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Incentives for energy efficiency measures in post-war multi-family dwellings

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Licentiate Thesis

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Overview

Introduction

Energy efficiency is an important question to society as well as to individuals and firms. Improving energy efficiency in the building sector is considered an important means to climate mitigation. For real estate owners energy is also a central expenditure item and reducing energy consumption may directly reduce operation costs while at the same time serve as insurance against future energy price increases. Since new buildings only add a few percent annually to the building stock, the potential to reduce total energy consumption primarily lies within the existing building stock. The building stock is ageing and the post-war part of the stock that is in need of renovation is growing. This has been suggested as a window of opportunity to improve energy efficiency, but so far the results have been few. Several factors have been put forward to explain the so called energy efficiency gap – the difference between actual and optimal energy efficiency – one of which is split incentives. What adds to complexity in this case is that distinct differences have been observed in the level of ambition between the real estate companies that have renovated so far. Some companies have undertaken extensive renovation and energy efficiency measures, whereas other companies have done little more than urgent maintenance measures. It seems that real estate owners in general don´t have strong economic incentives to improve energy efficiency in connection to renovation – but what can then explain the differences between strategies?

This licentiate thesis examines the incentives among real estate owners to improve energy efficiency, particularly in post-war, multi-family buildings in need of renovation. The purpose is to add knowledge about decisions concerning measures that increase energy efficiency in terms of incentives, barriers and different motives for real estate owners' strategies and actions.

Method

To analyze the questions above, an empirical investigation has been conducted, based on interviews and a survey on real estate owners' views on, attitudes towards and actions for renovating and improving energy efficiency. There is also a theoretical part that analyzes the matter of split incentives through simulations of how costs, benefits and ultimately incentives change for tenant and landlord if energy consumption is moved from an inclusive rent to an exclusive rent with individual metering and charging.

The thesis consists of three papers, one of which is co-authored with Hans Lind and Kristina Grange. The first paper presents the results from an interview based study on real estate owners' views on and attitudes towards renovation and energy efficiency. These findings are developed further in the second paper, where a number of hypotheses are tested concerning views and attitudes in different types of real estate companies are presented. The last paper presents the theoretical discussion about a particular case of split incentives concerning tenants and landlords. The distribution of costs, benefits and incentives are examined through simulated transitions from inclusive rent to exclusive rent with individual metering and charging.

Results

Real estate companies do not have the same approach to energy efficiency matters. Rather they can be divided into (at least) three ideal types relating to their level of energy efficiency ambition, but not simply according to the public-private ownership divide. The least ambitious company type is driven mainly by regulatory and economic motives and only carries out energy efficiency improvements that are profitable in a short-term perspective. The next level of ambition can be found with the company type that does "a little extra" and is partly driven by a sense of responsibility for the environment. This company type calculates profitability with a little longer time perspective or accounts for positive side effects for the company, such as good publicity. The most ambitious type carries out an extensive amount of energy efficiency improvements, and doing so is motivated partly by long term economic reasons but mostly by some other factor, which may include direct political directives.

The more ambitious companies do more extensive energy efficiency work, and are more forward planning than are less ambitious companies. They also to a higher extent need to motivate energy efficiency investments by other reasons than economy and regulations. Less ambitious companies place more emphasis on transaction costs, competing investments and financing problems than do more ambitious companies. There is no indication that perception of uncertainty, risk or profitability, or the use of calculation methods differ with respect to ambition level.

If real estate owner and tenant could find ways to negotiate over possible gains from improving energy efficiency and/or installing individual metering and charging, some of the split incentives could be avoided.

Discussion

The absence of strong economic incentives and the heterogeneity among real estate companies may make it difficult to address the companies with policy measures that aim to increase the level of energy efficiency in the building sector. On the other hand, given that energy is correctly priced, considering external effects of energy consumption, the current level of energy efficiency may be optimal from a social point of view. Resources are, as is well known, scarce, and careful consideration should be given to how they are spent to ensure that the marginal social cost of reducing energy consumption does not exceed the marginal social benefit from the reduction. In the case of individual metering for example, there is a risk that real estate owners over-invest in energy efficiency if they don´t consider the (possible) lower energy consumption achieved through individual metering before calculating the profitability of energy efficiency measures.

Conclusion

Real estate owners lack strong economic incentives to invest in energy efficiency in multi-family buildings and the level of investment is dependent on the different motivations real estate companies have. One important conclusion is that the heterogeneity between companies that was exposed in the interviews and survey implies that they will not respond similarly to policy stimuli. The heterogeneity should thus be considered when designing policy measures so that public and company resources can be allocated as efficiently as possible, as there are many challenges facing owners of post-war residential buildings. Another conclusion is that from an economic point of view it is important to take the interaction between different measures into account, e.g. between physical measures and measures focusing on changing household behavior.

Paper 1: Incentives for Improving Energy Efficiency When Renovating Large-Scale Housing Estates: A Case Study of the Swedish Million Homes Programme

The aim of this paper[1] is to explore the views and actions of real estate companies regarding renovation and energy efficiency improvements. Interviews were carried out with private and public housing companies, and based on the interview results the companies were categorized according to level of ambition in energy efficiency matters.

The semi-structured interviews covered 16 companies of which 13 were owned by municipalities and 3 had private owners. The questions covered views on, and actions for renovation and energy efficiency measures in the 1960's and 1970's residential building stock. The companies were categorized using an ideal types concept, which illuminates the differences and similarities in energy efficiency ambition and strategies in order to explain earlier behavior and predict possible outcomes.

The interviews indicated that the companies differ enough to argue that they cannot all be expected to (re)act in the same way in these matters, but neither can it be argued that they all will act completely individually. Based on the results from interviews with the real estate companies, the companies have been divided into four ideal types that highlight the differences in energy efficiency ambition and strategies; the Strict Profit Maximizing Company, the Little Extra Company, the Policy Led Ambitious Company and the Administration Led Ambitious Company. The categories represent the companies' motivations and levels of ambition to improve energy efficiency when renovating their post-war multi-family dwelling stock.

The Strict Profit Maximizing Company undertakes only those energy efficiency measures that are strictly profitable in the short run to medium run, and that has higher expected returns than competing investments. The Little Extra Company will make allowances for energy efficiency measures, motivated by e.g. other assumptions about the net operation costs or the value of goodwill. The Policy Led Ambitious Company and the Administration Led Ambitious Company have ambitious energy efficiency objectives, initiated either by the political management or by driving forces within administration. The ambitious efficiency work is motivated by internalization of external costs, a very long-run perspective or other manipulations of calculations, and does not necessarily need to fulfill profitability criterions.

The different strategies will determine how the companies respond to incentives to invest in energy efficiency, and affect the overall result in the energy efficiency work. The ideal types hence are important to have in mind when designing policies to increase energy efficiency.

[1] Co-authored with Hans Lind and Kristina Grange

Paper 2: Real estate owners' views on renovation and energy efficiency in post-war multi-dwelling buildings

The upcoming renovations of large parts of the Swedish residential building stock have been seen as a window of opportunity to undertake energy efficiency measures, which would contribute to reaching ambitious savings objectives. In this paper the indications that building owners don´t have strong economic incentives to undertake such measures are investigated, and it is tested whether company attitudes and strategies differ with respect to level of ambition in energy efficiency matters.

The findings of paper 1 and the ideal type concept are developed and explored further in this paper. The aim is to get a more comprehensive view of the renovation and energy efficiency state in Swedish companies, as well as to test hypotheses about whether the ideal type affects the views on and strategies for energy efficiency, to get an indication of what energy efficiency investments can be expected to occur spontaneously in the existing Swedish building stock.

111 public and private companies were surveyed through a web-based questionnaire to be classified as an ideal type. Their views on renovation and energy efficiency investment related matters were then tested to see if there are differences between the companies according to their level of energy efficiency ambition.

The hypotheses are centered around three main themes and predicted that ambitious companies would have carried out/be planning more (extensive) energy efficiency work than less ambitious companies; that less ambitious companies would perceive obstacles to be bigger than ambitious companies do; and that ambitious companies will require less from energy efficiency measures in terms of investment and its profitability.

The results indicate that renovations have started but will constitute a challenge to the companies, which may crowd out energy efficiency investments. They also indicate that the more ambitious companies do more extensive energy efficiency work and are more forward planning, but will not intervene "in excess", in comparison with less ambitious companies. There are also indications that energy efficiency may be hindered by transaction costs, uncertainty about future energy prices, competing investments or financing, and that less ambitious companies place more emphasis on transaction costs, competing investments and financing problems than do more ambitious companies. There is no indication that the importance of economic considerations or that perceptions of uncertainty, risk or profitability differ with respect to ambition level, nor are there indications that the use of calculation methods or discount rate differs. It appears that it isn´t primarily economic or regulatory drivers that make the ambitious companies invest in energy efficiency; rather they seem to need other motives for energy efficiency investments in order to "create" profitability, whereas less ambitious companies seem to value short term profitability higher than ambitious companies do. Taken together only moderate energy efficiency investments are expected.

Paper 3: Individual metering and charging in rental housing: Creating the right incentives for energy savings?

The third paper analyzes the split incentives problem related to energy efficiency in the building sector, exemplified by individual metering and charging of heating and hot water in residential housing. Changing user behavior by individually metering and charging tenants for their use of heating and hot water has been put forward as a means to reduce energy consumption in the building sector. This would give the tenant incentives to save energy, but at the same time weakens the landlord's incentives for improving energy efficiency in the building, since she is no longer responsible for energy costs. These split incentives problems should be possible to avoid if there is a net gain from improving energy efficiency and/or installing individual metering that could be shared between the parties.

The aim of this article is to problematize the concept of individual metering, to show through simulations that there are ways to avoid the split incentives problem involved, and to show that it should be possible to design contracts that give both landlord and tenant incentives to save energy.

Starting in a fictive situation where the tenant pays an inclusive rent to the landlord, it is studied how incentives for energy efficiency and savings are affected by investments in energy efficiency and/or individual metering, thus altering the distribution of energy cost between landlord and tenant.

The results indicate that few energy efficiency investments will manage to bear their own investment costs, given how low the present value of the energy savings is at given energy prices. The results also show how split incentives may hinder the energy efficiency investments, but that there are conditions under which such investments and/or individual metering may increase welfare for landlord, tenant or both. Without negotiations this gain will not be reached, but through co-operation this welfare gain could be split which would benefit both landlord and tenant and this should be considered when designing contracts. Finally the findings highlight the importance to take into account the interaction of different means to save energy to avoid over-investment.

Paper 1

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Article

Incentives for Improving Energy Efficiency When Renovating Large-Scale Housing Estates: A Case Study of the Swedish Million Homes Programme

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Abstract: Sweden has adopted ambitious energy savings objectives for buildings, but at the current rate of energy efficiency investments the objectives are unlikely to be reached. In this article we report the early findings of how real estate owners reason and act in energy efficiency investment decisions. Based on the results from interviews with the real estate companies, the companies have been divided into four ideal types that illuminate the differences in energy efficiency ambition and strategies; the Strict Profit Maximizing Company, the Little Extra Company, the Policy Led Ambitious Company and the Administration Led Ambitious Company. The different strategies will determine how the companies respond to incentives to invest in energy efficiency, and affect the overall result in the energy efficiency work. The ideal types hence are important to have in mind when designing policies to increase energy efficiency.

Keywords: energy efficiency in buildings; sustainable renovation; incentives for energy efficiency; ideal types

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1. Introduction

Sweden built more than one million housing units between 1962 and 1975, and now it is time to renovate most of this stock. A number of renovation projects have been carried out and there seems to have been very large differences in how much focus there has been on energy efficiency in these projects. Given the government's ambitious energy savings goals, and that it could be argued that there is a "window of opportunity" when large investments are planned anyway, so it is worrying that more is not being done. In earlier studies [1,2] it is claimed that there are a large number of profitable energy savings investments that the real estate companies do not carry out. The general purpose of the research project that is reported here is to understand why this is the case and what can be done to increase energy-saving investments in the housing stock that is in need of renovation.

Our starting point was that it is important to understand why the firms do what they do, and therefore interviews were initially made with a selection of housing companies. What is reported in this paper is to a large extent "work-in-progress". The strategy followed here is that from the interviews we try to construct a number of "ideal-types" which describe how different types of firms act in relation to energy-saving investments. These ideal types can help us understand better the action of the companies and also make it possible to, in general terms, predict how they will respond to different policy measures.

The interviews are also used to develop a more precise set of hypotheses about why not more is done, and what can be done to influence the decisions, and this will be investigated more in detail in later stages of the project.

The structure of the paper is as follows. The opening sections give some background information, starting with the Swedish policies in Section 2, and describing the part of the housing stock in question, known as the Million Homes Programme, in Section 3. Section 4 describes the method and data/interview material used. Section 5 reports the results from the interviews and the analysis based on the ideal types. Section 6 concludes with a discussion of the results found and their implications.

2. Swedish Energy Policies

To put the question of energy efficiency in buildings (in Sweden) into context, former and current Swedish energy policies, as well as the current energy consumption situation will be presented here.

2.1. Earlier Energy Efficiency Programmes

Public action programmes for energy economy have been an important element in Swedish energy efficiency policy since the 1970s [3]. The most important early policy measures, during the 1970s and 1980s, were investment subsidies and information campaigns. During the 1990s two programmes were introduced. The energy policy decision of 1991 included support for procurement and introduction of energy efficient technology, demonstration of energy efficient technology in dwellings and premises, grants to pilot plants, and renewed support to information on energy efficiency. In the energy policy decision of 1997, the so called short term programme, additional measures were proposed, among others measures for decreasing electricity consumption.

In the 1990s an initiative was taken for an action programme for energy efficiency, focusing specifically on the Million Homes Programme [4]. This never led to any political decision; however it did lead the former Prime Minister Göran Persson to the introduction of the somewhat visionary term *People's New Green Home*.

While energy policies in the 1970s and 1980s primarily aimed to reduce energy consumption in order to lessen the oil dependence (and following a referendum in 1980 also to replace nuclear power energy), today's energy policies predominantly have climate effect reduction in focus [5-7].

The first climate policy was adopted in 1988. The aim was to stabilize CO_2 emissions at that time's level, but this objective was later expanded to include all greenhouse gas emissions in all sectors, and in 1993 a national climate strategy was adopted. The strategy was in line with the United Nations Framework Convention on Climate Change (UNFCCC) and aimed at stabilization of 1990's level no later than 2000, followed by reduction in emissions. Sweden has signed the Kyoto protocol [8].

2.2. Current Energy Efficiency Programmes and Objectives

Today's energy efficiency policies are mainly based on guiding principles that were adopted in the beginning of the millennium, however, an important difference is that new policy objectives have been added [3].

Ever since the national climate strategy was adopted, the Swedish energy and climate policies have been closely tied together and strongly influenced by the EU policies, although many times more ambitious. One important issue has been the EU Directive 2006/32/EC on energy end-use efficiency and energy services (ESD), which requires all member states to draw up national action plans for energy efficiency. Energy efficiency is seen as a means to combat climate change, together with a higher degree of renewable energy sources. These two areas, along with a higher degree of renewable energy in the transport sector, are the plans of action to reach the overarching climate goal to reduce climate emissions by 40 percent [3]. Altogether this contributes to a secure and sustainable energy distribution.

The Swedish objectives are quantified as a 40 percent reduction in greenhouse gas emissions (in the non-trading sector), a 50 percent share of renewable energy, a 20 percent more efficient energy usage and a 10 percent share of renewable energy in the transport sector. These objectives are to be reached in 2020 and relate to the level of 1990. The ambition is that the energy savings will be reached through cost-effective measures, given the energy efficiency gap that has been identified [3].

The EU climate and energy goals, summarized in 20-20-20, imply a 20 percent reduction in greenhouse gas emissions (compared to 1990), and at least a 20 percent share of renewable energy sources by 2020. The EU also has goals for energy consumption in buildings, aiming at a 20 percent reduction by 2020 and at 50 percent improved efficiency by 2050.

In addition Sweden has 16 national, non-legally binding, environmental objectives that all strive toward a sustainable development, with the aim to solve the major environmental problems by 2020. The implementation of the objectives is divided between the national, regional and local level. The environmental objectives that directly relate to energy efficiency are a *Reduced Climate Impact*, *Clean Air*, *Natural Acidification Only* and *a Good Built Environment* [9].

2.3. The Public Sector as a Forerunner

A founding principle in the ESD is that the public, *i.e*., the national, regional and local governments, should have a key role and be forerunners in the energy efficiency field.

However, the Swedish government has decided that the government alone shall take responsibility for being an example to other actors. Regional and local governments are instead offered the possibility to sign voluntary agreements on energy efficiency. Whether the municipal housing companies adopt a role as a forerunner or not has thus primarily become a local political issue, stated in the municipalities' steering directives to the Housing Company. This question is further complicated by the ongoing EU investigation concerning whether municipal housing companies should act on the same premises as private companies, or if certain exceptions for non-profitable housing companies should be adopted [10].

2.4. Energy Consumption in Sweden

In 2007 the total energy usage in Sweden, with a population of 9 million, amounted to 624 TWh, out of which 404 TWh was for end use consumption. The share of renewable energy was 43.9 percent, which was contributed mainly by electricity production through hydroelectric power. Not including district heating originating from renewable waste heat or renewable electricity in electric heating furnace, the total renewable district heating production was 25 TWh in 2006. The buildings and services sector consumed 35 percent, 143 TWh, of the total end use consumption, out of which 60 percent is used for heating and hot water. The sector consumed approximately 70 TWh of electricity, mainly for operating electricity for premises [11].

A total of 27.2 TWh of energy was used in 2007 for heating and hot water in multi-dwelling buildings (with a total of 180 million heated square meters in 2.4 million apartments). The predominant source of energy for this purpose in Sweden is district heating, by which 82 percent of the total area in multi-dwelling buildings were heated in 2007. This corresponds to an average usage of 151 kWh per square meter. During the same year oil heated approximately 1 percent of the multi-dwelling area. The total water consumption was 272 millions of cubic meters [12]. In most cities in Sweden the energy company is owned by the municipality and run on a break even principle.

3. The Million Homes Programme

Energy efficiency in existing buildings is a general problem, but has come even more into focus in Sweden given the ageing housing stock, of which a large part was built during the 1960s and 1970s, and hence is anticipated to be in need of extensive renovations within the next 5 to 10 years.

3.1. Background

The Million Homes Programme was the political decision to build one million dwellings to cope with the housing shortage and in many cases low housing standard of the 1960's. The decision was taken by the Swedish Parliament in 1965 and involved governmental subsidies to stimulate construction. Because of the pressing time schedule and shortage of labor an industrial approach was adopted where pre-fabricated elements were used to a large extent. The goal was reached in 1974, when 1,006,000 dwellings of varying type had been built, of which two thirds were apartments in multi-dwelling units [13]. Another term, the Record Years, is sometimes mentioned in relation to the Million Homes Programme. This period dates back to 1961, and taken together during the period, 1961–1975 approximately 1.4 million dwellings were built of which two thirds were in large-scale housing estates. In this article no explicit distinction will be made between the buildings dating from the two periods, as many of the questions are applicable to the older part of the building stock as well.

The public owners, *i.e.*, municipal housing companies, took part to an increasing extent in building the Million Homes Programme and contributed with the construction of approximately 60 percent of the multifamily dwellings [13]. The municipal housing companies in Sweden build for a large section of the population and it is not social housing in the traditional sense. Out of the 650,000 multi-family apartments still left of the Million Homes Programme the municipal housing companies own almost 50 percent. However, it would be wrong to assume the same conditions for all public or all private owners respectively. In terms of size and economic strength there is as much variation between the public companies as it is between the private companies.

Both public and private owners operate under rent regulation. Rent is set following negotiations between the tenants' association and the municipal housing company, and the private companies have set their rent at the same level as in similar publicly owned and managed dwellings in the same area. Rent increases, except those reflecting general price changes, can only come about if a renovation increases the standard of the apartment but normally not because of energy efficiency measures. The vast majority pay an inclusive rent with respect to heating and hot water, but normally not with respect to electricity.

3.2. The Buildings' Condition Today

As it is now 40–45 years since the Million Homes Programme was built, the buildings' installations are now approaching the end of their technical life-length. Primarily this means that the main water and sewage pipes are in such bad condition that there is a high risk for damage by leakage. Furthermore the ventilation and electricity systems can be in need of replacement, all to maintain the living standard for the residents and the value of the buildings.

Apart from many installations being plain old, the Million Homes Programme in many cases suffers from additional difficulties typical for that period's buildings. New and untested construction techniques and materials as well as a too fast and sloppy work performance have led to other damages than those related to normal aging.

