of market integration for renewables and Hallegatte (2009) discusses general strategic approaches for long-term investment projects in the uncertain context of climate change. From an investor's perspective, they recommend for example to reduce the decision-making time horizons. Considering, however, the type of investment we deal with, it seems hardly reasonable to invest in a technology with a shorter service life as this will not significantly reduce the total costs of the investment. In target areas such as developing countries, where data is often scarce and the necessary calculation effort shall be kept low, there is hardly any information available in literature on how to identify and consider risks during investment planning. Therefore we would like to provide an approach for early stage investment planning under these rather difficult circumstances.

2. Methodology

Our institute has been engaged in various projects in the context of techno-economic assessment of industrial emission abatement systems for decades. Numerous publications resulted from this work and we got in touch with plant operators and political decision makers from all over the world. This experience inspired the idea of providing an investment decision support tool for users that do not need perfect results, but a good approximation based on adequate effort and possibly limited datasets. Yet the characteristics of emission abatement for large combustion plants are very complex in terms of investment calculation, as they have a long term perspective and many influencing risks and uncertainties may occur. Consequently we consider the examination of risks as necessary in order to make reasonable investment decisions. By comparing classical project and risk management approaches (cf. e.g. Epstein and Rejc Buhovac, 2014; Hubbard, 2009; Project Management Institute, 2008) with the experiences we got from plant operators and with the technological characteristics of emission abatement in LCP we developed the following six steps approach, displayed in Fig. 1.

We do not want to dig deep into the first step as we expect the project definition to be more or less completed once a user starts to apply our approach. It is important to collect as much data as possible about the project as well as about relevant surrounding conditions.

Several investment and cost calculation methodologies, tools and approaches have been published over the last 15 years. Therefore, the next step (cost calculation) is based on literature and already published cost calculation tools and will be discussed in detail in Section 3. Section 4 is providing an overview about possible risks which can be relevant for the next two steps of our approach. This chapter is also primarily based on literature research and shall give an overview about risks and risk categories to future users. Section 5 contains the next two steps of our approach, identification and evaluation of risks. In order to evaluate risks, we developed a modification of a standard risk portfolio, which is specifically suited to environmental decisions of the considered kind. The last step, consideration of risks, will be presented in Section 6 and is based on many recent publications concerning the Real Option Analysis (ROA), which we consider an interesting method in order to support the "waiting-option" decisions we are specifically looking at. ROA, however, is only one option, suitable for the most critical risks of a specific application. Other possibilities to consider risks, such as sensitivity analyses, will be introduced as well. The last step, decision making, is kind of a compilation of the steps before and has to be done by the user. The practical use of our approach, especially regarding the final decision making will be discussed in Section 6.3 (Practicability).

This approach has been developed on a theoretical base, i.e. on literature studies and conversation and collaboration with experts of the sector. It is not based on a quantitative case study as we decided to put the methodological approach in focus and not a specific example. Furthermore we tried to avoid that possible applications seem to be limited to the regarded or very similar case studies.

3. Investment and cost calculation

The goal of the methods to be presented in this chapter is not to calculate the investments and costs of a new installation in every detail, but to give an idea about investment and operating costs on "pre-study level" accuracy which is quantified to ±30% (Chauvel et al., 2003; Geldermann, 2014; Peters et al., 2003). While providing reasonable estimates the required effort and time shall be kept at a minimum. Following the stages of our approach we are going to introduce methods to calculate CAPEX (Capital Expenditures) and OPEX (Operational Expenditures) of considered investments as well as other cost components that might be relevant.

[2] Details about external costs can be found in Section 3.4, the technology options will be discussed in Section 3.1.

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