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Considering investment resources when assessing potential CO_2 reductions of CHP – a case study

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Abstract

Combined heat and power (CHP) can increase electricity production efficiency and decrease global CO_2 emissions. Studies have shown large unrealised economic CHP investment potentials. An assessment of profitable CO_2 reduction based solely on net present value (NPV) implicitly assumes unlimited investment resources. This study analysed the impact of the assumption of unlimited/limited investment resources on the assessment of profitable reduction potential of global CO_2 emissions due to CHP investment. The correlation between changes in direct and global fossil CO_2 emissions was also analysed. This was done by evaluating alternative CHP and heat-only boiler investments in a district heating system. When investment resources were unlimited, NPV was used to determine whether an investment was profitable and to rank the profitability of the investment. When investment resources were limited, equivalent annual annuity ratio (EAAR) was used to rank the investment's profitability and determine whether its level of profitability was acceptable.
The results showed that the profitability ranking of an investment can change depending on whether investment resources are considered unlimited or limited. Moreover, an investment with positive NPV may be regarded as insufficiently profitable when investment resources are limited. This could have an important impact on profitable CO_2 reduction potential. Furthermore, when CHP investments are considered, local views on CO_2 emissions may be counterproductive for global CO_2 emission reductions.

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Keywords: CHP; district heating; CO_2 emissions; GHG; reduction potential; investment resource

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1. Introduction

Combined heat and power (CHP) is advocated by the EU as a technique for increasing energy efficiency and thereby reducing fossil CO_2 emissions [1], [2]. Stankeviciute and Riekkola [3] found that the electricity output of profitable European CHP is potentially around 43 % greater than with existing CHP. Danestig et al. [4] found potential in Stockholm for profitable bio-fuelled CHP that was more than 100 % higher than the CHP production at that time. The existence of unrealised profitable energy-efficiency measures is often referred to as the energy-efficiency gap or paradox. As in the work of Stankeviciute and Riekkola [3] and Danestig et al. [4], studies on the assessment of profitable energy-efficiency potential are often based on the standard net present value (NPV) rule [5]. NPV is the net present value of the initial investment and all future changes in costs and revenues that are affected by the investment [6]. According to the standard NPV rule, all independent investments with positive NPV should be accepted in order to maximise a company's value [6]. Assessments of profitable energy-efficiency investments based solely on NPV implicitly assume that investment resources are unlimited, but in reality this is not always the case [7]. If investment resources are limited, the productivity of these limited investment resources should be maximised. Some discounting methods have been developed indicating how net cash flow relates to the investment cost, which can be used with NPV when investment resources are limited [7]. One method is to rank investments according to NPVR, which is the ratio of NPV to the initial investment (I0) [6]-[8]. The alternative with the highest ratio is then considered the most beneficial investment. Swedish literature also includes the annuity of NPVR, here called the equivalent annual annuity ratio (EAAR) [7], [9]. EAAR measures the annual increase in value or the annual "interest" gained in addition to the cost of capital. The investment alternative with the highest value is considered to be the most beneficial. EAAR is suitable for repeatable projects [7].

The aim of this study was to analyse the way in which the assumption of unlimited or limited investment resources affects the assessment of profitable reduction potential of global fossil CO_2 emissions due to bio-fuelled CHP or heat-only boiler (HOB) investment in CHP-based district heating systems (DHS). The correlation between changes in direct and global fossil CO_2 emissions for investments in CHP or HOB in a CHP-based DHS was also analysed. This was done by evaluating alternative investments in a real investment decision case at a local energy utility, using two cash flow-based investment measures: NPV and EAAR.

1.1. Related work

Academics have offered different explanations for the energy-efficiency gap, such as asymmetric information, organisational barriers, split incentives and market failures [10]-[12]. Jaffe and Stavins define the energy-efficiency gap as the difference between actual and optimal use of energy [10]. They found that the economists' economic potential is reached when "market failures in the market for energy-efficiency technologies" are removed, while the technologists' economic potential requires high discount rates due to irreversible investments and uncertainty to be eliminated, inertia around the dispersion of new technologies to be overcome and any heterogeneity to be ignored [10].

A number of studies concerning energy-related investment decisions are based on the real options theory, which assumes that the irreversibility of an investment and the uncertainty of future prices of fuel or electricity, for example, can increase the value of postponing an investment [13]. Using ex-post data, Löfgren *et al.* [5] studied the impact of uncertainty in the future price of polluting fuel. They found that the price of the polluting fuel would need to be 2.7-3.6 times greater in order to trigger the realised investments according to the standard NPV rule [5]. Sundberg and Sjödin [14] conclude that companies applying different rates of interest when calculating the profitability of investment may prioritise differently between CHP and HOB. Wickart and Madlener [15] developed an economic model for handling "the decision-making problem under uncertainty", taking volatile energy prices into account. They found that the standard NPV rule can be misleading when choosing between an investment in CHP or HOB since it does not consider uncertainties in policy measures or volatile energy prices. Investments often involve some kind of risk taking. Studies show that risk management can include the adjustment of discount rates or the adjustment of cash flow, for example [16], [17]. Another method of risk management that is sometimes used in practice is to apply safety margins, for example to EAAR [7].The main contribution of the present study to this body