Many of the buildings have had problems with damaged balconies, facades and roofs, most often due to faulty techniques and materials. In addition the buildings were constructed before the higher demands on air tightness and insulation were introduced after the oil crisis, and hence heat losses can be substantial [14]. At the time of construction thermal bridges were not included in any requirements on energy economy, and as a result thermal bridges are frequent where e.g., balconies or wall elements are connected to the building envelope. The ventilation system is commonly based on mechanical exhaust air with no heat recovery, or on natural ventilation. Taken together energy consumption for heating in buildings from the Record Years is on average 170 kWh per square meter and year, but can exceed 200 kWh for heating [15]. This can be compared to the current building regulations where the requirements are 110, 130 and 150 kWh, depending on the climate zone that the building is located in [16]. A very small part of this building stock has been demolished and there are currently no plans for major demolitions and redevelopment, even though there are some controversies about this.

3.3. Possible Energy Efficiency Measures in Existing Buildings

Given the fact that buildings have been pointed out as a sector with great potential for energy savings, the upcoming renovations of the Million Homes Programme are seen as a chance to undertake extensive energy efficiency measures. Many claim that the "window of opportunity" for renovation is now open and cannot be missed, since it is likely that it will take a long time until further renovation and maintaining work is performed.

Measures that can improve energy efficiency in a building can be divided into three categories. *First* there are the measures that aim to reduce heat leakage from the building envelope. This can be done by sealing leaks in the walls or around the windows, by replacing windows, by attending to thermal bridges, and by adding extra insulation to outer walls, basement floors and roofs. *Second* there are the measures that *recover energy*, which can be done by installing balanced ventilation with heat recovery, or by installing exhaust air heat pump or waste water recovery. *Thirdly* there are the measures that *limit the energy distribution*, such as adjusting temperatures, optimization of operating installations and installing more energy efficient equipment. Individual metering is another plausible measure but this aims to affect behavior so that energy isn´t used at all, *i.e.*, is saved, rather than to use energy more effectively [15].

The measures in the third category are minor in comparison and often very cost effective. The measures in the first and second category can be minor or extensive, depending on the conditions of the buildings. Some buildings are well suited for e.g., installing heat recovery while in others there is a need to reconstruct much of the ventilation shafts to achieve this, and the same is true for insulation which easily can be added to some buildings while other need extensive modification. It is therefore hard to say generally that some measures of these two categories are cost effective and others are not. However, regardless of the initial conditions the measures are quite extensive and require planning. Also, the investments in the first category generally have a longer life-length than most of the installations from the second category.

4. Method and Data

This section starts by describing the method of using ideal types, and continues with a presentation of the interviews.

4.1. Ideal Types

Ideal types are used to extract and highlight the most important features of a phenomenon. The concept of ideal types was developed by the sociologist Max Weber, and is commonly adopted in economics, e.g., the concept of the perfect market. The researcher constructs the ideal type by accentuating one or more points, and grouping concrete individual phenomena into an analytical construct. The idea is that one can learn something about the world by constructing a rational ideal type and comparing it with reality. Hence, an ideal type is neither what the world is, nor what it should be, but rather what the world would be like if it operated according to a certain simplified mechanism [17,18].

The motive for using ideal types as an analytic framework is the differences and similarities between the companies that have become apparent in the interviews. The similarities are not big enough to permit an overall generalisation for all of the real estate companies' motives and behaviour, but neither are the differences big enough to claim that nothing can be predicted about the behaviour of one company from looking at the behaviour of another.

Depending on some key factors relevant to energy efficiency and investment decisions the companies have been grouped into categories, which help illuminating the important differences in this context. These involves factors like how extensive are the energy efficiency measures undertaken, at what stage in the process are the questions taken into account, who drives the questions, length of payback time or how certain are the estimated profits. A more detailed description of the classification can be found in appendix. The ideal types simplify what is complex and permit the companies anonymity. Each real estate company may not have its exact counterpart in an ideal type, but each company can be compared to the ideal types to see which ideal type it resembles the most. By showing the variance and width between the ideal types it can be showed that there are different types of real estate companies, and after adding knowledge about how common the different types are, the ideal types can be used to predict and explain the behaviour of the actual real estate companies.

Following the differences in attitudes and how decisions are made, the companies will also respond differently to (different) political measures to increase energy efficiency. Hence, at a later stage the ideal types can be used to design policy measures more effectively in order to reach a higher level of energy efficiency in buildings.

4.2. Interviews

During the period from April through September of 2009 representatives of sixteen real estate companies agreed to meet to give their view on energy efficiency and renovation of the Million Homes Programme. The purpose of the interviews was to get a broad view of how different kinds of real estate owners reason and act regarding these questions. A longer run purpose was for the interviews to serve as a basis for further questions and hypothesis testing in a future questionnaire to a larger sample of companies. The meetings were a form of semi-structured interviews with a pre-formulated questionnaire, where some questions were discussed only with some of the companies when it was of particular interest in that case, and other questions were added to the questionnaire along the way as experience and knowledge grew. The basic structure of the questionnaire can be found in appendix.

The interviews have been supplemented with information such as instructions from the board of directors and policy documents in order to construct the ideal types.

4.3. The Companies

The companies vary in size and range from approximately 3,000 through 34,000 apartments. The real estate companies are active in different parts of Sweden but are not geographically, nor size-wise representative for Sweden as a whole. As the interviews were made as part of an orientation phase the companies were only partly chosen strategically. They were primarily located in the central or southern part of Sweden, which among others include the largest Swedish public companies. The decision to focus on middle sized and large companies was seen as a screening criterion at this stage, in order to include as large part of the Million Homes Programme stock as possible. The chosen companies' respective share of Million Homes Programme buildings also differ, but the company whose absolute number of Million Homes Programme apartments was the smallest still had a share corresponding to approximately 20 percent of their apartment stock. This means that the question of the Million Homes Programme buildings is a major issue for all of these companies within the next 10 years. Public companies were matched with a small number of private companies to look for indications of different strategies for public and private companies. Out of the sixteen companies thirteen have public and three have private owners. Since there are Swedish examples of extensive sustainable renovation in the Million Homes Programme, there was an impression beforehand that there are ambitious and not ambitious companies, both of which were intended to be covered in the interviews.

Table 1. Interviewed real estate companies, type of ownership and size.

Company	Public/private	Size
A	Public	Small
B	Public	Large
C	Private	Small
D	Public	Large
E	Public	Large
F	Public	Large
G	Public	Small
H	Public	Large
I	Public	Small
J	Private	Small
K	Public	Large
L	Public	Large
M	Public	Small
N	Public	Small
O	Private	Small
P	Public	Large

The companies have been represented by experts, strategists, coordinators and controllers in the energy/environment field, by project leaders, heads of business units such as Residential Buildings, Technique or Environment, and in one case by the Managing Director. All of the real estate companies, except for one, have some sort of expressed objective to reduce energy consumption, but all were of course aware of the questions of energy efficiency. The companies represented are briefly presented in Table 1, and in this table the limit between large and small was drawn at 15,000 apartments. This limit can possibly be further refined to include middle sized companies when the sample grows bigger. One of the companies included among the private (Company O) is owned by a pension fund.

5. Analysis: Ideal Types

This section will present the results from the interviews that were held with real estate companies in order to get a better understanding of how they reason and act regarding energy efficiency measures in existing buildings. The results from the interviews have led to the classification of real estate companies into four ideal types, which are presented below. They are ranked according to level of ambition in relation to energy-efficiency measures.

5.1. The Strict Profit Maximizing Company (SPMC)

The strict profit maximizing real estate owner is risk averse and undertakes only those energy efficiency measures that are strictly profitable in the short run to medium run. For this kind of company an implemented energy related project is one with higher expected returns than that of a competing project, and the profitability has to be unquestionable in the profit estimates.

A typical approach is to talk about *saving*, *i.e.*, not using, energy rather than making the actual energy use more efficient. One example would be to turn off the lights (e.g., by using timers) as opposed to changing the lights for more efficient ones, however, both of those approaches are usually part of the energy efficiency work of any real estate company.

Common energy saving measures for the SPMC are found in the third category of Section 3.3, and include adjusting the temperature in the apartments or the staircases, changing the light bulbs for low energy lights or changing equipment in need of replacement for more energy efficient one (which is not necessarily a choice based on energy awareness). These are measures that don´t require a lot of investment cost or other resources, but that show an almost immediate pay-off, both in terms of energy consumption and operating costs. More extensive energy efficiency measures are possible, but must be profitable in terms of significantly lower operating costs (or give a clear profit in terms of goodwill) to cover the investment cost in maybe five years.

Out of the sixteen interviewed firms four can be categorized into this category. It would be intuitive to sort all the private companies into this category but only the two smaller of them, companies C and J, are strict profit maximizing in the sense defined here. Two large, municipal housing companies, B and E, are also close to this type. Companies B and E don´t necessarily allow a longer payoff time, but may do so in specific cases and hence can be considered profit maximizing in the medium run.

5.2. The Little Extra Company (LEC)

Some companies do a little extra above the strictly profitable limit, to show environmental responsibility or because they value energy efficiency higher than the profit maximizing firm does (based on other assumptions about the net operation costs or the value of goodwill). This implies the cost estimates tend to be a little more optimistic in favor of energy efficiency measures, but it is not seen as a tradeoff between energy efficiency and economic goals. Although not always clearly defined, the LEC have got objectives concerning energy efficiency, but these objectives are not given first priority.

The LEC will do all those profitable investments in energy savings that the SPMC does, but also make allowances for energy efficiency measures in e.g., renovation calculations. This type of company will not go through with an investment that implies a loss in order to reduce energy consumption, but is willing to lower demands on return and is more likely to choose an energy efficient product when facing competing alternatives of different energy standard, even if there is no detailed calculation that shows that this is more profitable.

Common strategies for the LEC is to choose the energy efficient alternative when the product has reached the end of its life length and needs replacement either way, or to advance measures that were not yet due, in order to improve energy efficiency. This type of company is also more open to "package solutions" to finance investments in energy efficiency, *i.e.*, a very profitable measure finances the energy savings brought about by other less (/not) profitable measures. By seeing a number of measures as an energy efficiency package, the package as a whole can be profitable even if some of the individual measures need not to be (or is to a less extent).

Four out of the sixteen companies have been identified as belonging to this category. One of these, company O, is a small, private company, but its owner structure may allow or encourage it to undertake measures to improve energy efficiency that are possibly profitable only in the longer run. The other three companies, F, H and P are large, municipal housing companies.

5.3. The Policy Led Ambitious Company (PLAC)

In this type of company the official energy efficiency goals are ambitious and come, to a large extent, in the form of owners' directives or the like. Energy efficiency has been given high priority and is seen as a greater good, or it is seen as something that is necessary in the long run and might as well be undertaken now. Another possibility is that the owners through energy efficient renovation want to fulfill some other goal (e.g., to combat unemployment or social decline).

The PLAC undertakes the profitable measures and is open to package solutions, but since the instruction to give priority to energy efficiency comes from the owners, this company also has a greater freedom to undertake measures that cannot be shown to be profitable. Profitability is however the ideal and this kind of company may well justify an economic loss by arguing that it internalizes the damages of greenhouse gas emissions, and the profit estimates are "manipulated" to show a profitable investment where the company wants to see it, e.g., by assuming high future energy prices.

The PLAC will consider energy efficiency measures from all the three categories, but since decisions are influenced by (company) politics there may be a difference in where in the planning process the measures are first considered. In the "worst case scenario" owner directives are given late in the process, hence increasing the risk that costs will be higher because of ad hoc solutions, however, this is not necessarily so for all the PLACs.

Four public companies have been sorted into this category. Three, D, K and L, are large and one, N, is small. These companies have got instructions to undertake energy efficiency measures, preferably in the renovation phase, and sometimes with an expressed permission to ignore profitability. This is not to say that energy efficiency work would not have happened without the initiative taken by the owners, but under the PLAC conditions no "organizational fight" is needed, and the employees only have to act upon the instructions given.

5.4. The Administration Led Ambitious Company (ALAC)

The Administration Led Ambitious Company has ambitious energy strivings but these arise mainly from the employees in the company, most often found in the managerial body. As with the PLAC economic profitability is not the obvious objective, but it may be harder to gain acceptance for expensive measures. Even if the owners are supportive of the overall ambition, they are not who initiated the ambitious energy efficiency strategy, and there might therefore be more conflicts within the managerial group in this case.

The ALAC undertakes the same measures as the PLAC, but since the ideas (may) have been present in the organization a longer time, they may also have had the time to be integrated properly in the renovation planning process, and therefore the risk of ad hoc solutions is smaller.

As noted, the ALAC will undertake measures from all three categories, and this will be done in a holistic way, although pilot projects are commonly used to start the process, to reduce the risk and to take advantage of the learning process.

The four small, public companies A, G, I and M all fit into this category. The smallness of the company may give the necessary conditions for employees to strongly influence the decision making process, through the work of individual enthusiasts.

5.5. Overview of Ideal Types

To get a better overview the companies are presented according to ideal type in Table 2. The Strict Profit Maximizing Companies are a mix of public, private, small and large companies, whereas the Little Extra Company, the Policy Led Ambitious Company and the Administration Led Ambitious Company are somewhat more homogeneous categories.

Table 2. Real estate companies sorted by ideal type.

SPMC	LEC	PLAC	ALAC
B (public, large)	F (public, large)	D (public, large)	A (public, small)
C (private, small)	H (public, large)	K (public, large)	G (public, small)
E (public, large)	O (private, small) [vii]	L (public, large)	I (public, small)
J (private, small)	P (public, large)	N (public, small)	M (public, small)

6. Conclusions and Discussion about Future Research

6.1. Conclusions

Given the results from the interviews we have seen that there is a variety in real estate companies' approaches to energy efficiency investments, which implies that we cannot expect a common response from them—not in the current situation, nor given possible future policy measures.

What drives companies to adopt one strategy rather than another can depend on a number of factors, a few of these have already been touched upon above. For example, a real estate company that has a strong economic position and gets instructions from the owners to reduce energy consumption will become a PLAC and energy consumption will be reduced. On the other hand, a company that goes through hard times with falling demand is more likely not to make big investments in energy efficiency, and to become a SPMC by necessity. Another factor influencing on the energy strategy adopted is related to the building stock in question. A company that has a large share of the building stock from this period, a share that is in a poor state of repair, may not afford to do anything more than what is strictly profitable, while a company that has a smaller share of this type of housing might afford to do a little extra and become a LEC-company.

What are the prospects of reaching the energy efficiency objectives, given the types of companies identified in the study? The SPMCs will not undertake extensive energy efficiency measures unless the investments are clearly profitable in a rather short term. This means that this category of companies, that already does little, will be marginally affected by most policy measures. Unless very generous subsidies are given, the investments will probably not become profitable enough for this type of company.

The LECs will continue doing marginal extra measures, and this group may be more affected by policy intervention. Many countries have introduced such subsidies (see e.g., Amstalden *et al*. 2007 that describe the situation in Switzerland [19]), but a risk is that companies postpone measures if they anticipate that subsidies are coming.

The ALACs and the PLACs are already on their way to achieving the ambitious objectives within their own stocks. However, a risk with the PLACs is the high dependence on policy decisions, meaning a shift in government may change the picture rapidly. If an energy aware political majority loses power, energy efficiency work may be cancelled. On the other hand, if an energy aware majority comes into power large investments may be done that aren´t well thought through, and this can lead to set-backs. Hence, the PLAC is an unstable structure that should not be relied upon too heavily in the energy efficiency work. A similar type of instability can be expected in the ALAC-company, as changes in the administrative staff can lead to policy changes.

The overall result in succeeding to reach the energy savings objectives will then depend on how many companies undertake energy efficiency measures, and on how much these companies do. With today's rate of investment energy efficiency objectives will not be met and at least two of the ideal types will not be more than marginally affected by indirect policy intervention. A more direct intervention might thus be called for, but the design of this should take into account how the real estate market is structured and on what the existing incentives and obstacles are.

6.2. Future Research Issues

One important remaining issue is to find out how large share of the companies are close to each of the ideal types. As mentioned above we plan a questionnaire to collect information about this. The research carried out so far also raises a number of further issues:

How many measures are "really" profitable? The result so far indicate that the belief that there is a large number of measures that are profitable, but not carried out might be mistaken. The impression from the interviews is that the firms that make large-scale energy related investments when they renovate cannot show that this is profitable and often add other more broad arguments—in terms of pilot studies and that they want to show that they are willing to contribute to the national goals about energy saving. If it turns out that many measures are not profitable, and if the SPMCs and LECs represents the majority of the Swedish real estate companies, it is either necessary with some kind of subsidy if the government want the companies to do more, or that energy taxes are raised. More direct regulations might also be needed.

How is profitability really calculated? Calculating profitability of an investment is not easy and a number of assumptions must be made. Perhaps the companies are making mistaken assumptions and therefore come to the conclusion that measures are not profitable? There are three points where such "mistakes" are possible, and that is assumptions about costs, revenue (energy saving and energy prices) and the discount rate. An example could be that the firms are using their traditional discount rates which might be around 5–8 percent. During the last ten years the interest rate has however on average been clearly below that, and the aggressive use of interest rate reductions by Central Banks in recession, might lead to lower average interest rate of the business cycle, so maybe a "correct" discount rate would be 3–5 percent. Such a change could to a large degree affect the profitability of long run investments.

How can policy affect firms that are not profit-maximizers? If the companies, in line with the theory put forward by Herbert Simon, are "satisficers" and currently are making a reasonable profit they might not be interested in doing things to increase profits more. The Swedish property owners' association has argued that many small property owners do not even do the simplest and most profitable things, like adjusting heating and ventilation equipment [20]. In our sample no such companies were found but this could be seen as a fifth ideal type. One way to affect the "satisficing" firms could be to give information about what can be done, and all Swedish properties must now have an "energy declaration" that should be posted in the hallway. This declaration not only describes the current energy status of the building but should also list measures that (easily) could reduce the energy consumption. As it might not "look good" if the company does not carry out these measures and some environmentally aware tenants might complain if this is not done, it might actually affect the "lazier" satisficing companies. The Swedish Property Federation is discussing a campaign focusing on these owners where the basic message should be how simple, how cheap and how profitable these measures are—but also that everyone has to contribute if the national goals should be reached!

Are measures affected by "perverse" incentive structure (split incentives)? This issue has come up during some of the interviews and concerns:

Cost-based rents: The Swedish municipal housing companies' rents are determined by negotiation with the local tenants' union. These negotiations often start from how costs develop in the firm. If energy costs are falling, because of energy reducing investments this might lead to a demand for reduction in rents, or at least a smaller increase. In this way the profit for the firm is reduced.

Individual metering: If the tenant directly pays at least part of the energy cost, and the landlord makes an investment, part of the gain would go to the tenant in the form of reduced costs, leaving less profit for the landlord.

The tariff structure of the energy company: In most cities in Sweden the housing stock is heated through district heating, and the energy company is owned by the municipality and run on a break even principle. As earlier described district heating is most common in Sweden for heating the housing stock. The energy companies' tariff is sometimes constructed in such a way that there is a large fixed part that does not change with energy consumption, and sometimes when their sales go down because of energy savings they increase their tariffs to cover the total cost. All this means that the final reduction in cost for the housing company that reduces their energy consumption might be rather low, lower than the "actual cost" saved. Of course, if the true short run saving in costs is low, then there is no perverse incentive. There are e.g., cases where heating comes from excess heat from nearby plants and where the true cost reduction actually is small.

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Appendix A. Structure of Questionnaire for Interviews with Real Estate Companies

The stock: Size of the stock, current renovation state

Energy efficiency in general and for the company: Views on profitability. Main drivers of policies. Who initiates energy efficiency measures?

Energy efficiency in conjunction with renovation: Views on coordination possibilities. Measures carried out and motives for these.

Investment assessments: Views on future energy prices, payback periods, how the risk is assessed, effect on rent levels, financing of energy efficiency measures.

Other issues: How do the energy declarations affect the company? The role of the government and need for support and probable future legislation. Attitudes towards individual metering and effect on decisions by tenants and landlords.

Appendix B. Detail on Classification of Companies

The companies have been classified using a combination of their answers to interview questions and their policy and steering documents.

Objectives/Scope of Measures

In some cases it was known in advance that extensive energy efficiency measures had been made, and these companies could be sorted into ambitious companies right away. This was the case for the Administration Led Ambitious Companies (ALACs) A and G. For other companies it was not until the interview that it became known that the company does work extensively with energy efficiency investments. This was the case for ALACs I and M, but also for all of the Policy Led Ambitious Companies (PLACs). Companies I and M were both in more of a planning phase so there is no absolute guarantee that they carry out all of the measures in the end, however, it was expressed officially on the company webpage and in documents, and they had both signed a Swedish declaration of purpose for public real estate companies, which has got more ambitious energy objectives than the official Swedish objectives. The PLACs had directives from the board, and also in the case of companies D, K and L extra financing to improve energy efficiency, and hence are expected to follow through with this. The Little Extra Companies (LECs) were sifted out from the not ambitious companies through their intention to improve energy efficiency as an end in itself, expressed through energy efficiency objectives (although not as ambitious as those above). The Strict Profit Maximizing Companies (SPMCs) all agreed that extensive measures were unlikely to be undertaken since other investments have better returns. They carry out the savings measures that have a guaranteed fast payback.

Profitability

From the interviews it was clear that the ALACs and the PLACs saw profitability in the very long run, and viewed energy efficiency measures as insurance more than as a safe investment. Companies D, K and L even had an expressed permission from the board to overlook profitability in order to fulfill energy efficiency objectives as well as employment objectives. The SPMCs on the other hand only carry through energy efficiency investments that have better expected returns than a competing project, which according to them was rare. As earlier mentioned, they do however carry out the savings measures, which will pay back almost immediately. The LECs make a more optimistic assessment of the parameters affecting profitability than do the SPMCs, but differed from the more ambitious companies in not being able to justify profitability only in the very long run, the LECs did need at least a medium run payback.

Initiator/Driving Force

One hypothesis before the interviews was that the extensive measures won´t be initiated "by themselves" but rather need a real driving force. For the ALACs the administration worked rather independently and planted the ideas of energy efficiency in the board, whereas the PLACs (however supportive of the ideas) to a larger extent merely followed orders.

Paper 2

Real estate owners' views on renovation and energy efficiency in post-war multi-dwelling buildings

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Real estate owners' views on renovation and energy efficiency in post-war multi-dwelling buildings

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Abstract

The upcoming renovations of large parts of the Swedish residential building stock have been seen as a window of opportunity to undertake energy efficiency measures, which would contribute to reaching ambitious savings objectives. In this paper the indications that building owners don´t have strong economic incentives to undertake such measures are investigated, and it is tested whether company attitudes and strategies differ with respect to level of ambition in energy efficiency matters.

The aim of this paper is to get an insight into the renovation and energy efficiency state in Swedish housing companies, and to test hypotheses about how much energy efficiency work has been carried out and how potential obstacles and energy efficiency in terms of investment opportunities are perceived in order to give an indication of what energy efficiency investments can be expected to occur spontaneously in the existing Swedish building stock.

The results indicate that renovations have started but will constitute a challenge to the companies, which may crowd out energy efficiency investments. They also indicate that the more ambitious companies do more extensive energy efficiency work and are more forward planning, but will not intervene "in excess", in comparison with less ambitious companies. There are also indications that energy efficiency may be hindered by transaction costs, uncertainty about future energy prices, competing investments or financing, and that less ambitious companies place more emphasis on transaction costs, competing investments and financing problems than do more ambitious companies. There is no indication that the importance of economic considerations or that perceptions of uncertainty, risk or profitability differ with respect to ambition level, nor are there indications that the use of calculation methods or discount rate differs. It appears that it isn´t primarily economic or regulatory drivers that make the ambitious companies invest in energy efficiency; rather they seem to need other motives for energy efficiency investments in order to "create" profitability, whereas less ambitious companies seem to value short term profitability higher than ambitious companies do. Taken together only moderate energy efficiency investments are expected.

Keywords: Energy efficiency, renovation, incentives for energy efficiency, obstacles to energy efficiency, residential buildings, housing companies, ideal types

1 Introduction

Sweden has adopted ambitious objectives to improve energy efficiency in buildings, as a response to the EU Directive 2006/32/EC on energy end-use efficiency and energy services (ESD). The success in achieving these objectives depends on the outcome of the work done in the entire Swedish building sector, not the least within the housing sector. This will require substantial effort from housing companies, who also struggle with upcoming renovations of the large part of the stock that was built during the post-war era, in particular the so called Million Homes Program (1961-75).

It has been argued that the upcoming renovations are a window of opportunity to substantially improve energy efficiency in a cost efficient manner. However, indications from interviews with Swedish housing companies suggest that clear economic incentives for doing so are weak or absent. Following the results in Högberg *et al.* (2009) housing companies are expected to invest in energy efficiency according to the *ideal type,* based on level of "ambition" regarding energy efficiency improvements, they belong to. Difference in response to economic incentives due to heterogeneity among companies has been discussed earlier. The novelty presented here lies in that companies *within the same sector*, private as well as municipal, are distinguished as different types.

In this paper the results from a web survey carried out among Swedish housing companies are presented, giving an overview of the renovation status and the companies' attitudes to and strategies for energy efficiency investments. After classifying the companies into ideal types a number of hypotheses are tested within three overarching themes:

- the *scope of the energy efficiency measures* the companies have carried out or plan to carry out,
- the *perceived presence of obstacles* preventing more improvements in energy efficiency to be carried out, and
- how the companies view *energy efficiency measures in terms of investment*.

Overall, the more ambitious companies are expected to plan or to have carried out more (extensive) energy efficiency improvements than less ambitious companies, whereas the less ambitious companies are believed to place more emphasis on obstacles, profitability and how to properly account for profitability than more ambitious companies.

The aim of this article therefore is twofold; firstly to get a better picture of how these matters are handled in the housing companies, and secondly to test the hypotheses presented above and draw conclusions of what can be expected of (spontaneous) energy efficiency improvements in Swedish housing companies.

The paper will continue with a background and theory presentation in section 2, to go on to presenting the method and data in section 3. In section 4 the survey results related to renovation status are presented and in section 5 the survey material is used to the hypotheses. The results are analyzed in section 6, and concluding remarks can be found in section 7.

2 Background and theory

2.1 Renovation in the Swedish post-war building stock

The last ten years' debate in the Swedish building sector has been characterized by worrisome reports about the renovation state in the so called Million Homes Program [MHP][1] (e.g. Boverket 2003; VVS Företagen & Svensk Ventilation 2008; SABO 2009). In 2007 there were approximately 2,460,000 multi-dwelling building apartments in Sweden, 35 percent of which were MHP apartments (Boverket 2008). Only relatively small parts of this building stock have yet been renovated as can be seen in table 1.

Table 1 Estimation of the multi-dwelling building stock constructed 1961-75*, by owner category in 2002* (Boverket 2003).

The Million Homes Program	No of apartments	In need of renovation
Municipal companies	390,000	300,000
Private owners	222,000	
Housing co-operatives	242,000	
Total	**850,000**	**650,000**

The need for technical renovation includes change of pipe systems, bathrooms, electrical wiring, ventilation, windows, balconies, façades, elevator installations, and yards. To avoid serious maintenance problems, a scaling up of renovation is needed in the next 10 years; from today's approximately 25,000 apartments per year to around 65,000 per year (Boverket 2003). Given the multi-challenging nature of these areas, which often suffer from economic and social problems, and given the apartments' noncompliance with current building standards regarding e.g. accessibility, renovations are expected to be demanding and expensive (Industrifakta 2008).

The extent to which the public housing companies would be able to renovate depends on the size and degree of degradation of their 1960's and 70's stock, and on their varying economic conditions. Nevertheless, no public company is expected to be able to completely renovate (including energy efficiency improvements) all of their MHP buildings, as this would be too costly (SABO 2009). Thus, the need for financial support to housing companies for renovation and/or energy efficiency has been considered (BKN 2008; Energimyndigheten 2010b).

Muyingo (2009) suggested that, compared to private real estate companies, public real estate companies "over-maintain" their buildings (maintenance levels measured in reported maintenance costs). Along with several possible factors affecting maintenance levels avoidance of bad publicity was pointed out as a reason for over-maintenance.

[1] The Million Homes Program is the name for the political initiative in 1964 to build one million dwellings in ten years (1965-74) in order to combat housing shortage and poor housing standard. The wider period 1961-74 is also known as the 'Record years' and no distinction between the two will be made in this study, as the challenges addressed here apply to (renovation of) buildings from the whole period 1961-75.

Historically it has been possible for public companies to "compete" with maintenance at a level higher than what is profitable, as they have operated under a non-profit policy. However, new legislation coming into effect in 2011 commit the public housing companies to operate on a businesslike basis which will limit the degree of freedom of the housing companies (Lind & Lundström 2011). The EU has stated that the public sector should act as a forerunner in the energy efficiency work but in Sweden this has been limited to the state level and does not include the municipal housing companies (Näringsdepartementet 2009). Municipalities, however, may sign voluntary agreements with the Swedish Energy Agency [SEA, Energimyndigheten] with the aim to work exemplary with energy efficiency in exchange for e.g. information and other support (Energimyndigheten 2008). In addition, the Swedish housing market is rent regulated which will complicate the achievement of the energy efficiency targets, as investments costs only can be transferred to tenants to the extent made possible through rent negotiations between real estate owners and the Swedish Union of Tenants [SUT] (Lind 2011).

2.2 Energy consumption and efficiency in the Swedish building sector

In 2009 the Swedish building sector consumed 149 TWh[2], which corresponded to 39 percent of total end use consumption. Almost 60 percent of this was used for heating and hot water. 24 TWh was needed for heat and hot water in multi-dwelling buildings (Energimyndigheten 2010a). The building sector is pointed out by the EU as key to reducing energy consumption, and it has been claimed that a lot of cost-efficient energy efficiency measures are not carried out (SOU 2008:110 2008; Granade *et al*. 2009). The upcoming renovations of the MHP have been promoted as a window of opportunity to improve energy efficiency in the building stock as a whole. This given that such big a part of the stock is to be renovated, and that it is notoriously energy inefficient (Sveriges Byggindustrier 2008).

The Swedish Property Federation [SPF, Fastighetsägarna] has made a number of investigations to see how their member companies work with energy efficiency, and wherein the challenges lie. In one of these, the members' energy efficiency work from 1995 through 2008 has been investigated to get an idea of what and how Swedish private real estate owners do when improving energy efficiency. The 44 interviewed companies varied in size; which also seemed to be connected to the energy efficiency work they had carried out. The general impression was that most of the companies did work with the question, although not necessarily in a structured way. Many of them also stopped as soon as a bigger improvement had been carried out, not considering it to be necessary or economically viable to go on further (Fastighetsägarna 2010a). Another study included interviews with a smaller number of companies and a telephone survey with more than 200 companies; member (i.e. private) companies as well as public housing companies. The results indicated that between 70 and 90 percent of the companies have carried out measures that directly and indirectly have lowered energy consumption during the last five years. This has resulted in savings of about 10-15 percent, but since many of the companies haven´t followed up the results of the investments these figures are estimations (Fastighetsägarna 2010b).

[2] Not temperature corrected.

2.3 Barriers to energy efficiency

A natural starting point when investigating the incentives for energy efficiency is the so called energy efficiency gap, referring to the difference between the actual and optimal energy use, i.e. the cost-effective measures that aren´t being carried out (Jaffe & Stavins 1994c). This gap for the Swedish building sector has been estimated to 16 TWh of final energy (SOU 2008:110). A profit maximizing company should undertake all investments with a positive net present value, but the apparent failure to do so is commonly explained by market barriers and market failures. Jaffe & Stavins (1994a; 1994b), Golove & Eto (1996) and Linares & Labandeira (2010) all provide overviews of the obstacles to increased energy efficiency.

Market failures stem from malfunctioning and should be corrected to get a more efficient market. These include (incorrect pricing of) external effects from energy use, information problems such as limited knowledge about energy efficiency technology, split incentives (principal-agent issues) and the necessary learning process for new technology (Jaffe & Stavins 1994b). The latter, however, is only a market failure if it implies positive externalities are held back. A correct pricing of energy from a social point of view will reflect the marginal social damage from consumption, and is crucial to reach a socially optimal level of energy consumption. For example, the Swedish Property Federation has looked at incentives effect of district heating price models (Fastighetsägarna 2010b). To create incentives for energy efficiency energy prices may have to be raised (if not currently correct). However, Nässen *et al*. (2008) suggest that price elasticity in the real estate sector is low due to the limited share energy costs make up of total expenses, meaning this would require substantial energy price increases to have an effect in the building stock. Taken together: market failures are those barriers stemming from externalities (which leads to over- or under-consumption of a certain good), imperfect competition, public goods and imperfect information (Golove & Eto 1996).

Market barriers are factors that make energy efficiency investments less appealing or not profitable to the company. They hold back improvements in energy efficiency, but don´t mean that *not* investing in energy efficiency is irrational. Among the market barriers are hidden costs or transaction costs, e.g. the search for information on new technology may cost too much in time and effort and therefore discourage companies from investing. A second barrier may lie in the way the companies carry out their investment calculations. For example, it may follow from high discount rates that estimations appear unprofitable. A high private discount rate may be, but is not necessarily, a market failure in need of intervention. Similarly, low current or expected future energy prices will result in lower estimated profitability compared to if energy prices were (expected to be) high (Jaffe & Stavins 1994a; Linares & Labandeira 2010). In this aspect, uncertainty is an important factor, which either can make the investment seem too risky, or which can make postponing the investment rational awaiting better/cheaper technology or policy measures (van Soest & Bulte 2001; Gaeta 2010). Another barrier arises from imperfections in capital markets resulting in limited (investment) resources; either from a difficulty to raise capital or from competing investment opportunities. This could be significant for the soon to be demanding post-war part of the stock that is in focus here – in terms of capital as well as in terms of labor (time). There may also be institutional barriers or organizational inertia impeding energy efficiency investments, which can be coupled with transaction costs. Moreover, energy efficiency technology may be cost efficient on average, but not to the individual firm, e.g. due to mix of technology use, geography or other conditions affecting the investment. Lastly, there is the possibility that energy use is only a secondary property for a certain product, that is, energy use is a hidden property (Jaffe & Stavins 1994a; Linares & Labandeira 2010). The last factor is also something that can contribute to the risk that improvements in energy efficiency don´t lead to reduced energy consumption due to the rebound effect (Linares & Labandeira 2010). There are hence a number of possible explanations for the claimed energy efficiency gap, and consequently a questioning of whether it is right to talk about an energy efficiency gap at all, that the non-adoption of energy saving technology may be the rational behavior of companies (Golove & Eto 1996; Linares & Labandeira 2010).

de Groot *et al*. (2001) empirically investigated energy savings decisions in a sample of 135 Dutch companies in seven industry sectors (none of which were housing or building). A third of the companies thought energy efficiency was important or very important in general investment decisions. There were, however, barriers to investing in new technology – most of them purely economic. The more emphasized barriers were competing investment opportunities, the need to wait for replacement of existing technology before investing in new, that existing technology was sufficiently efficient, that energy costs weren´t sufficiently important or that energy efficiency was not a priority (all with an average of at least 3 on a 5 point scale). Other tested obstacles that were of intermediate importance were internal organization resistance, internal budget constraints (and to some extent external financing), uncertainty regarding quality and the wish to wait in hope for subsidies, cheaper technology or experience of colleagues. The importance of the different barriers varied over the investigated industrial sectors, particularly in relation to energy intensity.

In one of the investigations made by the Swedish Property Federation, using telephone interviews to reach 40 member companies, the companies could value a number of suggested barriers (Fastighetsägarna 2010b). The two most important barriers were financing of investments and uncertainty about how to proceed with the next step carrying out measures. In an interview and survey study the results showed that profitability and financing were mentioned most often by both types as the biggest obstacles, whereas lack of time/other priorities and uncertainty about the promised effect were the highest ranked among a number of stated problems the companies could value (Fastighetsägarna 2010d).

2.4 Differences in strategies/firm behavior

There are examples of companies that have adopted a more offensive approach to energy efficiency matters (Högberg *et al*. 2009; Fastighetsägarna 2010d). We will soon look at firm behavior and motivations related to company behavior, but start with a more general approach. Since energy efficiency can be regarded not only an economic question but also an environmental question it is useful to look at what drives companies to more general environmental pro-activity, for example voluntary pollution reduction programs or environmental certification. In the management and business literature there are plenty of studies investigating what factors affect companies’ degree of pro-activity.

On a general level, van Marrewijk & Werre (2003) discuss six levels of ambition for corporate sustainability. The ambition levels hierarchically range from pre-Corporate Sustainability through Holistic Corporate Sustainability and originate in "core value systems", adopted in accordance with external conditions and level of company maturity.

Among external factors, the degree of pro-activity varies over business sector; companies in more polluting and risky industrial sectors seem to be more inclined towards pro-activity. Geographical location also seems to matter, perhaps due to environmental regulation (where companies adapt to the strictest) and social pressure from nearby activities (J. González-Benito & Ó. González-Benito 2006).

On the organizational level, mainly relating to the company itself, larger companies are again found more likely to be proactive. This is suggested to be connected to the necessity to reach economies of scale within the company to free resources that can engage in running practical environmental activities and/or research and development. The importance of publicity could also be more important to larger companies. Companies performing poorly environmental-wise seem to go into voluntary program to a higher degree, *if* it will help address their own specific pollution, which may be an attempt to avoid stricter regulation (J. González-Benito & Ó. González-Benito 2006; Videras & Alberini 2000; Anton *et al*. 2004). Moreover, the more internationalized the company is, and the closer to the customer in the value chain, the more pro-active. A generally strategic investment behavior indicates a flexible organization and an ability to see investment opportunities, and could hence influence the degree of pro-activity as well (*ibid*). An example from the hotel industry shows that the age and size of the facilities, chain affiliation, the use of operation management techniques and stakeholder environmental pressure all affect the probability of the companies engaging in environmental practices (Álvarez Gil 2001).

Parts of the literature specifically address management which seems to play an important role. Dedicated managers will facilitate resource availability and coordination (see e.g. Delmas & Toffel 2004). Furthermore, the beliefs of management will affect their perception of e.g. stakeholder pressure. If they are dedicated this will lead them not only to profit maximize but also to utility maximize by e.g. lowering energy consumption when operating the company (Nakamura *et al*. 2001).

Stakeholder pressure is a factor of more institutional kind that also seems to play an important role, and as noted the companies can act upon such pressure reactively or proactively (J. González-Benito & Ó. González-Benito 2006; Anton *et al*. 2004). Stakeholders can be regulatory (e.g. national governments, the EU), internal (e.g. owners, customers) or external (e.g. NGO´s) (Delmas & Toffel 2004). The more pressure, the more proactive the company gets, and this is suggested to be regardless of what stakeholder(s) is (are) exercising the pressure (Murillo-Luna *et al*. 2008).

The companies can also be said to be driven by different motivations, and the dominant type of driver will affect the environmental response. The different drivers; economic, regulatory and "other", can be described in various ways. An example of categorization is into ethical, competitive or relational motivations (J. González-Benito & Ó. González-Benito 2006).

Paulraj (2009) used another division which starts from legislation, competitiveness and ethical motivations and results in three corresponding company clusters; coercive, competitive and comprehensive companies. There is a progression in the way the companies in the clusters respond to different drivers. Companies in the coercive cluster primarily responded to legislation and regulation, the competitive cluster do so as well but are more affected by competitive and/or economic reasons, and the comprehensive cluster is driven by all of the above mentioned motives, but also by ethical motivations (Paulraj 2009).

Turning to what has been written about energy saving, besides for the obvious regulatory or economic drivers (when energy efficiency investments are profitable), different kinds of pro-active investment behavior have also been addressed in the literature. For example, return on energy-saving investments has been found to vary over financial and organizational characteristics of the company, which will affect investment behavior as well as investment outcome (DeCanio 1993). Financial performance and company size have been found positively related to the decision to invest in energy efficiency, and that the choice varies over geographical location and business sector. Furthermore, ownership seems to play a role – a larger share of "insider ownership" (in terms of shares owned by e.g. managers) affects the investment decision negatively (DeCanio & Watkins 1998).

de Groot *et al*. (2001) found that motives for implementing new energy-saving technology for the investigated companies in seven producing sectors were the possibility to reduce costs and the green image of the company, but also policy measures such as fiscal arrangements or investment subsidies mattered. As a response to financial policy measures (energy taxes) the more likely response was claimed to be energy saving technologies or increase of final product price. The results in attitudes varied over company size, energy intensity (between sectors) and competitive position (de Groot *et al*. 2001).

Looking at five companies from real estate related sectors, Selmer (1994) suggested that the type of a company's mission and goals – offensive (typically private) or defensive (typically public) – and real estate management's share of core business affected energy saving management in the 1970's and 80's. The exploratory nature of the investigation did not allow generalization beyond the sample, but the results indicated that the perception of external pressure varied over company type. Public companies, for example, relied heavily on political and financial support. Out of the investigated companies with large real estate management share, the defensive public housing company quickly institutionalized energy conservation management which legitimized the matters within the organization and made it subsist despite weaker political and financial support. In the offensive private real estate company (with a majority of commercial real estate) on the other hand, organizational recognition was small and the energy conservation question was handled *ad hoc*. The location of the commercial buildings was mainly in high rent locations so heating costs were only a minor part of total rents, and hence they *avoided* energy conservation (Selmer 1994). Rapp & Selmer (1985) had also investigated the effect of policy measures for different categories of companies. They concluded that few policy measures would have any impact, especially on the offensive companies, who only responded somewhat to loans. Informative measures, e.g. branch information, did have some effect on defensive companies. Investment subsidies were questioned as they wouldn´t affect offensive companies enough whereas defensive companies probably would have conserved energy anyway (Rapp & Selmer 1985).

Malmqvist & Noring (2009) investigated the role of added value as a driver for energy efficiency, particularly looking at a smaller number of ambitious real estate companies in Stockholm. On the rental housing side tenant satisfaction was the main value-adding aspect in the short run, and better control over buildings, strengthened image and readiness to meet future requirements were important elements in a longer perspective. Factors that were favorable to make companies lead the development were driving spirits within the organization and a strategic behavior (e.g. to forego regulation); to lower operation costs in order to enable other investments or for moral reasons, whereas the difficulty to spread enthusiasm about the question constituted an obstacle. The authors also highlighted the importance to see the heterogeneity among companies regarding e.g. business strategies and psychology, meaning they can be passive or active, with or without driving spirits, risk averse or risk inclined, and interested in building their trademark or not. The companies were also distinguished with respect to knowledge and ambition; among housing companies the knowledgeable and driven companies were already working with energy efficiency, owners of MHP apartments were examples of knowledgeable companies with little incentive to improve energy efficiency and smaller private owners were companies with little knowledge and little incentive. The characteristics of the interviewed companies placed them in the first category, integrating and reinforcing the energy efficiency work. The continuously increased knowledge within these companies decreases their perception of risk connected to energy efficiency investments. The two latter types on the other hand needed to be targeted by different policy measures to increase their efforts (Malmqvist & Noring 2009).

The Swedish Property Federation's findings (Fastighetsägarna 2010a; Fastighetsägarna 2010d) support the indications that company size matters; the smaller companies have planned and carried out less (advanced) measures, have less follow-up of energy consumption and don´t work in a strategic way with the question, in contrast to many of the bigger companies. The bigger companies aimed to reduce energy consumption although often constrained by other necessary investments and uncertainty about the actual results of energy efficiency measures. There does however seem to be a tendency to take the opportunity to carry out some energy efficiency work when doing other renovations. The investigated obstacles also seem to be perceived differently by the bigger, more ambitious companies, than by the smaller companies. Public companies also seem to do more energy efficiency work than private companies. The SPF set up four requirements that are necessary for a company to be pro-active rather than reactive: someone within the organization has to understand and draw attention to the energy (cost) issue; the question needs to be anchored, understood and supported within management, which leads to organisatory integration with formulation of objectives and follow-up routines; there has to be (competent) human resources available inhouse and externally; and finally there has to be other resources available (Fastighetsägarna 2010a; Fastighetsägarna 2010d).

3 Method and data

3.1 Survey

A web based questionnaire was sent out to Swedish housing companies in January and February of 2010. The questions had been tested on a reference group consisting of people from the industry. The public companies received the questionnaire through the Swedish Association of Municipal Housing Companies' [SABO] internal survey system. The private companies were addressed through a web survey tool (Surveymonkey 2010). The aim was to investigate the total population, whereby the survey was sent to all member companies of SABO (288 housing companies owned by municipalities), and to all private companies that could be found on industry web pages (a total of 60). The private companies who were not reached are assumed to be "too small", considering that they don´t market themselves, and are therefore not expected to affect the implications of the survey results. 87 public and 24 private companies responded, a total number of observations [Obs, n] of 111.

3.2 Response rate and non-response

111 companies answered the survey, which constitutes a response rate of 32 percent. The responses of those who have answered the survey after a reminder have served as proxy for the non-responding, to test if their answers differ from the average of those who have answered. No systematic differences have been found among those late respondents compared to the sample as a whole. Since only bigger companies were targeted among the private the answers may suffer from bias based on this. As previously mentioned this is not believed to affect the implications of the results, but may be taken into consideration.

A brief overview of the companies in the sample is given in table 2. 78 percent of the sample companies were public and 22 percent were private. As can be seen in the second column, there was some partial falling off in the sample.

Table 2 Descriptive statistics

	Obs	Mean	Min	Max
Public	111	0.784	0	1
Number of apartments	110	4 174	356	30,000
Number of MHP apartments	109	2 031	52	10,000
Share of MHP apartments	109	0.533	0.047	1
Have EE objectives	108	0.843	0	1

3.3 Categorization

The starting point of this paper's analysis is four ideal company types, in terms of ambition in energy efficiency matters. The ideal types are based on views, attitudes and strategies that the real estate owners expressed during interviews, formulated in Högberg *et al*. (2009). The two more ambitious types have been merged into one, the Ambitious Company (AC), along with the (least ambitious) Strict Profit Maximizing Company (SPMC) and the Little Extra Company (LEC).

Some of the survey questions, primarily those related to energy efficiency objectives, were intended for classification of the companies into ideal types (see Appendix A). After studying the answers more closely there turned out to be deficits in using them as classification tools[3]. Complementary information was hence collected through the companies' web sites, annual reports, policy documents and so forth to clarify the companies' levels of ambition. The classification questions were then used for confirmation, and to decide specific categories in those cases where the web sites left assessment hard. This procedure was followed for both private and public companies.

Table 3 summarizes the ideal types' characteristics. The SPMC is the least ambitious company with regards to energy efficiency improvements. They are expected to do only those improvements more profitable than competing investments, i.e. not much more than savings measures and they demand a short payback period. The LEC has higher ambitions for improving energy efficiency, but still needs for the investments to pay off, albeit with a little longer time perspective than the SPMC (and possibly considering "investment packages" of measures, rather than each measure individually, as an option). Both public and private companies were found in these two ideal types. Finally the ACs, which are all public, aim to improve energy efficiency rather radically, and profitability is not their main concern. The ACs can be top-down driven, where politicians formulate ambitious energy savings goals that company officials need to implement, or be bottom-up driven, where primarily enthusiasts in the staff have engaged in energy efficiency and work to improve it. Depending on management, energy efficiency work can be initiated with short notice or taken into account early in the (renovation) planning process in a holistic manner.

Table 3 Overview of Ideal type characteristics

Strictly Profit Maximizing Company (SPMC)	**Little Extra Company (LEC)**	**Ambitious Company (AC)**
Private or public	Private or public	Public
Non-existing/vague/very modest energy efficiency objectives*	Energy efficiency objectives (most often) specified into numerical terms	Clear and high energy ambitions stated into numerical terms
Aim to reduce energy consumption mainly through saving measures	Examples of efforts made to reach the objectives (surpassing mere saving measures)	Ambitious examples of work done so far
		Guidelines
	Guidelines for replacing technical equipment with energy efficient ditto /packages	Believe they will achieve their objectives

* And which cannot be proven otherwise by survey/web site, assuming actively working companies would know and promote this.

[3] One example was a number of public companies who, although renowned for ambitious energy efficiency investments, had not affiliated, or answered that they had affiliated, to the Swedish Association of Municipal Housing Companies' "Skåne initiative", which aims a little higher than the national objectives for energy efficiency.

The most common ideal type was the LEC; a little more than half of the sample belong to this category. The second most common was the SPMC, made up by a third of the companies, whereas the remaining 15 percent were categorized as AC.

Table 4 Summary of categorization for sample companies

	SPMC	LEC	AC	Total
Private	16 (67 %)	8 (33 %)	0	24 (100 %)
Public	19 (22 %)	52 (60 %)	16 (18 %)	87 (100 %)
Total	**35 (32 %)**	**60 (54 %)**	**16 (15 %)**	**111 (100 %)**

3.4 Hypothesis testing

The survey consisted of questions and statements. For the statements a five step Likert scale was used, with the alternatives *Fully agree*, *Mostly agree*, *Don´t know*, *Somewhat agree* and *Don´t agree at all*, generating data on the ordinal scale. Hypotheses were tested using the non-parametric Pearson's Chi-square test (Pearson 1900), where answering shares are compared to the expected shares given the observed frequencies. The null hypothesis is that answering shares are independent of the characteristics of the company, and rejecting the null implies that the observed answers are significantly different between company types (on the chosen significance level). Hypotheses are rejected on probability levels above 10 percent.

H_0: Attitudes are independent (of company type)

Attitudes were divided into (a) Fully agree versus other, a joint (b) Agree category (Fully agree and Mostly agree) versus other and (c) Don´t agree at all. All of the ideal types have been tested against all of these polarizations. Depending on how the other questions and answering alternatives were formulated the answers have been polarized in ways that enable analysis, and many times several options have been tested. After investigating how the responses were divided for the sample as a whole, the answers were polarized into to the *a) Fully agree*, *b) Agree* and *c) Don´t agree at all* options above, and the answering shares for each ideal type was investigated.

A hypothesis will have the strongest support if the answering shares for the more extreme choices (i.e. *a) Fully agree* or *c) Don´t agree at all*) differ between the ideal types in the expected direction. However, weaker support will also be considered, see example below. The ideal types have also been polarized in different ways, meaning either grouping the two more ambitious types together against the SPMC, or grouping the less ambitious types against the AC. An example: SPMCs are expected to agree with a certain statement to a higher degree than the other two more ambitious company types. The hypothesis will have the strongest support if SPMC companies have responded *a) Fully agree* statistically significantly more often than both other types (as one group, i.e. SPMC versus "other"). However, if this cannot be supported by outcome, it will be also analyzed against *b) Agree*. It will also be analyzed through the opposite case, using *c) Don´t agree at all* – which means the opposite response pattern will be expected; SPMCs are expected to c) *disagree* to a *lesser* extent than the other two company types.

If several of the groupings show diverging patterns the more statistically significant is reported. Only in those cases where results are statistically significantly different between the ideal types will they be presented. It is recommended not to conduct the Chi-square test if there are less 5 observations in each cell, and results based on too few observations will therefore also be excluded.

4 An overview of the renovation status in the companies

Despite the alarming picture that has been reported, real estate companies have been undertaking some renovation. Only 5 percent of the companies answered that they *haven´t done anything* with these buildings in the past. 6 percent have done *large interventions* in the *1970's* and 14 percent have done likewise in the *1980's*. 28 percent have carried out large renovation a measure in the 1990's, possibly indicating that not all of their stock is in urgent need of renovation now. The larger part, 48 percent, of the companies has been performing running interventions, perhaps better characterized as running maintenance.

31 percent of the companies have made large interventions during the last 10 years. 35 percent have *started* their work with renovating the 1960's and 70's stock; 18 percent by doing *large interventions*, 7 percent by doing *pilot projects* and 10 percent have started *planning* large interventions. In addition, 23 percent have initiated (/have had to do) *selected interventions*, which may be of more or less urgent kind. 11 percent say they are not working with renovation in these buildings at all.

14 percent believe they will have renovated *more than 60 percent* of the 1960's and 70's stock in two years time, and two thirds of the companies, 66 percent, expect to have renovated *less than 30 percent* in two years. These 66 percent possess approximately 140,000 MHP apartments, meaning they expect to have renovated at most 42,000 apartments (0.3* 140,000) in two years.

In table 5 below it is shown how renovation is perceived by the sample companies – more than 70 percent agree that renovation is a challenging question for the company. Results differ somewhat over ideal types.

Table 5 "Renovation is a challenging question for our company", *percental shares*

	Fully agree	Mostly agree	Agree to some extent	Don´t agree at all	Don´t know
Total (n=108)	**49**	**22**	**20**	**8**	**0**
SPMC (n=33)	39	27	27	6	0
LEC (n=59)	51	24	17	8	0
AC (n=16)	63	6	19	13	0

Most notable perhaps is the polarized views the ambitious companies (ACs) have stated; on the one hand a larger share of them think renovation is a heavy question, on the other a larger share of them don´t think renovation is a heavy question. How the question is perceived may of course differ depending on the housing stock in question, but (as expected) it is clear that the renovations do constitute a challenge for the upcoming years.

5 Hypothesis testing

14 hypotheses have been formulated, which have been divided into three overarching themes. These themes consider (1) the stage and scope of energy efficiency work in connection to the renovation process, (2) the perceived or expressed obstacles to improving energy efficiency and (3) the views on energy efficiency as an investment opportunity. The hypotheses formulated within each theme are sometimes tested using several of the survey questions, and sometimes the same question serves to test several hypotheses. See Appendix B for a full set of questions, statements and answering options.

5.1 Scope of energy efficiency work (related to renovation)

The overall hypothesis for the first theme is that ambitious companies to a larger extent plan or have carried out more energy efficiency [EE] improvements, in scope as well as in magnitude. Less ambitious companies on the other hand are believed to renovate as needs turn urgent to a larger extent than ambitious companies, which assumingly leaves less room for extensive measures. The hypotheses are based partly on intuition, partly on the results in Muyingo (2009), from which parallels can be drawn to the stakeholder pressure explanations to why some companies are more environmentally pro-active. It is also a test of the indications in Selmer (1994); that companies with offensive mission and goals, to which the less ambitious companies in this study can be compared, have a more *ad hoc* approach to energy matters, whereas defensive companies, comparable to the ambitious ideal types, work in a more integrated way.

> *Hypothesis 1* Ambitious companies will have implemented more (extensive) energy efficiency measures in connection to renovation of their 1960's and 70's buildings

Among the types of energy efficiency measures that were brought up in the survey, general savings measures and water saving armatures are those most commonly carried out, see upper panel of table 6. Individual metering and charging [IMC] is the type of measure that least commonly has been implemented, followed by the presumably more extensive building envelope measures.

Table 6 The extent to which energy efficiency related measures have been carried out, *descriptive statistics percental answering shares*

	A Majority of the stock	B Smaller parts of the stock	C Hardly at all
Savings measures (n=101)	64	28	8
IMC (n=99)	7	34	59
Water saving armatures (n=104)	54	35	11
Installations (n=104)	17	71	12
Building envelope measures (n=104)	14	50	36

Table 6 continued

Cases where answering shares differed for alternative A "Majority of the stock", *percental shares*		
A Have carried out savings measures in the majority of the stock	**SPMC**	**Other**
$X^2 = 5.1931$	43	66
Pr = 0.023		
A Have installed water saving armatures in the majority of the stock	**SPMC**	**Other**
$X^2 = 7.3991$	31	59
Pr = 0.007		

Cases where answering shares differed for alternative C "Hardly at all", *percental shares*		
C Have hardly at all undertaken building envelope measures	**SPMC**	**Other**
$X^2 = 10.3205$	54	24
Pr = 0.001		

Upon differentiating over ideal types, how many had chosen the different options for the various energy efficiency modes, the answering shares did sometimes diverge compared to what could be expected based on the sample as a whole, as seen in the two lower panels of table 6.

In particular, SPMCs have chosen option A to a lesser extent than other companies for savings measures and for water saving armatures. SPMCs had also to a higher extent than other companies stated that they hardly at all had undertaken energy efficiency measures in the building envelope. These three cases provide support to the hypothesis. For the other energy efficiency related interventions investigated no significant deviations from what could be expected of the sample as a whole were found.

Hypothesis 2 Ambitious companies are more forward planning

Three questions were used to test this hypothesis. The first indicator was how commonly the companies had stated that their main mode of renovation is according to urgent needs. In the sample as a whole, 48 percent of the 111 answering companies had stated this.

Table 7 Cases where answering shares differed for alternative "Mode of renovation: Mainly where needs are more urgent", *percental shares*

	SPMC	**Other**
$X^2 = 11.4898$	71	37
Pr = 0.001		

The subsamples deviated from this, particularly the SPMCs who to a higher extent than the other companies had stated this option. The results support the hypothesis.

The second indicator was a statement about how forward planning the company is, which if chosen would mean they also stated they would escape serious maintenance problems in the 1960's and 70's stock. The companies took a stand by choosing one out of five options, which have then been grouped and tested in the ways described in section 3.4 (i.e. *a) Fully agree, b) Agree* or *c) Don´t agree at all*).

Table 8 "We are forward planning and will manage renovations without particular maintenance problems", *descriptive statistics percental answering shares*

	Fully agree	Mostly agree	Agree to some extent	Don´t agree at all	Don´t know
Total (n=111*)	11	29	35	20	2

Cases where answering shares differed, *percental shares*

Agree	AC	Other
$X^2 = 6.6211$ Pr = 0.010	69	35

*No answer: 4 percent

In the subsamples, the ACs had agreed to the statement to a higher extent than other companies, which supports the hypothesis.

The third indicator was another statement related to how early in the renovation process energy efficiency measures are planned, which is presented in table 9. In the whole sample 25 percent fully agreed and another 43 percent mostly agreed to that energy efficiency measures were planned early.

Table 9 "We plan energy efficiency measures early in the renovation process", *descriptive statistics percental answering shares*

	Fully agree	Mostly agree	Agree to some extent	Don´t agree at all	Don´t know
Total (n=111)	25	43	25	2	1

Cases where answering shares differed, *percental shares*

Fully agree	AC	Other
$X^2 = 9.5400$ Pr = 0.002	56	20

Cases where answering shares differed, *percental shares*

Agree	SPMC	Other
$X^2 = 12.2593$ Pr = 0.000	46	79

*No answer: 4 percent

Looking at the subsamples, ACs were found to fully agree to a higher extent than other companies, and SPMCs agreed to a lesser extent than other companies, which is in support of the hypothesis.

Hypothesis 3 Ambitious companies will intervene "in excess"

To test the third hypothesis three statements related to how much energy efficiency measures the company intends to carry out were used. Within the sample as a whole more than half of the companies agreed fully or mostly that they would seize the opportunity to improve energy efficiency when renovating, and a third of the companies stated that they would carry out all of the energy efficiency measures suggested in the Energy Performance Certifications [EPCs]. Only 17 percent agreed fully or mostly to moving forward replacement investments to improve energy efficiency.

Table 10 *Descriptive statistics percental answering shares*
(1) “When renovating, we seize the opportunity to implement all possible EE measures”
(2) “We will carry out all suggested measures in the EPCs”
(3) “We move forward replacement investments to improve EE”

	Fully agree	Mostly agree	Agree to some extent	Don´t agree at all	Don´t know
1 (n=111*)	14	37	37	8	1
2 (n=111**)	7	22	48	14	5
3 (n=111*)	3	14	46	30	5

*No answer: 3 percent
**No answer: 4 percent

When distributing the responses to these statements over ideal types, no statistically significant differences were found. There was no support for the third hypothesis.

5.2 Obstacles

Since different company types are believed to have different motives for intervening to a certain degree in their MHP stock, they are also expected to put different emphasis on possible obstacles. In particular, ambitious companies are expected to emphasize obstacles relatively less since they are assumed to have stronger incentives for the investments to be carried out. The less ambitious companies on the other hand, are expected to emphasize obstacles relatively more. The hypotheses are based on the idea of stakeholder pressure; on the findings of de Groot *et al*. (2001) according to which the importance of barriers varied over different sectors, and on the indications in Malmqvist & Noring (2009) – that an ambitious approach led to a lower perceived risk connected to energy efficiency investments.

Hypothesis 4 Less ambitious companies will perceive *transaction costs* to be bigger

As an indication for transaction costs a statement was used about the degree to which the companies felt they had knowledge to carry out energy efficiency investments. Having to search for new methods and technology instead of using old and proven ones takes time, and may thus constitute a barrier.

Table 11 “We have enough knowledge to carry out EE measures”, *descriptive statistics percental answering shares*

	Fully agree	Mostly agree	Agree to some extent	Don´t agree at all	Don´t know
(n=111*)	24	42	30	1	0

Cases where answering shares differed, *percental shares*

Agree	SPMC	Other
$X^2 = 5.3414$	51	74
Pr = 0.021		

*No answer: 3 percent

Within the sample 24 percent agreed fully to having enough knowledge and another 42 percent mostly agreed. 31 percent did not agree, or only agreed to some extent.

In support of the hypothesis, the SPMCs agree to this statement to a lesser degree than other companies in the sample do, as can be seen in the lower panel of table 11.

Hypothesis 5 Less ambitious companies will perceive *uncertainty and risk* to be bigger

As noted, uncertainty and risk are factors that don´t constitute a market failure, and may in fact vary for different companies for logical reasons. However, it may still be that the company type influences how those factors are perceived. To test this hypothesis three rather explicit statements had been made that related to uncertainty and risk. The companies were asked to take a stand regarding how they perceive risk connected to new/unproven techniques, future energy prices (that investments won´t be as profitable if energy prices go up by less than expected) and energy company tariffs (the concern that gains from improving energy efficiency may be offset if the variable price in tariffs is raised).

Table 12 *Descriptive statistics percental answering shares*
(1) "EE investments are risky due to unproven techniques"
(2) "EE investments are risky uncertain future energy prices"
(3) "EE investments are uncertain due to energy company tariff structures"

	Fully agree	Mostly agree	Agree to some extent	Don´t agree at all	Don´t know
1 (n=111*)	3	5	41	47	3
2 (n=111**)	1	5	38	52	0
3 (n=111*)	14	19	40	21	5

*No answer: 3 percent
**No answer: 4 percent

The companies in general did not seem to perceive energy efficiency investments as very risky due to unproven techniques or future energy prices, only 8 and 6 percent respectively agreed to this. Approximately half of the companies don´t agree at all with either of the two statements. A bigger share, 33 percent, of the sample (fully or mostly) states that energy efficiency investments are uncertain since the energy company may change prices and offset the calculated gains.

There were no statistically significant differences between the ideal types. The closest to being significant was the differences between how SPMC and other companies viewed uncertainty in energy tariffs, seen in table 12 above. SPMCs to a higher degree than other companies stated that energy tariffs are connected with uncertainty, which points in the same direction as the hypothesis, but the results were significant only on an 11 percent level.

Hypothesis 6 Less ambitious companies will put more emphasis on *competing investments*

Four statements were used as indicators for this statement. According to the classification the less ambitious companies will undertake those investments that in comparison to other investment alternatives have the higher return. As mentioned earlier the Swedish rental housing market is rent regulated so that only some types of investments – standard improving measures – will entitle to rent increases. Energy efficiency is generally not such an investment, which implies that energy efficiency investments need to be more profitable only in terms of energy/maintenance cost savings to be considered by the less ambitious companies. Furthermore, if the area in question also is generally deteriorated the housing company may feel the need to attend to the outdoor environment to revive the area as a whole. Hence, when renovating the MHP many things other than energy efficiency will be needed to attend to, making energy efficiency only one of several competing investments. In addition, many of the buildings do not live up to the building code regulations about accessibility, and following the building regulations, extensive energy efficiency improvements may lead to consequential requirements making the total costs high. If this is the case the consequence would be that less ambitious companies refrain altogether from doing the investments in the first place, or only do so much as not to pass the threshold.

Table 13 *Descriptive statistics percental answering shares*
(1) "Standard improving measures are more important than EE"
(2) "Outdoor environment is more important than EE"
(3) "Accessibility is more important than EE"
(4) "It is not profitable to carry out EE measures due to consequential building regulations"

	Fully agree	Mostly agree	Agree to some extent	Don´t agree at all	Don´t know
1 (n=111*)	4	14	38	42	1
2 (n=111*)	1	2	27	68	1
3 (n=111*)	2	8	38	46	5
4 (n=111**)	4	9	35	34	15

Cases where answering shares differed for (3) "Accessibility is more important than EE", *percental shares*

(3) Don´t agree at all	SPMC	Other
$X^2 = 6.2134$	29	54
Pr = 0.013		

Cases where answering shares differed for (4) "It is not profitable to carry out EE measures due to consequential building regulations", *percental shares*

(4) Don´t agree at all	SPMC	Other
$X^2 = 6.6324$	17	42
Pr = 0.010		

*No answer: 2 percent
**No answer: 3 percent

Standard improving measures is what in general is seen as more important to the respondents – 18 percent agree that this is more important than energy efficiency improvements in connection to renovation. Outdoor environment on the other hand, is not generally seen as more important than energy efficiency investments, 68 percent disagree to that this would be more important than energy efficiency investments.

Distributed over the ideal types most of the stated views did not differ significantly between them. The only statements where views differed significantly were about accessibility and consequential building regulations, and even for these statements the support was not very strong; it did not differ significantly in how many agreed, but only in how many disagreed. Compared to the other companies' statements the SPMCs to a lesser extent disagree to that accessibility is more important than energy efficiency investments in connection to renovation. This provides some support to the hypothesis. Furthermore, a smaller part of the SPMC than of the other companies disagree to the statement that building regulations make it not profitable to carry out energy efficiency investments. This also gives some support to the hypothesis.

Hypothesis 7 Less ambitious companies will see *financing* as a bigger problem

To test the hypothesis two statements were used that relate to available capital and possible income increase energy efficiency investments may give rise to. If the companies don´t have specific motives other than economic for wanting to improve energy efficiency, and they don´t see clear profitability in energy efficiency investments, financing will be perceived as a bigger problem.

Table 14 *Descriptive statistics percental answering shares*
(1) "EE measures are profitable but don´t fit within investment budget"
(2) "We would do more EE improvements if we could raise rents"

	Fully agree	Mostly agree	Agree to some extent	Don´t agree at all	Don´t know
1 (n=111*)	17	22	40	19	1
2 (n=111**)	31	15	41	11	0

Cases where answering shares differed for (1) "EE measures are profitable but don´t fit within investment budget", *percental shares*

(1) Agree	SPMC	Other
$X^2 = 3.4686$ Pr = 0.063	51	33

Cases where answering shares differed for (1) "EE measures are profitable but don´t fit within investment budget", *percental shares*

(1) Don´t agree at all	AC	Other
$X^2 = 7.5144$ Pr = 0.006	44	15

*No answer: 2 percent
**No answer: 3 percent

17 percent of the companies fully agree, and another 22 percent mostly agree that energy efficiency investments are profitable but cannot be fitted into the investment budget. 19 percent don´t agree at all that this would be the case. A third of the companies claim they would do significantly more to improve energy efficiency if only they could raise rents to do so.

For the first statement there were statistically significant differences in how the ideal types had responded. The SPMCs agreed to a higher extent to that energy efficiency measures are profitable but cannot be fitted into the investment budget. This supports the hypothesis that SPMCs will emphasize financing as a bigger problem. Furthermore, ACs disagree to a higher extent to the same statement. It is not clear however, whether the companies who disagree think energy efficiency measures are profitable but still can´t be fitted into the budget, or if they don´t believe energy efficiency measures are profitable. The statement should thus be interpreted with caution. There were no statistically significant differences in views between the ideal types for the second statement about raising rents.

Hypothesis 8 Less ambitious companies don´t perceive energy efficiency investments as profitable

If the companies conclude that a certain energy efficiency investment is not profitable, it may be considered a barrier but not a failure. However, the less ambitious companies are expected to put relatively more emphasis on profitability. In particular the factors in calculations that affect profitability may be viewed differently. Since experience so far shows that many companies don´t undertake energy efficiency measures to a high extent these investments don´t seem to be considered profitable. On the other hand, large renovation projects that have lowered energy consumption significantly have been carried out. To test the hypothesis that less ambitious companies to a higher extent than other are of this opinion three statements were tested. All of the statements have to do with factors that affect the calculations; the time horizon, current energy consumption and current energy prices.

Table 15 *Descriptive statistics percental answering shares*
(1) "EE improvements not worthwhile since the buildings need to be demolished soon"
(2) "EE improvements not worthwhile since our buildings are too energy efficient"
(3) "We would do much more EE improvements if energy prices doubled"

	Fully agree	Mostly agree	Agree to some extent	Don´t agree at all	Don´t know
1 (n=111*)	0	1	13	84	1
2 (n=111*)	0	4	24	70	0
3 (n=111*)	39	31	24	4	1

*No answer: 2 percent

The general opinion seem to be that improvements in energy efficiency are worthwhile, at least if the alternative is demolition or if considering the current energy consumption. A third of the company, however, does seem to agree somewhat that their buildings currently consume too little energy for energy efficiency improvements to pay off. On the other hand, two thirds of the companies agree that they would improve energy efficiency significantly more if energy prices doubled.

Neither of these statements deviated statistically significantly when differentiating the results over ideal types, so no support was found for the hypothesis. The closest to being significant was that SPMCs disagreed to a lesser extent than other companies (60 percent versus 75 percent) to their buildings being too energy efficient for energy efficiency improvements to pay off. This pointed in the same direction as the hypothesis but was only significantly different on a 10.8 percent level.

5.3 Investment decisions

The main hypotheses for the third theme are that companies who are ambitious in energy efficiency matters will place less emphasis on profitability and how to properly account for it. The basis for the hypotheses is found in the different types of motivations for pro-active behavior; the companies that have financial drivers need the investment decision to be sanctioned by a positive net present value, whereas the companies that are motivated also by other factors will argue that energy efficiency adds value beyond what investment calculations can show.

Hypothesis 9 Economic considerations are more important to less ambitious companies

This hypothesis was tested by letting companies state how important a number of factors were in their decision to improve energy efficiency. The answering alternatives were not mutually exclusive, i.e. it was possible to choose "very important" for all of the suggested factors. In table 14 only the results for the alternative regarding economy is presented.

Table 16 The importance of various factors in companies' EE decision, *descriptive statistics percental answering shares*

	Very important	Pretty important	Less important	Not at all important	Don´t know
1 The economy of the company (n=111*)	81	14	1	0	0

*No answer: 5 percent
**No answer: 6 percent

Not surprisingly economy is the factor that is stated as an important factor to the highest degree, 81 percent of them have stated it was very important. The results were differentiated by polarizing the share of companies stating the different factors to be "very important" and "not important at all" over ideal types. There were no statistically significant differences between ideal types regarding views on economy and the hypothesis was not supported.

> *Hypothesis 10* (Short term) profitability will be more important to less ambitious companies

Three statements relating to profitability were made that are used here to test the hypothesis. The more short-sighted ideal types are believed to only carry out energy efficiency measures that are clearly profitable, and that are so in the short run. The more profit-maximizing companies are also believed to only carry out an energy efficiency measures if it bears its own cost, and they´re not believed to tolerate package solutions (implementing a package of energy efficiency measures profitable that is profitable even if each measure individually is not).

Table 17 *Descriptive statistics percental answering shares*
(1) "We only do EE measures that are profitable in 3-5 years"
(2) "Each EE measure must bear its own cost"
(3) "EE investments must be clearly profitable for us to carry them out"

	Fully agree	Mostly agree	Agree to some extent	Don´t agree at all	Don´t know
1 (n=111*)	2	19	26	50	0
2 (n=111**)	14	30	36	17	1
3 (n=111*)	24	43	24	5	0

Cases where answering shares differed for (1) "We only do EE measures that are profitable in 3-5 years", *percental shares*

(1) Don´t agree at all	SPMC	Other
$X^2 = 3.6214$ Pr = 0.057	37	57

Cases where answering shares differed for (2) "Each EE measure must bear its own cost", *percental shares*

(2) Fully agree	SPMC	Other
$X^2 = 2.9536$ Pr = 0.086	23	11
(2) Don´t agree at all	**AC**	**Other**
$X^2 = 9.3467$ Pr = 0.002	44	13

Table 17 continued

Cases where answering shares differed for (3) "EE investments must be clearly profitable for us to carry them out", percental shares

(3) Fully agree	SPMC	Other
X^2 = 2.7556 Pr = 0.097	34	20

*No answer: 3 percent
**No answer: 2 percent

Approximately a fifth of the companies agree that energy efficiency measures need to pay off already in the short run to be considered, but half of the companies disagree to this. 44 percent state that an energy efficiency measure must bear its own cost to be carried out, whereas 17 percent disagree. Two thirds of the companies only carry out clearly profitable energy efficiency measures.

When distributing the responses over the ideal types some differences were found statistically significant and in support of the hypothesis. SPMCs disagree to a lesser extent than other companies that energy efficiency measures need to be profitable in the short run. Furthermore, SPMCs agree to a higher extent, and ACs disagree to a higher extent to that energy efficiency measures must bear their own costs. SPMCs also agree fully to that energy efficiency measures must be clearly profitable to be carried out, to a higher extent than other companies do. Overall these indications give support to the hypothesis.

Hypothesis 11 Ambitious companies will use calculations to suit their needs (wants)

When considering an investment the company may use different methods to assess how profitable the investment will be. The less ambitious companies are believed to do more careful calculations, whereas more ambitious companies are believed to use simpler calculation methods, or even not use calculations at all and assess the profitability of the investment using gut feeling. However, Selmer (1979) investigated the use of different calculation methods for a number of real estate related companies and found that several of them used simpler calculation methods due to the inherent uncertainty, meaning it may as well be the other way around; that the less ambitious companies, who stress uncertainty, will be those who use simpler calculation methods to a larger extent.

Table 18 "When we make investment calculations we use…", *descriptive statistics percental answering shares*

	Almost always	Sometimes	Rarely	Never	Don´t know
(1) Formal calculations (n=111*)	47	20	16	6	1
(2) Simpler calculations (n=111**)	41	38	7	2	0
(3) Rule of thumb/experience (n=111***)	17	33	13	13	1
(4) Predetermined policy (n=111*)	14	19	21	23	2

*No answer: 10 percent
**No answer: 13 percent
***No answer: 23 percent
The decreasing response rate for this question probably depends on respondents not considering it necessary to answer more than one if the first response was "Almost always".

There were no statistically significant differences between the ideal types that would have provided support for the hypothesis. The only statistically significant difference was that ACs never use a predetermined policy for when renovation measures should be carried out to a higher extent than other companies (50 versus 18 percent). It was also investigated if and how the companies differed when choosing the option "Sometimes" – as this could be an indication that the companies adopt a pragmatic approach to the matter (using whatever calculation/decision model that suit their needs better). However, there were no indications that the companies statistically differed from each other in this respect.

Hypothesis 12 Ambitious companies will use a lower discount rate

The discount rate used in calculations, based on a risk free return and risk adjusted for factors that may influence the investment, will affect how profitable investments appear in calculations. If "reluctant" to carry out an energy efficiency investment, a less ambitious company may add a higher risk premium based on e.g. expected risk connected to unproven techniques. If on the other hand the company wants to show profitability through calculations the risk premium should be lower. However, the calculation results depends on many factors, for example the actual cost of capital (the interest rate required by the bank). If the company needs to borrow to carry out the investment it may feel obliged to add a risk premium since loans increases risk for bank. Hence, there may be more than one explicable reason for using a discount rate. Four indicators were used to test the hypothesis that ambitious companies use a lower discount rate than other companies do.

Those companies who had responded that they use formal calculations were given an open-ended follow-up question about what discount rate they then use. 62 companies answered this question with a mean value of 5.6, ranging from 4 through 11 percent. The mean differed between the ideal types, and in the expected direction: SPMCs on average used the highest cost of capital compared to other companies (but LECs, not ACs, used the lowest). Testing the differences using a t-test did not generate significant results, however.

As was seen under hypothesis 5 energy efficiency investments are perceived uncertain or risky by some of the companies. However, there were no statistically significant differences between the ideal types in perception of risk or uncertainty connected to new and unproven techniques, future energy prices or energy company tariffs.

A separate factor in the investment calculations is future energy prices. If energy prices are expected to increase drastically the expected energy (cost) savings will be bigger than if energy prices are expected to only increase moderately. 16 percent of the companies believed that energy prices would increase substantially more than inflation. There was no support, however, that the ideal types differ in this belief.

There is no support for the hypothesis that ambitious companies use lower discount rates than less ambitious companies do.

Hypothesis 13 Ambitious companies will "create" profitability

Ambitious companies will make energy efficiency investments (appear) profitable. This hypothesis is tested by looking at the extent to which they add unprofitable energy efficiency measures and profitable energy efficiency measures into investment packages, assume that energy efficiency is profitable even when unable to show it in calculations or attribute a high value to the goodwill assumingly generated in the public opinion by doing something good for the environment. One question and four statements were used to test this hypothesis.

The question and two of the statements were used to see if companies consider investment packages that on average meet the required rate of return even when each measure individually doesn´t. The respondents were asked in what way the mainly renovated and 36 percent stated they mainly finish one building or area at a time.

Table 19 Difference in answering shares for "Main renovation mode", *percental shares*

One building/area at a time	AC	Other
$X^2 = 8.6799$ Pr = 0.003	69	31

Ambitious companies prefer to finish one building or area at a time to a higher extent than less ambitious companies. Preferring the one building/area option is considered a (weak) indication that a company adds measures together to create profitability for a package since this may as well be matter of regular economies of scale; it may be rational to carry out more than one measure at a time when intervening even if it´s not to do with packages in that sense. It could however also be that this is possible thanks to the better planning among ambitious companies noticed earlier. In table 21 below is a further and more explicit look into the same question.

Table 20 *Descriptive statistics percental shares*
(1) "Packages of EE measures are a good way of lowering energy consumption at a profitable total return on investment"
(2) "We rather finish one measure at a time than doing several measures parallelly in one building"
(3) "We believe EE pays off even if we cannot show it in calculations"
(4) "We may consider unprofitable EE investments to strengthen our trademark"

	Fully agree	Mostly agree	Agree to some extent	Don´t agree at all	Don´t know
1 (n=111*)	15	36	34	6	5
2 (n=111**)	7	14	34	41	2
3 (n=111***)	9	27	42	18	1
4 (n=111**)	6	14	53	23	2

Cases where answering shares differed for (1) "Packages of EE measures are a good way of lowering energy consumption at a profitable total return on investment", percental shares

(1) Agree	LEC	Other
$X^2 = 3.9000$ Pr = 0.048	60	41
(1) Agree	**SPMC**	**Other**
$X^2 = 5.9594$ Pr = 0.015	34	59

Cases where answering shares differed for (2) "We rather finish one measure at a time than doing several measures in parallell in one building", *percental shares*

(2) Don´t agree at all	AC	Other
$X^2 = 3.7398$ Pr = 0.053	63	37

Table 20 continued

Cases where answering shares differed for (3) "We believe EE pays off even if we cannot show it in calculations", *percental shares*

(3) Agree	LEC	Other
X^2 = 4.5523 Pr = 0.033	45	25
(3) Agree	**SPMC**	**Other**
X^2 = 7.9162 Pr = 0.005	17	45
(3) Don´t agree at all	**SPMC**	**Other**
X^2 = 3.8542 Pr = 0.050	29	13

Cases where answering shares differed for (4) "We may consider unprofitable EE investments to strengthen our trademark", *percental shares*

(4) Don´t agree at all	SPMC	Other
X^2 = 3.3626 Pr = 0.067	34	18

*No answer: 4 percent
**No answer: 2 percent
***No answer: 3 percent

Approximately half of the companies agree that packages are a good way to improve energy efficiency without having to refrain from the less profitable measures, and only a small share disagrees all together. Moderately ambitious companies (LECs) are positive to packages to a higher extent than other ideal types, whereas the less ambitious companies support packages to lesser extent. This gives some support to the hypothesis.

A fifth of the companies prefer to finish one measure at a time, whereas around 40 percent disagree to that finishing one measure at a time would be preferable compared to doing several measures parallelly in one building. The ambitious companies disagree to a higher extent than other companies, i.e. they prefer to do several measures parallelly to a higher extent, which supports the hypothesis.

A third of the respondents fully or mostly agree that energy efficiency investments are profitable even if it cannot be shown in calculations. It is not clear whether the 18 percent who don´t agree at all disagree because they don´t believe it is profitable when they *cannot* show it, or because they believe it is possible and *are* able to show it (possibly through "manipulating" the calculations" the way that has been discussed above). Moderately ambitious companies agree to a higher extent than other, whereas less ambitious companies agree to lesser extent and disagree to a higher extent. All of the differing cases support the hypothesis.

20 percent fully or mostly agree that they may carry out unprofitable energy efficiency measures to strengthen their trademark, but slightly more, 23 percent, would not consider this at all. The less ambitious companies disagree to a higher extent than the other companies, which supports the hypothesis.

Hypothesis 14 Ambitious companies will need other motivations than economic to improve energy efficiency

Following the classification of drivers by J. González-Benito & Ó. González-Benito (2006) and Paulraj (2009), and adding stakeholder pressure as an explanatory variable (Delmas & Toffel 2004; Murillo-Luna *et al*. 2008) the hypothesis will be tested using indicators for relational drivers/stakeholder pressure and for ethical drivers. More conventional regulatory driver will also be investigated.

Under hypothesis 3 it was investigated to what extent companies would follow the recommendations from energy performance certificates and carry out all the suggested measures. About a third of the companies agreed that they would do so, whereas about 15 percent disagreed altogether. However, there was no significant difference between the company types.

Under hypothesis 9 it was investigated whether the companies differ in how important the companies' economy is to their decision to save energy. In table 22 the results for the other investigated factors from the same question are presented.

Table 21 The importance of various factors in companies' EE decision, *descriptive statistics percental answering shares*

	Very important	Pretty important	Less important	Not at all important	Don´t know
(2) Tenant demands (n=111*)	23	53	14	2	2
(3) The political pressure (n=111**)	10	36	41	5	2
(4) The environmental issue (n=111*)	44	40	7	4	1

Cases where answering shares differed for (2) "How important is tenant demand to EE decision?", *percental shares*

(2) Not important at all	AC	Other
$X^2 = 10.4314$	44	12
Pr = 0.001		

Cases where answering shares differed for (4) "How important is the environmental issue to EE decision?", *percental shares*

(4) Very important	LEC	Other
$X^2 = 6.2415$	55	31
Pr = 0.012		
(4) Very important	**SPMC**	**Other**
$X^2 = 15.1149$	17	57
Pr = 0.000		

Almost half of the companies say that the environmental issue is very important to their decision to save energy, and adding another 40 percent who say it´s pretty important this clearly indicates that environmental pro-activity can be explained by ethical drivers. Almost a fourth of the companies say tenant demand is very important to their decision, which adds up to more than 75 percent when including those saying it is pretty important – despite the fact that energy efficiency measures hardly give rise to rent increases even if efficiency would be demanded by tenants. However, as real estate companies are so close to the customer in the value chain, this supports what Videras & Alberini (2000) put forth. Political pressure is not perceived as very important to the companies' decision to save energy. This is interesting and may have policy implications, if the companies remain relatively unaffected by political directions. For this explanatory factor no significant differences between the ideal groups were found.

Of course, even if considered by the companies, the answers to the above questions don´t say anything about how much pressure (and in what direction) the stakeholders actually exert, or how much energy efficiency work will be put into practice in the end. The answers do however support the idea that factors other than economic drivers matter (and are interconnected) to decision making.

Ambitious companies to a higher extent think that tenant demand is unimportant to their decision to save energy. This may seem surprising, but a suggestion is that ambitious companies already have decided to aim for a high level of energy efficiency and that few tenants will require that high levels of energy savings. LECs to a higher extent than other companies think the environmental issue is very important to their decision to save energy, but both of the ambitious ideal types think so to a higher extent than do the SPMCs. This supports the hypothesis.

Finally the respondents were asked if they think legal requirements should be tougher in order to reach the national energy efficiency objectives. If energy efficiency is something the companies strive for, stricter regulations would give equal and transparent conditions to all of the companies in the market. Besides, tougher legal restrictions would not affect the more ambitious companies, so they are expected not to mind, but rather welcome it.

Table 22 "Legal EE requirements should be stricter", *percental answering shares*

	Fully agree	**Mostly agree**	**Agree to some extent**	**Don´t agree at all**	**Don´t know**
(n=111*)	10	16	35	33	3

Cases where answering shares differed, *percental shares*

Agree	**AC**	**Other**
$X^2 = 3.0085$ Pr = 0.083	44	23
Agree	**SPMC**	**Other**
$X^2 = 3.7132$ Pr = 0.054	14	32

*No answer: 3 percent

A fourth of the respondents agree that the energy efficiency requirements should be stricter, whereas a third don´t agree at all. As hypothesized the ambitious companies are the ones who to a higher extent than other companies would like to see stricter regulations and less ambitious companies are those who agree to a lesser extent.

5.4 Summary of hypothesis tests

In table 23 below the results from the hypothesis testing are compiled.

Table 23 Overview of hypothesis test results

Hypothesis		Results
1	Ambitious companies will have implemented more (extensive) energy efficiency measures in connection to renovation of their 1960s and 70s buildings.	Support
2	Ambitious companies are more forward planning	Support
3	Ambitious companies will intervene "in excess"	No support
4	Less ambitious companies will perceive *transaction costs* to be bigger	Support
5	Less ambitious companies will perceive *uncertainty and risk* to be bigger	No support
6	Less ambitious companies will put more emphasis on *competing investments*	Some support
7	Less ambitious companies will see *financing* as a bigger problem	Some support
8	Less ambitious companies don´t perceive energy efficiency investments as profitable (investment calculations)	No support
9	Economic considerations are more important than other to less ambitious companies	No support
10	(Short term) profitability will be more important to less ambitious companies	Some support
11	Ambitious companies will use calculations to suit their needs (wants)	No support
12	Ambitious companies will have a lower discount rate	No support
13	Ambitious companies will "create" profitability	Support
14	Ambitious companies will need other motivations than economic to improve energy efficiency	Support

Some of the hypotheses gained support; the ambitious companies have implemented and plan to implement more (extensive) energy efficiency measures in connection to renovation. They are also more forward planning. Ambitious companies will "create" profitability and will need other arguments than strictly economic to motivate the energy efficiency investments. Less ambitious companies on the other hand perceive transaction costs to be bigger than do more ambitious companies.

Other hypotheses gained weak support, namely that less ambitious companies see competing investments as more important, financing as an obstacle to a larger extent and value short term profitability higher than more ambitious companies do.

There were also hypotheses that were not supported by the results. According to the results ambitious companies do not intervene "in excess" to a higher extent than other companies, and do not use a lower discount rate or calculation methods to justify their needs or wants to a higher extent than the more ambitious companies. Neither do less ambitious companies to a higher extent than other companies consider energy efficiency investments as unprofitable, they don´t value economic considerations in relation to energy efficiency decisions any higher than other companies and they don´t perceive uncertainty or risk in the investment to be bigger than other companies perceives it.

6 Analysis

6.1 Renovation status

Renovations have started in the post-war building stock, but will constitute a challenge. If larger renovations have been undertaken lately (in the 1990's), as for a third of the companies, the state of the buildings may be relatively good. Furthermore, 40 percent of the companies say they are forward planning and will manage the renovations without serious maintenance problems. On the other hand, almost 50 percent of the companies have stated that their main mode of renovation is "where needs are more urgent", and at least 20 percent believe that they will have difficulties managing the renovation of the MHP without problems. The picture is hence somewhat divided, neither entirely worrisome, nor completely reassuring. As we will see next, the same could be said about energy efficiency in the MHP.

6.2 Theme 1: Scope of energy efficiency measures

Energy efficiency improvements are considered by the majority of the companies; at least two thirds of them have carried out smaller measures in the majority of their MHP stock. However, even for the large part of companies that have undertaken measures to improve energy efficiency, it has mainly been carried out in smaller parts of the stock (so far).

There were around 10 percent that stated that they hardly at all have undertaken energy efficiency measures of even the simpler kind, such as savings measures. The less ambitious companies have undertaken savings measures, but to lesser extent than the other company types. Having installed IMC was the type of investigated measure that was least commonly implemented by all of the company types. Other types of technical installations that (also) improved energy efficiency have been carried out to quite a large extent, but mainly in smaller parts of the stock; probably as their service life had run out. Regarding the more extensive energy efficiency measures, e.g. in the building envelope; approximately a third of the companies had hardly undertaken them at all, and to an even higher extent among the less ambitious companies. These are most likely the kind of measures that will be needed to reach the stated goal levels of energy efficiency.

The results indicate that ambitious companies are more forward planning, which probably is a prerequisite for being able to fit larger energy efficiency measures into the renovation projects. This also supports the indication that ambitious companies, comparable to Selmer's (1994) "defensive" companies, may have a more integrated approach to the energy efficiency matter, or in other words, that they may have an institutionalized organization to handle the issues, just like Selmer (1994) suggested. Less ambitious ("offensive") companies, on the other hand, handle energy efficiency in a more *ad hoc* fashion.

One of the hypothesis under the first theme didn´t gain support; that more ambitious companies intervene in excess. Perhaps this is not so surprising considering the large amount of work that needs to be done in the MHP anyway – it would be hard for the companies to go beyond the high levels of both renovation and energy efficiency only to please external stakeholders. Muyingo's (2009) results related to maintenance in general and not particularly in relation to the MHP or extensive renovation.

The general impression is hence that real estate companies are aware of energy efficiency possibilities and needs for their MHP buildings, but won´t always go through with undertaking measures to improve it. The fear that real estate owners lack strong economic motives for improving energy efficiency is hence reinforced. In the same way the renovations of the MHP will be relatively manageable for some but a real challenge to most, so will energy efficiency work. Even though energy efficiency is considered by most real estate owners, of all ideal types, the really extensive investments are quite rare. Consequently, the really large savings of energy and the ambitious energy savings objectives will be hard to achieve.

6.3 Theme 2: Obstacles to energy efficiency

The results suggest that the five possible barriers that were investigated do contribute to holding back the improving energy efficiency. Whether the obstacles are real or imagined isn´t really important, for the companies will be able to use them as arguments for doing less than they should in either case.

Many of the companies don't experience transaction costs (here a question about "knowledge" was used as a proxy), as a problem, but a smaller share does. About a third of the companies only agreed to some extent that they have the knowledge necessary to carry out energy efficiency measures. Less ambitious companies experience the lack of information to an even higher degree than other companies.

That companies experience uncertainty and risk in investment projects differently is quite common and usually taken into account by the companies by correcting the discount rate. A smaller share of the companies experience energy efficiency investments as risky because of the new, unproven technology, or because of unstable future energy prices. A third of the companies, however, experience uncertainty because of the difficulty to predict the energy companies' tariffs, although there was no support that less ambitious companies would put relatively more emphasis on uncertainty and risk as obstacles. A reason for this could be that the individual conditions are so different that it is difficult to isolate a relation between uncertainty/risk and the ideal type.

Interestingly, when investigating the views on competing investments and what factors weigh more compared to energy efficiency measures, the companies seem to put more weight on the alternatives in a falling scale. Economic issues, or more specifically standard improving measures which can be a reason to raise rents are more important. This is followed by regulatory matters such as accessibility and additional building code requirements. Tending to the outdoor environment is less of a competing investment compared to energy efficiency measures. Only the two types of regulatory competition give rise to some differences between the ideal types. That there is no difference between less and more ambitious companies may be have to do with that the necessary investments in renovation will require so much resources that the individual conditions are more important than ideal type differences.

This view is somewhat reinforced when looking at financing as an obstacle. Almost 40 percent agreed that energy efficiency investments are profitable but cannot be fitted into the investment budget. Here on the other hand differences between the ideal types were found; the more ambitious companies agreed to a higher extent with this statement, whereas the less ambitious companies disagreed to a higher extent. If this was because they disagreed on whether it´s profitable or whether it cannot be fitted into budget is not clear. Furthermore, 45 percent stated that they would improve energy efficiency more if they could raise rents, but ideal types did not differ from each other in this view, so in total the support for this hypothesis is rather weak. Where raising capital is hard, it is so for more ambitious as well as for less ambitious companies.

The last hypothesis relating to obstacles concerned profitability, since the perception of how profitable an investment in energy efficiency is also can be seen as a possible barrier. Hardly any of the companies agreed that their buildings were too energy efficient already or that the buildings were too close to demolition for energy efficiency investments to be considered. On the other hand, a substantial share stated that they would improve energy efficiency "considerably more" if energy prices doubled. This contradicts the result in Nässén *et al.* (2008). It does not however mean that raising energy price, by for example levying a tax, is the evident solution to bringing about energy efficiency improvements, as this wouldn´t necessarily reflect the true social cost of energy consumption. The views on these matters did not differ between the ideal types. A reason that the stated response to energy price increases doesn´t vary with ideal type may suggest that in reality only relatively moderate energy efficiency improvements are being undertaken at the moment, even for the more ambitious companies. If the ambitious companies aren´t doing so much (yet), they would also be affected by price signals/increases – since they too are affected by the economic incentives in addition to the "other" motives. Higher energy prices may thus make them go for the more extensive investments.

6.4 Theme 3: Investment considerations

Overall, the results indicate that economic result is the most important driver, but not the only one that matters. Energy efficiency improvements don´t seem to be as evidently profitable as they have been claimed to be by some, but on the other hand, this may be of less importance if economy isn´t the only driver.

The company's economy was by far the most important motive for energy efficiency investment, for all of the companies. There was no support for the hypothesis that less ambitious companies to a higher degree than others think that this is a more important driver for energy efficiency investments. This may however have to do with how the question was put; the respondents did not need to rank the factors but could give importance to all of the suggested factors. Even the very ambitious companies are likely to state economic result as an important factor when they are allowed to choose several.

In general, and as expected, profitability is important to most of the companies, but not only in the very short run. Half of the companies allow longer pay-back period than five years for energy efficiency measures, but a fifth wouldn´t allow more than that. There is some support that this is the case to a higher extent for the less ambitious companies. The majority of the companies demand that a measure carries its own costs, particularly the less ambitious companies. However, a fairly high share of the companies disagrees on this; ambitious companies especially so. More than 50 percent of the companies need the energy efficiency investments to be clearly profitable, especially so the less ambitious companies. However, 5 percent of the companies completely disagree and don´t require that the investment is clearly profitable a priori. The results give some support to the hypothesis that profitability is more important to less ambitious companies, which again highlights the importance of economic drivers if results in energy efficiency are to be expected.

Most of the companies use formal investment calculations or simpler calculations. Smaller shares do however use rules of thumb or predetermined policies, at least sometimes, to make investment decisions. This indicates that not all investment decisions are guided by careful calculations, but there seems to be no difference between more or less ambitious companies in how the calculation methods are applied. Irrespective of what method is used, the assumptions can always be altered so that the company can push the results in the desired direction, should they have one *a priori*. Hence, it may as well be the less ambitious companies who use less formal calculation methods to escape undertaking energy efficiency investments if calculations for energy efficiency investments would turn out profitable. The lack of calculation is then for them a way of avoiding transaction costs or an indication of organizational conservatism. The lack of calculation can, in the case of the more ambitious companies, be done in order to avoid dealing with calculation results showing that their desired energy efficiency measures aren´t profitable.

Out of those companies who have responded to the follow-up question for those who use formal calculations, the discount rate used varied from 4 through 11 percent. Following this it doesn´t seem like any of the companies use an overoptimistically low discount rate for their projects. If anything, the maximum observed discount rate seems quite high and the question is how many investments calculation will be profitable with a discount rate of 11 percent. The mean discount rate was 5.6 percent, but even though the subsample means appeared to differ from each other, a t-test showed that there were no significant differences.

In general there are quite a few companies who consider investment packages to permit energy efficiency measures that aren´t profitable. The majority of companies prefer to finish one building at a time instead of doing one measure at a time throughout the stock, particularly so the ambitious companies. This reinforces the indications of a more holistic approach among these companies. A third of the companies believe that energy efficiency is profitable even if they cannot show it in their investment calculations, but as expected, less ambitious companies disagree to this to a higher extent than other companies. If these attitudes will lead their investment behavior, and energy prices correctly reflect social costs of energy consumption, these companies will invest more in energy efficiency than what is socially optimal. A fifth of the companies consider undertaking energy efficiency to strengthen the trademark of the company, which is in line with competitive motivations suggested by J. González-Benito & Ó. González-Benito (2006). The results also differ between the company types and the hypothesis that ambitious companies will "create" profitability is supported.

A large share of the companies in the sample says that the environment is important to their decision to save energy, giving support to the ethical driver explanation (Paulraj 2009). Tenant demand and political pressure are also indicated, which supports the relational driver stakeholder pressure explanation of pro-activity (J. González-Benito & Ó. González-Benito 2006). In addition, perhaps the calls for increased regulatory strictness may be interpreted as a wish for an equal and transparent system, especially from the companies who already surpass the regulations today. Either way the results support the hypothesis that the ambitious companies put more emphasis on other (value-adding) motivations than the less ambitious companies do.

6.5 Critique of results and suggestions for future research

Geography is not a factor that has been considered when looking into the different motivations of the companies. The climate in Sweden differs from north to south, which may affect the energy consumption or renovation needs in the buildings. Furthermore, energy prices vary over the different municipalities, which will affect the profitability calculations for the same measures in different parts of the country. In future studies it may be interesting to see if attitudes and strategies vary with geographical location.

The survey consisted of a rather large set of question and statements which was thought necessary in order to test answers against each other. This in turn will most likely affect the answering frequency negatively. Moreover, the questions and statements that served as indicators to test the hypotheses were not in all cases asking explicitly for what was later tested. Even if there was an underlying idea by doing so (to avoid having companies answer what is considered "right"), there is always room for interpretations, and even more so if the questions are indirect.

Earlier research has suggested that company size and financial performance affect environmental pro-activity. This paper has not had the possibility to look specifically at neither, but it can be assumed that these factor matter. In Högberg *et al.* (2009) the ideal types were connected to some extent to size, and even if size has not been used as a determining factor when categorizing the companies in this study (due to demarcation difficulties) it may be related. An interesting question would therefore be to see to what extent the two factors correlate with the ideal types; to see if the ideal types better explain variation than do size and financial performance. Moreover, only private companies that were big enough to have a web page were investigated in this survey, which may bias the results. The smaller real estate owners are probably less inclined and have smaller possibilities to undertake extensive energy efficiency measures, so the general picture in this paper may be too optimistic for the private companies. However, as the results did not show an exaggeratedly bright view of the renovation and energy efficiency status in Swedish real estate companies the risk that the problem is overseen is small. It may be kept in mind though, that the smaller owners may constitute an even less ambitious ideal type better characterized as unaware, following what has been suggested in Högberg *et al*. (2009) and Fastighetsägarna (2010d).

7 Concluding remarks

This study aimed to get a better picture of how the renovation and energy efficiency matters are handled within the housing companies. It also aimed to test the hypotheses that the level of ambition would affect how much energy efficiency work the housing companies have carried out, how they perceive potential obstacles and how they perceive energy efficiency in terms of investment opportunities.

Even though the renovations will constitute a challenge, the question is high on the agenda. That so much renovation work needs to be carried out during a relatively short time period, will probably result in less energy efficiency measures carried out in connection to the "window of opportunity" than would otherwise have been the case; as the workload will demand prioritizing. Many companies will not be able to, or even want to, take the opportunity to improve energy efficiency when renovating their MHP buildings. Some of the companies are forward planning and will be able to fit energy efficiency measures into the renovations but they are not the majority. The type of energy efficiency measures that most commonly has been carried out is more of the continuous savings measure kind. This indicates that the energy savings that should be expected in connection to renovations of the MHP are rather modest.

The results in the hypothesis testing section supported the overall idea that views and action will differ between real estate companies, even if there were aspects where no differences could be shown. This implies a challenge for policy makers who will need to take into account different possible responses to central policy measures.

Based on the results from the hypothesis testing some (spontaneous) reductions in energy use can be expected, but also here the expectations on scope and level should be modest. The distribution of companies over the ideal types suggests that most companies will do the little extra, i.e. measures of savings character, but not the more extensive measures. The efforts of the companies who do the more extensive work will be at least partially outweighed by those who only do the smallest efforts to follow regulations.

Energy efficiency measures may be held back by transaction costs, uncertainty about future energy prices, competing investments or financing, and the obstacles are not perceived in the same way by all of the company types. This suggests that it may be hard to target these obstacles to increase energy efficiency investments among the companies. If the companies view the obstacles differently now, they are likely to view them differently even if they have been addressed by policy measures.

Taken together, the results indicate that it isn´t economic drivers that make the ambitious companies invest in energy efficiency – when the investments don´t appear profitable these companies find ways to carry them out anyway. This investment behavior will be hard to keep up when the new legislation requires all municipal companies to operate in a business-like manner. On the other hand, these companies seem determined to improve energy efficiency because it is “the right thing to do”, and will not be too put off by varying investment conditions. As long as they can motivate the investments with some kind of added value they will go through with it.

The companies are likely to respond differently to policy measures, and possibly do more or less what they would have done anyway. With this starting point it could be argued that more emphasis should be put on promoting energy efficiency where there is likely to have the most effect, and not waste efforts on addressing those who will do little anyway. In other words, policy design could be differentiated according to different company types, and to different conditions. The companies who do a little extra are likely to be the easier group to appeal to, since they generally are positive towards energy efficiency work, and constitute the biggest group of companies. Furthermore, unless substantial public resources are to be invested to make all companies do everything, policy could address e.g. the biggest energy eaters among the buildings. This rather pragmatic attitude towards encouraging energy efficiency would mean that some companies would lead the development which may possibly lower the barriers for the other companies, similar to the idea of a learning process for new technology suggested by (Jaffe & Stavins 1994b). In other words, the companies who have the possibility to improve energy efficiency alongside renovations to do more can do more, while the burden could be lightened for the companies who struggle with renovations if they can focus on renovations first and if necessary do energy efficiency work in a later stage, when technology is more tested and information barriers are lower. The idea is similar to how the Swedish Energy Agency and municipalities work today with voluntary agreements (Energimyndigheten 2008). This may have positive effects on total energy efficiency in the longer run, in contrast to a situation where all renovation and energy efficiency measures are postponed due to lack of resources to do everything at the same time.

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Appendix A

Classification questions

C1: Has the board adopted any objectives to reduce energy consumption in your building stock?
C2: Who initiated these objectives?
C3: Do you have objectives specifically for

a. new production?
b. renovation?
c. existing buildings?

C4: Do you believe you will reach your objectives?
C5: If the board has not adopted any objectives, do you work in any way particular to reduce energy consumption?
C7: Do you have guidelines saying that replacement of technical equipment (e.g. appliances or fans) should be for energy economic alternatives?
C8: Statement "In our company there are clear management directives/demands to save energy"
C9: Statement "In our company there are a number of employees who push the energy matter hard"

Appendix B

Table B1 Hypothesis testing questions: Indicators [Answering alternatives, see bottom of table]

Hypothesis 1: Ambitious companies will have implemented more (extensive) energy efficiency measures in connection to renovation of their 1960s and 70s buildings

H1: What type of energy efficiency measures have been implemented in the 1960's and 70's buildings? [1]

a. Saving measures, e.g. lowering indoor temperatures or switching to low-energy bulbs
b. Installed individual metering
c. Changed to economic water saving armatures
d. Replaced/installed equipment, e.g. fans or exhaust air heat recovery
e. Extensive measures, e.g. in building envelope (additional insulation, windows, etc.)

Answering shares for "In the majority of the stock" was tested against the three ideal types

Hypothesis 2: Ambitious companies are more forward planning

H2a: In what way do you renovate? [2]
H2b: We are forward planning and will manage the renovations of the 1960s and 70s stock without risking particular maintenance problems [3]
H2c: We plan extensive energy efficiency measures in an early stage of the renovation planning phase [3]

Hypothesis 3: Ambitious companies will intervene "in excess"

H3a: When we are about to carry extensive renovation measures we seize the opportunity to implement all possible energy efficiency measures [3]
H3b: We will carry out all the measures suggested in the EPCs [3]
H3c: We often move forward replacement investments in order to improve energy efficiency [3]

Hypothesis 4: Less ambitious companies will perceive *transaction costs* to be bigger

H4a: We have enough knowledge to carry out energy efficiency measures [3]

Hypothesis 5: Less ambitious companies will perceive *uncertainty and risk* to be bigger

H5a: Energy efficiency investments are risky since the techniques are so unproven/since future energy prices are uncertain [3]
H5b: Energy efficiency investments are uncertain since the energy companies can raise tariffs if energy consumption decreases [3]

Table B1 continued

Hypothesis 6: Less ambitious companies will put more emphasis on *competing investments*
H6a: In connection to renovation accessibility of the buildings is more important than energy efficiency [3] H6b: In connection to renovation standard improving measures in the apartments is more important than energy efficiency [3] H6c: In connection to renovation outdoor environment is more important than energy efficiency [3] H6d: It is not profitable to carry out extensive energy efficiency measures as it implies additional costs due to the consequential requirements in building regulations [3]
Hypothesis 7: Less ambitious companies will see *financing* as a bigger problem
H7a: Extensive energy efficiency measures would be profitable but cannot be fitted into the limits of the investment budget [3] H7b: If we could raise rents we would carry out more energy efficiency investments [3]
Hypothesis 8: Less ambitious companies don´t perceive energy efficiency investments as profitable
H8a: It´s no use improving energy efficiency (renovate) in parts of our 1960s and 70s stock since it needs to be demolished soon anyway [3] H8b: Our 1960s and 70s properties consume too little energy for it to pay off to improve energy efficiency [3] H8c: If energy prices doubled we would do substantially more to improve energy efficiency [3]
Hypothesis 9: Economic considerations are more important than other to less ambitious companies
H9: State how important the following factors are in contributing to your attitude to saving energy [4] a. the economy of the company b. tenant demands c. the political pressure d. the environmental issue itself
Hypothesis 10: (Short term) profitability will be more important to less ambitious companies
H10a: We only carry out energy efficiency measures that have paid off in 3 to 5 years [3] H10b: Each energy efficiency measure must bear its own cost [3] H10c: It is important that an energy efficiency measure is clearly profitable in our calculations in order for us to carrying it out [3]
Hypothesis 11: Ambitious companies will use calculations to suit their needs (wants)
H11: When we make decisions about renovations/energy efficiency investments we use [5] a. formal calculations (net present value with certain required rate of return, internal rate of return or such) b. simpler calculations, such as payoff time c. rule of thumb/experience d. a predetermined policy of when things are to be done
Hypothesis 12: Ambitious companies will have a lower discount rate
H12a: If you use formal calculations, what rate of return do you use? [6] H12b: What assumptions do you make (in any calculations) about future energy prices? [7] H12c: Energy efficiency investments are risky since the techniques are so unproven [3] H12d: Energy efficiency investments are risky since future energy prices are uncertain [3]

Table B1 continued

Hypothesis 13: Ambitious companies will "create" profitability

H13a: In what way do you renovate? [2]
H13b: We consider energy efficiency to pay off even if we´re not always able to show it in our calculations [3]
H13c: We may consider carrying out non-profitable energy efficiency measures to strengthen the trademark of the company [3]
H13d: Packages of several energy efficiency measures is a good way of lowering energy consumption a lot, without having to refrain from some less profitable energy saving measures [3]
H13e: "Each measure in its own time" – we rather finish doing the same energy efficiency measure throughout the stock than doing a several measures in on building [3]

Hypothesis 14: Ambitious companies will need other motivations than economic to improve energy efficiency

H14a: We will carry out all the measures suggested in the EPCs [3]
H14b: Legal requirements should be stricter for society to reach the energy objectives [3]
H14c: State how important the following factors are in contributing to your attitude to saving energy [4]

a. the economy of the company
b. tenant demands
c. the political pressure
d. the environmental issue itself

Answering alternatives:
[1] In the majority of the stock / In smaller parts of the stock / Hardly at all / Don´t know
[2] Mainly by finishing one building/area at a time / Mainly by finishing one measure throughout the part of the stock in question at a time / Mainly by intervening where maintenance problems are most urgent
[3] Fully agree / Mostly agree / Don´t know / Somewhat agree / Don´t agree at all
[4] Very important / Pretty important / Don´t know / Less important / Not important at all
[5] Almost always / Sometimes / Rarely / Never / Don´t know
[6] Open
[7] Increase significantly more than inflation (5 percent or more above inflation) / Increase somewhat more than inflation (2-4 percent more) / Follow inflation

Paper 3

Individual metering and charging in rental housing: Creating the right incentives for energy savings?

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Individual metering and charging in rental housing: Creating the right incentives for energy savings?

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Abstract

Changing user behavior by individually metering and charging tenants for their use of heating and hot water has been put forward as a means to reduce energy consumption in the building sector. This would give the tenant incentives to save energy, but at the same time weakens the landlord's incentives for improving energy efficiency in the building, since she is no longer responsible for energy costs. These split incentives problems should be possible to avoid if there is a net gain from improving energy efficiency and/or installing individual metering that could be shared between the parties.

The aim of this article is to problematize the concept of individual metering, to show through simulations that there are ways to avoid the split incentives problem involved, and to show that it should be possible to design contracts that give both landlord and tenant incentives to save energy.

The results indicate that few energy efficiency investments will manage to bear their own investment costs, given how low the present value of the energy savings is at given energy prices. The results also show how split incentives may hinder the energy efficiency investments, but that there are conditions under which such investments and/or individual metering may increase welfare for landlord, tenant or both. Without negotiations this gain will not be reached, but through co-operation this welfare gain could be split which would benefit both landlord and tenant and this should be considered when designing contracts. Finally the findings highlight the importance to take into account the interaction of different means to save energy to avoid over-investment.

Keywords: Split incentives, individual metering, incentives for energy efficiency, energy savings, principal-agent problem

1 Introduction

Individual metering [IM] of heating and hot water is common around Europe and even statutory in some countries, such as Germany and Denmark. In Sweden IM is something of a recent trend and has been suggested to, through changed user behavior, help reduce the 40 percent share of energy consumption that the building sector accounts for. However, increasing IM is not unproblematic. One of the more debated aspects is how to ensure a fair charging for tenants in the same building, when physical properties such as poor outer wall insulation or high heat/cold transmission through inner walls may cause variations in energy consumption regardless of behavioral differences (see e.g. Siggelsten & Hansson 2010).

Another aspect, although less discussed, is whether individual metering and charging [IMC] brings about an optimal level of energy savings. A number of reports have argued that many profitable energy efficiency measures are neglected in the building sector (see e.g. SOU 2008:110 2008; Granade *et al.* 2009). Even if this is not obviously so (Högberg *et al.* 2009) the matter may be further complicated by the division of who consumes and pays for energy, and who is responsible for the building (Maruejols & Young 2010). In this paper it is argued that under a rental system dominated by inclusive rents, such as the Swedish, installing IMC may weaken the incentives to improve energy efficiency as the landlord is now detached from energy costs; something that has been supported by empirical findings showing that individually metered rental households are less likely to have energy efficient appliances provided by the landlord (Davis 2010). This means that going from an inclusive rent system to one of exclusive rent combined with IMC may make reaching the ambitious energy saving targets set up nationally and internationally even more difficult.

What, from society's point of view, is the efficient level of energy savings, and who is responsible for achieving them can of course be argued. Evaluations suggest that introducing heating and/or hot water IMC may reduce this energy consumption by on average 15-30 percent (Berndtsson 2005). This is less than for example the Swedish national efficiency target of 50 percent to be reached by 2050, and even potentially less than the EU target of 20 percent set up for 2020. Furthermore, the energy savings from introducing IMC rely on a continued economic behavior. In order to ensure stable reductions in energy consumption, reductions that not only relies on changes in user behavior (however important its contribution) – complementary investments to improve the building physical capacity may be necessary. In other words, to optimize the energy consumption level investments in efficiency measures, IMC or both may be necessary. For these to be undertaken it is required that the real estate owner has the incentive to do so, even when he is no longer paying the energy bill.

The aim of this article is to problematize the concept of individual metering, and to show through simulations that there are ways to avoid the split incentives problem involved. The purpose is to show that it should be possible to design contracts that give both landlord and tenant incentives to save energy. This paper will center on the existing rental housing stock and in general terms discuss the problems of energy IMC, be it for electricity, heating or hot water purposes.

The paper is organized as follows. In section 2 the background to IMC is presented along with a description of its spread in Sweden. Section 3 describes the theory behind IMC, the problems connected to IMC, and also gives a research overview. A theoretical model is developed in section 4, which is used as a base for the simulations in section 5. The results are analyzed in section 6 and conclusions are drawn in section 7.

2 Background

In 2009 the Swedish building sector consumed 149 TWh out of which approximately 26 TWh was for heating and hot water purposes in the 2.4 million multi-family dwellings. 91 percent of this was distributed through district heating, whereas less than 2 percent of the multi-family building area was heated with oil. The average annual energy consumption per square meter in 2009 was 148 kWh (Statens energimyndighet 2010; Statens energimyndighet 2011).

For tenants in rental housing, energy consumption can be paid either as an inclusive rent, with energy consumption included, or as an exclusive rent where each tenant individually, in addition to the rent, pays for its own energy consumption. The landlord is usually responsible for the contract with the energy company in both cases, and in most cases it is the landlord who charges the energy by distributing the cost of the observed consumption among the tenants. Hence, with exclusive rent individual metering is necessary to ensure that the correct actual energy consumption is charged to the tenants. However, IMD can also be used by tenant and landlord to monitor energy consumption without charging for it, e.g. to improve building operation.

Experience suggests that introducing IMC on average reduces hot water consumption by 15-30 percent and that cold water consumption also decreases as a consequence of metering hot water. The energy used for heating doesn´t necessarily decrease when tenants get to choose their own indoor temperature, but the energy savings when introducing heating IMC are estimated to 10-20 percent (Berndtsson 2005).

2.1 The spread of IMC in the Swedish housing sector

Individual metering is still rather marginal in Sweden. During a period in the 1950s and 1960s IM was starting to become more common as installing meters meant eligibility for additional loans. Hence evaporation meters were installed in approximately 200,000 apartments, but the vast majority of meters were taken out of use when these loan conditions stopped. Inclusive rent has since been the standard in Sweden, mainly motivated by a solidarity argument. The oil crises of the 1970s brought the question of IM back to attention, and it was investigated several times in the 1980s and 1990s, but it wasn´t until the late 1990’s that the interest for the system started to spread in Sweden (Berndtsson 1999).

Starting off from a low level the implementation of IMC has almost quadrupled in Sweden during the last ten years. Less than 15,000 (0.6 percent) of the Swedish apartments had individual heat or hot water measuring in 2003, which in 2007 had increased to 29,000 (1.2 percent). Heating was individually measured in 70-90 percent of the 29,000 apartments; earlier evenly distributed over three different measuring methods (see section 2.2 below) but tipping towards temperature metering during the last few years. 70-80 percent of these apartments had meters for hot water (Boverket 2008).

2.2 IMC installation - who, why and how?

In Sweden, mainly public housing companies have installed IMC so far. According to the estimations made by the National Board of Housing, Building and Planning [NBHBP, Boverket] 75 percent of the IMC was installed in publicly owned apartments, 25 percent in apartments owned by housing co-operatives, whereas no private landlords had installed IMC in 2007 (Boverket 2008). However, in a web questionnaire sent out in 2010, both private and public housing companies (24 and 87 respondents respectively) were asked to what extent they had carried out selected measures within their buildings. 7 companies (6 public, 1 private) said they had installed IM(C) in the majority of their stock, 34 companies (31 public, 3 private) said they had installed IM(C) in smaller parts of the stock, and 58 companies (15 private, public) said they had hardly installed IM(C) at all. Hence, although the latter was more of anecdotic evidence interest does seem to have increased for IMC also among the private companies (Högberg forthcoming).

IMC is generally motivated by *increasing consciousness* meant to evoke a changed behavior among tenants, but also by *fairness*, *saving the environment* and *reducing energy consumption* and/or *energy costs* (Jagemar & Olsson 1999). In the investigation among some 30 housing companies made by Berndtsson (1999) the stated motives for IMC installation were *necessary cost savings* (called for by the inability to raise rents), that rental apartments with IMC is seen as *more attractive by tenants* since tenants don´t need to pay others' wasted energy, that it would be a natural *step towards individually adapted living*, *environmental motives* and *fewer tenant complaints* on indoor temperatures, which is positive for the maintenance division. Siggelsten & Hansson (2010) who carried out a survey among 26 Swedish municipal housing companies suggested that the most important motive for Swedish real estate owners to introduce IMD is *Saving energy and hence the environment*, followed by *Creating an equitable allocation* of heat and water costs. *Trying the techniques/curiosity* and *Making an economical profit* were chosen by some respondents, although not as popular motives. The potential difficulty to use economic profit as justification was discussed as a possible explanation for using environmental reasons to gain acceptance for the new system (Siggelsten & Hansson 2010).

Out of the IM(C) installations estimated in 2007, half of those in public housing and two thirds of those in housing co-operative apartments were installed in existing buildings. This was the case both for apartments with IM(C) for heating and/or hot water and for apartments with IM(C) for water only. Approximately 25 percent of the installations in public housing apartments, and 15 percent in housing co-operatives apartments were in new buildings. Less than 10 percent of the installations in public housing apartments, and 15 percent in housing co-operative apartments were made after renovation (Boverket 2008). Nevertheless, for a number of interviewed housing companies the more common procedure seems to be to first improve energy efficiency, then install IMC (Based on interviews described in Högberg *et al*. 2009).

Individual metering as basis for charging of energy consumption is the focus of this paper, and as such, the energy bills give instant feedback of the tenants' consumption.. There are three types of meters that are commonly used for heat measuring. *Flow metering* measures the flow and temperature of the water in the radiator system, *radiator metering* measures the emitted heat from radiators using sensors, and *temperature metering* ("comfort metering") measures the actual temperatures through sensors placed at specific locations around the apartment. The tenants could also have individual boilers each with their own contract with the energy distributor. For hot water, devices placed in or on the armatures are used to measure the flow and temperature (Boverket 2008). Electricity, when individually metered, is almost exclusively charged directly by the electricity company.

A number of technical problems connected with the different heat measuring methods and incentives for saving have been discussed in the Swedish IMC debate, e.g. relating to manipulation of meters/temperatures or heat transmissions between apartments. However, these incentives problems will not further be considered in this paper, interested readers are recommended to see the discussions in e.g. Boverket (2008) or Siggelsten & Hansson (2010). For the sake of this paper the technical parts of measuring are assumed to work accurately.

2.3 Contract design – some examples

The Swedish housing market has a rent regulation and as there are not yet any directives on the forms of how IMC should be implemented, transitions from inclusive to exclusive rents are negotiated between the housing company and the Swedish Union of Tenants [SUT]. As noted above, IMC has been installed in new and existing buildings, pre- as well as post-renovation. It appears to be common to introduce IMC *after* making improvements related to energy performance and this may be an indication (of the effect) of SUT's involvement in the process, looking after their members' interests.

Generally, one important question when moving from inclusive rent to exclusive rent with IMC, is how rents should be adjusted. As energy costs no longer are included in the rents the intuitive action is to lower rents by removing the part constituted by the energy costs. It is not however obvious what and how much is to be removed. Furthermore, the costs for installing IMC can be borne by the landlord, the tenant or shared between them, which actually can lead to higher rents even after energy costs have been excluded. What are *fixed* and *variable energy costs* need to be defined and distributed. Fixed costs can be distributed according to apartment size, but this could also be done for a share of the variable energy costs, while the rest of the variable cost is charged according to observed/measured consumption. Agreement is also sought to whether the energy consumption should be charged completely variably or if some base or "normal" consumption is included in the rent, from which only deviations are charged. Moreover, this cost can be charged according to measured consumption, for which time for charging (e.g. monthly) needs to be set, or it could be preliminarily charged and adjusted when actual consumption figures are available. Finally, the energy prices that should be applied for charging tenants are often also a matter of negotiations (Boverket 2008).

A handful of contracts have been studied to get an idea of how terms and conditions have been formulated when Swedish housing companies have gone from collective to individual metering. The sample of existing contracts between tenants and landlords in Sweden that has been analyzed shows how costs and liabilities are distributed between them when installing IMC. Below is a synoptic description of the terms with reference to the (theoretical) description by Bohman (1995), in which four rental contract types have been analyzed with respect to how the landlord's and tenant's incentives for energy efficiency depend on how energy costs are charged. For more details of Bohman's contract types and the analyzed contract types, see appendix A.

Lease terms for of electricity

Metering electricity is simplified by the ease of measuring accurately and equitably, and by the possibility to have individual contracts with the electricity company. Two cases of electricity IMC have been observed, and for both the contracts follow a completely cost adapted price setting principle, meaning electricity costs are excluded from rents and the tenant pays a price per consumed unit (here kWh). In these two cases rents have been adjusted downwards and the adjustment in one of them included fixed *and* variable costs. The price is given by the electricity company without involvement of landlord or the SUT. This type of contract gives incentives to the tenant but not to the landlord to save energy.

Lease terms for IMC of hot water

Five observed cases included hot water metering, but only three of them presented any contract details. All of the three follow the completely cost adapted price setting principle. For two of the cases a standardized consumption has been calculated based on the total consumption from when inclusive rent was still in use (i.e. when marginal price to tenant equaled zero, see more below), so that the average consumer will have the same costs for rent and energy with inclusive as with exclusive rent. Energy prices are either set as an average unit price based on total pre-IMC energy costs, or after negotiations between landlord and the SUT. Fixed costs are also charged based on apartment size. In the third case the rent adjustments are negotiated, which is likely to be the case also for energy prices, but this, however, is not described. Again, this gives incentives to the tenant but not to the landlord to save energy.

Lease terms for IMC of heating

For the two observed companies who have introduced IMC of heating, one has chosen the completely cost adapted price setting principle, with the standardized consumption cost reduced from rents. The other company has chosen a partially cost adapted price setting principle, which means that the landlord offers a default temperature that can be varied by the tenant within an interval. The default temperature is included in the rent, which then equals the inclusive rent, but each deviating degree (Celsius) is compensated for/charged based on apartment size. The energy price has either been negotiated by landlord and the SUT or calculated as the average unit price based on the total energy costs pre-IMC.

In the cases where energy costs are not paid directly to the energy company, the landlord still may have an incentive to improve energy efficiency; as long as the negotiated/calculated price paid by tenant to landlord exceeds the actual price charged by the energy company, the landlord can make a profit if a) template consumption is included in the rent and b) she improves energy efficiency (using less energy to provide the pre-determined consumption).

On the other hand, if the tenant is charged completely freely the landlord actually gains the more the tenant consumes, as long as agreed price exceeds charged price. In general, to give the landlord incentives to undertake energy efficiency improving measures there should be opportunities to negotiate the terms of the contracts as a whole. This is only done in one of the observed contracts: the partially cost adapted price setting principle for heating, where the landlord and tenants agree to evaluate the system after a certain period of time. In one other case, for a company using completely cost adapted price setting principles for electricity and hot water, the contract specifies that the housing company has the right to initiate new price negotiations if the actual price differs too much from the agreed price. In the latter case the incentives to improve energy efficiency on behalf of the landlord is at least partly taken away, but perhaps such price negotiations may be an opening and trigger demands from tenants that landlord should undertake such improvements.

3 Theory

3.1 Optimal energy savings

The "problem" of reducing energy consumption can either be seen on a business level or a social level. For the individual consumer (tenant) or firm (landlord) the optimal level of energy consumption is when the marginal cost for reducing energy consumption with one unit equals the marginal benefit from such reduction. During the last years several reports have claimed that many profitable energy efficiency measures aren´t carried out (SOU 2008:110 2008; Granade *et al*. 2009). It is, however, questionable that this is true for as large number of improvements as is claimed (Högberg *et al*. 2009).

If energy consumption contributes to negative side-effects, energy prices should also incorporate this social cost. External effects therefore need to be estimated and priced to estimate the optimal level for society. As energy consumption in the building sector accounts for 8 percent of global greenhouse gas emissions (25 percent if household electricity is included) energy consumption does bring about negative externalities, making the social cost of energy consumption higher than what is reflected in a (free market) price (Metz *et al*. 2007; SOU 2008:110 2008). Hence the energy savings that are optimal for society exceed those that are optimal for individual firms; or more specifically where the marginal *social benefit* equals the marginal *social cost* for reducing energy consumption. The actual size of externalities is of course difficult to estimate but policy measures such as carbon dioxide taxes aim to estimate and transmit the cost of the externality and thereby align consumers' and society's interests. For a tenant faced with inclusive rent, however, the marginal cost for energy will be zero, which almost certainly leads to overconsumption; consumption where marginal utility is lower than the marginal cost for the last consumed unit of energy.

Even if so few real estate owners stated economic profit as motive for installing IMC, maybe because it would be hard to gain acceptance in tenant negotiations for it, it cannot be denied that economy matters; the bigger the original energy consumption, the bigger the possible energy (cost) savings. This should be a strong motive for firms to install IMC in high consuming buildings. At the same time, the bigger the original consumption of the building, the bigger are the energy costs that will be borne by the tenants after installing IMC.

Intuitively real estate owners would prefer to introduce IMC to escape energy costs. However, once IMC is introduced the landlord has less incentive to improve the energy efficiency of the building, which could make it harder to reach a socially optimal level of energy efficiency. On the other hand, if energy is correctly priced, no further investments should be made after installing IMC unless they are still profitable.

3.2 Revelation of marginal willingness to pay

The introduction of IMC can be seen as a way to reveal the true private utility of energy. Making the tenants aware of the cost implies that they will consume energy up until the point where marginal cost equals the tenant's marginal utility for that unit. Given that the marginal cost of energy was zero when energy consumption was included in the rent, and assuming negative price elasticity, energy consumption is expected to decrease on average, as some of the tenants find the new, higher price exceeds their willingness to pay at their initial, pre-IMC energy consumption level. Some tenants, however, may still value energy consumption higher than the marginal cost and will continue consuming at the same or even a higher level than before if they now more easily can control the energy level.

3.3 Split incentives

When more than one party are involved in buying and using energy-consuming devices (including housing itself), and in paying the energy bill, their interests will necessarily be unaligned, as long as the upfront cost of more energy efficient appliances is lower than that of less efficient appliances. In owner-occupied housing the costs and benefits of saving energy would be financed and enjoyed by the same person. The owner of the building has an incentive to improve the building's physical capacity if this results in benefits for the one(s) living in the building. In contrast, in rental housing the IMC situation can be described as a two-way principal-agent [PA] situation; a case of split incentives. In this particular case two scenarios are possible. In the first, with inclusive rent the tenant pays a rent to the landlord to enjoy consumption of housing including energy consumption. The landlord in turn pays the energy bill but is unable to affect the energy consumption of the tenant. Hence, the landlord can be seen as the principal who needs the agent, i.e. the tenant, to act in a way to save energy on its behalf. In the second, with exclusive rent where the tenant pays its own energy bill and rent to the landlord, the tenant can be seen as the principal who wants the agent, landlord, to act on its behalf to keep the building in an energy efficient state.

3.4 Align interests: contract design

In order to reduce energy consumption both parties must be given the incentive to save energy. Assuming that a changed behavior following greater awareness leads to energy savings, and that this results in energy *cost* savings, IMC could generate an economic surplus. In a world with no transaction costs Coase (1960) argued that cooperation or trade would lead to the implementation of such measures and to a division of such surplus. In reality however, as Coase also noted, transaction costs (and other limitations) do exist. This means that even if action could benefit the two (or more) parties involved, the potential will not necessarily be realized.

In commercial real estate during the last few years a new type of rental contract aiming to reduce environmental impact has sprung up; so called green leases. The idea behind green leases is that landlord and tenant agree on some target(s) such as energy savings or waste management for the rented premises, and have a shared responsibility to reach these targets. Both carrots and sticks are used to incentivize; the tenant could e.g. get rent abatements if the landlord fails to meet his responsibilities to cut energy consumption, or they could both share the capital costs and resulting operation cost savings for an energy efficiency investment (Brooks *et al*. 2008; Wilcher & D'Agostino 2006). This type of contract is not available on the housing market, but a similar model would make it easier to improve energy efficiency when split incentives exist.

3.5 Benefits and costs of IMC

As noted above, there are three arguments usually brought forward when advocating for exclusive rent with IMC. Fairness is mainly argued for in the Swedish debate; making low consumers pay for high consumers' energy use is not seen as just. The second and third arguments both stem from the assumption that increased awareness will lower energy consumption, which will lead to cost savings and less environmental impact. In this way, the revelation of energy´s true cost can be seen as an internalization of (parts of) its environmental effect. A fourth argument could be that the metering itself facilitates the operation of the building and hence improves real estate management. If this enables more efficient management, energy use reduction can be a welcome "side effect". Finally, if individual metering makes it possible for the tenant to individually control indoor temperature to better suit preferences this is also a benefit of IMC. For this paper, however, only energy cost savings are addressed on the benefits side.

Installing IMC also brings about direct and indirect costs. Investing in IMC equipment implies a capital cost and the cost of operating, administrating and maintaining the system. The installation of the equipment, together with informing the tenants, can be considered transaction costs. In addition to these costs the possible reduced comfort of tenants needs to be taken into account as a negative value in the calculation. However, this paper assumes that tenants reduce energy consumption only up until the point where the marginal cost equals their marginal utility. For the calculations in this paper only the capital cost for installing IMC and the operation costs are considered on the cost side.

3.6 Earlier research

The principal-agent problem is well known and has been highlighted as one of the obstacles to improved energy efficiency in the buildings stock. For example, Meier & Eide (2007) found that 2-100 percent of end use energy consumption was affected by PA problems. Murtishaw & Sathaye (2006) made an attempt to quantify the effect of the PA problem for US residential energy use. Their results showed that out of the investigated households 78 percent and 53 percent respectively were affected by PA problems related to water heaters and main space heating, the corresponding shares for refrigerators and lighting were 33 and 5 percent. They estimate that 6.4 Trillion Btu[1] per year could be saved if the PA problems related to refrigerators and water heaters could be overcome.

More empirical evidence of the PA problem was presented by Maruejols & Young (2010), who found that split incentives and information asymmetry are factors that matter for energy saving behavior in the Canadian multi-family housing market. Using data from the 2003 Survey of Household Energy Use comprising 1057 dwellings, their multiple regression analyses showed temperature was generally set lower for residents who paid their own utility bills.

Indications that landlords refrain from keeping their buildings in an energy efficient standard when tenants pay the energy bill were found by Meyer-Renschhausen (1983). In his study energy-conserving investments have been carried out less frequently in German rented housing compared to owner-occupied housing (implying a higher cost for German low-income households, who were more likely to be renters). Meyer-Renschhausen suggested that the inability to transfer energy conservation costs to the tenant was one reason for this, and that lack of transparency in the housing market was another; it could otherwise have led to a demand for lower rent as a result of worse energy efficiency standard. Furthermore, Davis (2010) found that individually metered US renters are less likely than homeowners to have energy efficient appliances, and suggested that landlords buy cheap inefficient appliances when their tenants pay the energy cost.

The inclusive rent system, although less efficient than IMC, is still common in the US, which at least in part is due to landlords' preference for this system (Levinson & Niemann 2004). Levinson & Niemann suggest this could be because of high installation costs for IM, or that landlords wish to signal a high degree of energy efficiency through inclusive rents. This is in line with the theoretical results of Bohman (1995), who noted that the landlord won´t install individual metering voluntarily if he has the option to split the energy costs evenly over the tenant collective instead, thus minimizing his costs for installation, maintenance and administration. Bohman went through available Swedish rent setting principles – inclusive, semi-inclusive and exclusive rents – to investigate the effect on incentives for energy efficiency following each. In a pure investment problem seen from a profit maximizing landlord's point of view the choice in stage one is between two heat distribution systems. Given the distribution system, the second stage consists of choosing between two packages of savings measures. The systems and packages differ in capacity, fixed and variable cost levels, and in consumption limits of the system. The optimal choice will depend on type of applied rent principles, but also on the shape of the cost and demand curves. Moving further, Bohman includes the tenants' perspective to find a socially optimal situation, i.e. the better solution for landlord and tenant, which will not be spontaneously reached unless rental contracts are designed particularly for this objective (Bohman 1995).

Earlier calculations of potential cost savings following introduction of IMC has been made by Berndtsson (1999), who looked at three fictive buildings with different levels of initial energy

[1] The heat required to raise the temperature of 1 pound of water with 1 degree Fahrenheit.

consumption. Demand for energy was assumed to fall with 9, 14 and 21 percent respectively for the low, middle and high consumption buildings. If energy prices were moderate he concluded that IMC would be profitable in a high consumption case for both high and low investment costs, and in a middle consumption case if installation costs were low. If energy prices doubled IMC would be profitable in all cases accept for the low consumption – high investment cost case.

4 The model: Creating incentives for optimal savings

Bohman (1995) analyzed the conditions necessary to reach an optimal level of energy consumption from the point of view of a profit maximizing landlord´s as well as from a social point of view. In the analysis below the choice of distribution system is considered given and the optimization problem is restricted to choosing whether or not to implement a package for energy efficiency and/or installing IMC. As Bohman pointed out, only installing IMC is in most cases insufficient to reach a social optimum; the landlord would, if she has the possibility, choose the system associated with the lowest fixed costs (and the energy efficient system is assumed to have higher fixed costs). In either case she has no economic reason to further reduce the energy consumption.

Hence, a simple model will be constructed to depict the conditions necessary to reach a socially optimal energy consumption level. Assuming a situation with a distribution system already in place and where tenants face inclusive rents, energy consumption (presumably) is too high given the effective energy price of zero to the tenants. The first necessary condition is that total energy cost savings (*E*) exceed the (investment) cost of saving energy (C^e), irrespective of how energy savings are reached (through IMC and/or investment package in energy efficiency improvements).

$$C^e < E \tag{1}$$

Simply put, if the above holds the energy saving action in question should be carried out.

Normally the relationship between rents and energy costs can be described as

$$R > r + e \tag{2}$$

where R is the inclusive rent, r is the exclusive rent and e is the energy cost that the tenant needs to pay separately if there are inclusive rents. If (2) holds the tenant would have no objections to introduce IMC from an economic perspective. However, the intangible benefit from having the possibility to individually choose energy consumption (e.g. decide indoor temperature), and the intangible cost of reduced comfort as tenants feel obliged to reduce energy consumption, also need to be considered. This implies that IMC may be motivated from a tenant perspective even if (2) does not hold.

Thus, assuming that at least (1) holds, a transition to exclusive rent with IMC and/or investments in energy efficiency is motivated. This would give incentives to both landlord and tenant to share the costs and benefits from such a reduction and both be better off.

To make the tenant willing to finance a reduction in energy consumption the following must hold (at this stage we compare the willingness to pay with the situation before IMC has been installed):

$$R > r + p + e \qquad (3)$$

where p is a rent premium that finances the investment in energy efficiency improvements. To make the landlord willing to finance such a reduction the following must hold:

$$e + p > c \qquad (4)$$

where c is the capital cost for improving energy efficiency.

The landlord is responsible for the building capacity and it is only when the energy cost savings is of benefit to her that she has direct incentives to carry out the installation/investment. Of course, it could be the tenants who finance the energy efficiency investment, but in rental housing doing so necessarily includes the landlord's participation, not the least given the legal restrictions. This is in contrast to the similar situation of housing co-operatives, where the occupants own the right to live in the apartment and a share of the building, and thereby exercise influence over the building's investment decisions (i.e. no split incentives).

Depending on the potential savings the maximum possible investment size (and whether investment should be undertaken at all) can be deduced.

5 Simulations: Identifying conditions for optimal energy savings

In this section a number of selected simulations are performed to highlight the effect of energy cost allocation under different circumstances. The simulations are made using a simplified cash flow analysis where the net present value [NPV] for both landlord and tenant from different scenarios are compared. The figures in the examples are realistic but fictive. Real world results are, as Bohman (1995) also pointed out, dependent on cost and demand functions as well as on time horizon, energy savings and energy prices. Hence, the aspiration for the simulations is not to show the optimal contract design, but rather to point out cases where there are potential benefits from reducing energy that may benefit both parties.

In addition to highlighting Pareto improving re-allocation possibilities, theoretical profitability limits stated in equation (1) are investigated. This is done by looking at how big the energy cost savings following an energy efficiency investment must be to maintain a positive net present value for the investment as a whole, or put differently, what would be the maximum investment cost (C^e) given certain energy reductions (e) and under the stated assumptions. This is done by deducting the size of the largest possible energy efficiency investment. Again, the results are subject to the specified assumptions regarding, among other things, previous consumption, expected savings and energy prices.

5.1 Cash flow analysis

A ten year period is used to analyze the positive and negative cash flows for that period, under certain assumptions. The cash flows have been modified for influence of time; the time series are inflation adjusted and discounted to account for the alternative use of capital using a moderate and a high discount rate, for a normal risk and high risk scenario respectively. The assumed figures can be found in table 1 below.

The net operation income [NOI] per square meter each year for the landlord consists only of rent income and, when applicable, energy cost or IMC operation costs. The NOI beyond the calculation period is capitalized in eternity to account for future cash flows. Capital costs for IMC and/or energy efficiency [EE] improvements will be added.

For the tenant the cash flow consist of rent and energy costs. Besides studying how the NPV changes for each actor individually the welfare effect is considered. A welfare increase for the landlord occurs if the NPV of its future NOI (including investments) is higher, whereas a welfare increase of the tenant is when the NPV of its total costs is lower. Total welfare increases if the sum is positive. Note that the examples below refer to an assumed average tenant.

Table 1 Assumptions for cash flow analysis inputs

Variable	**Base scenario (A)**	**High energy price scenario (B)**	**High risk scenario (C)**
Inclusive rent (rent+energy cost)/m^2 (R)	1,200		
Energy consumption, cost/m^2/year (e)	200		
Discount rate, %	7	7	12
Inflation, %	2		
Energy price increase, %	-	5	-
Exit yield, %	5		
Installation cost IMC /m^2	43		
Operation cost IMC, m^2/year	7		
Energy efficiency investment, m^2 (C^e)	1,000		
Time period, years	10		
Expected energy savings IMC, %	20		
Expected energy savings EE, %	25		

The investment cost per square meter is derived from an assumed installation cost of 3,000 SEK per apartment. This is an estimation loosely based on the estimated costs in recent Swedish reports. The operation cost is based on an assumption of 500 SEK per apartment and year (Boverket 2008). The cost per square meter is calculated using an apartment size of 70 m^2.

The estimated energy efficiency investment cost is loosely based on example figures from the

National Board of Housing, Building and Planning, referring to efficiency improvements suggested in the newly introduced EU Energy Performance Certificates. This example in particular is based on the stated cost for additional insulation of an outer wall. The estimated energy savings for heating are 67 percent and the estimated investment cost is 900 per square meter, given that the façade needs to be re-pargeted. Hence, compared to the capital cost assumed in this example the NBHBP example counts with bigger savings and smaller costs, but also has a longer time perspective and builds on the assumption that the façade needed to be taken care of anyway (Abrahamsson & Adalberth 2011). Investigations from SABO indicate that the figure may well be an underestimation of the investment cost as they have estimated the additional cost of going from "minimal" to "limited" to "complete" renovation in the Million Homes Program would increase cost from 2,000 to 6,000 to 12,000 SEK per square meter. For intuition it is easy to think of costs expressed in SEK. However, although derived from real world examples they will not be stated in SEK in the paper (except for calculations of maximum investment), partly to improve readability, partly to focus on principles rather than prices that may be questioned.

In the base scenario (A) the inclusive rent is set to 1,200 per square meter and year. Out of this the landlord pays 200 for energy consumption per square meter and year, given the assumed energy price of 1 per kWh. A sensitivity analysis is also performed showing what happens if energy price is assumed to increase faster than inflation, here with an annual energy price increase of 5 percent above the inflation rate seen in scenario (B), and if risk is expected to be higher, here increasing the discount rate to 12 percent instead of 7 percent as seen in scenario (C).

The present values for scenarios A-C given the basic assumptions are then contrasted with alternate scenarios showing how present values for landlord and tenant change if IMC is introduced, energy efficiency is improved or both. Contract changes following a transition to exclusive rent with IMC need to include the removal of energy costs from the rent, the decision of how energy consumption is to be charged (variably or partly fixed) and settling the energy price. In this example the fictive energy costs are removed altogether from the rent when IMC is installed, i.e. charged completely variably. Moreover, energy price is assumed to be fixed and charged one for one to clarify the relations.

5.2 Case I: Energy efficiency investments with no IMC

Using the assumed capital cost (1,000) for improving energy efficiency with 25 percent, the resulting NPV changes for such an investment under the three stated scenarios are showed in table 2.

In case I the landlord pays both the energy costs and finances the investment in energy efficiency. In scenario A, where energy price increases follow inflation, the result is exactly the same for both parties before and after improving energy efficiency. The energy cost savings exactly offsets the investment cost. This is however depending on the assumptions; a higher investment cost would have resulted in a welfare loss for the landlord, whereas a lower investment cost would have resulted in a net gain. The tenant remains unaffected by changes in energy expenses since these are paid entirely by the landlord in this simplified inclusive rent setting. In scenario B, where energy prices increase faster than inflation, the landlord experiences a net gain from investing in energy efficiency measures compared to not investing, despite having to finance it all by herself as she is able to escape some part of the increased energy costs. The total welfare effect is a net gain of 479, since the tenant again remains unaffected. In high risk scenario C the total welfare is a net loss of 500, again carried by the landlord.

Table 2 Total effect in NPV when improving energy efficiency under inclusive rent

	NPV inclusive rent	NPV inclusive rent+EE	Difference NPV	Welfare effect	Total welfare effect
Base scenario (A)					
- landlord income	20,000	20,000	-	( )	0
- tenant costs	24,000	24,000	-	( )	
High energy price scenario (B)					
- landlord income	18,085	18,564	479	(+)	+479
- tenant costs	24,000	24,000	-	( )	
High risk scenario (C)					
- landlord income	10,000	9,500	500	(-)	-500
- tenant costs	12,000	12,000	-	( )	

Based on the assumptions, the maximum possible investment cost for equation (1) to hold can be derived. According to the above, an investment in energy efficiency will lead to energy savings of 25 percent; here 50 SEK per square meter and year. For (1) to hold the maximum investment per square meter that can be made in energy efficiency improvements is the present value of annual savings of 50. For base scenario A this corresponds to 1,000 per square meter (depending on the assumed energy savings – bigger energy savings at this energy price would lead to a higher possible investment, whereas lower savings would lead to lower possible investment). For scenario B, in which energy prices increase more than inflation, the possible investment per square meter is higher; 1,479 SEK per square meter, because of the higher potential energy savings. For high risk scenario C, the higher discount rate makes the maximum possible investment per square meter 500 SEK.

5.3 Case II: IMC installation in existing buildings

5.3.1 Option II (i) Installing IMC without energy efficiency investment

With no investments in the building's physical properties energy consumption is expected to decrease with on average 20 percent due to installation of IMC, going from 200 to 160 per square meter and year. The original energy cost is moved from the landlord, reducing the rent income from 1,200 to 1,000 in year 0 but at the same time reducing energy costs from 200 to 0. However, the landlord also pays for installing and operating the IMC system, according to above. The average tenant now pays 1,000 in rent to the landlord and 160 to the energy company, a total of 1,160 compared to the original 1,200 in year 0. In table 3 below the effect over a ten year time period is presented.

Table 3 Total effect in net present value (NPV) when going from inclusive rent to exclusive rent with IMC

	NPV inclusive rent	NPV exclusive rent+IMC	Difference NPV	Welfare effect	Total welfare effect
Base scenario (A)					
- landlord income	20,000	19,814	186	(-)	+614
- tenant costs	24,000	23,200	800	(+)	
High energy price scenario (B)					
- landlord income	18,085	19,814	1,729	(+)	+997
- tenant costs	24,000	24,732	732	(-)	
High risk scenario (C)					
- landlord income	10,000	9,886	114	(-)	+286
- tenant costs	12,000	11,600	400	(+)	

In scenario A the net present value of the cash flows for the landlord is reduced with 186, from 20,000 to 19,814. The tenant experiences a decrease in net present value of its total costs, which are reduced with 800, from 24,000 to 23,200. In sum there is a welfare increase (800 > 186) which is enjoyed by the tenant only.

In scenario B the effect of energy price increases which are higher than inflation are analyzed. When still using inclusive rents the landlord's NPV is lower in B than in A because of the higher energy costs. In scenario B, introducing IMC would lead to an increase in NOI and hence in the NPV, from 18,085 to 19,814. Even though consumption is reduced, the increasing energy prices cause the tenant cost NPV to increase from 24,000 to 24,732 when introducing exclusive rent with IMC. Despite the loss in tenant welfare that this implies, the total welfare effect of installing IMC is positive and enjoyed only by the landlord, since the decrease in energy costs from reducing consumption exceeds the cost of installing and maintaining IMC.

In scenario C a higher discount rate is used for the cash flows reflecting a higher risk. In this example the NPV of the landlord's NOI is the lowest and further decreases if moving from inclusive rent to exclusive rent with IMC, a decrease of 114. The tenant improves its welfare, as its costs decrease in the IMC case compared to the inclusive rent case. The total welfare effect is positive (400 > 114) and enjoyed only by the tenant.

In sum there is a welfare increase in all of the three cases, albeit distributed differently. In the base and high risk scenario the landlord is who lose from installing IMC, but in the energy price increase scenario the landlord gains.

5.3.2 Option II(ii) Installing IMC after energy efficiency investment

If energy consumption is to be reduced more, or more permanently, investments in the building's physical properties may be needed. In this example the base case is compared to scenario in which 1,000 has been invested year 0 to improve energy efficiency in addition to the installation of IMC. Energy consumption thus decreases from original 200 to 120, a total decrease of 40 percent.

Table 4 Total effect in NPV when having exclusive rent with IMC and making an EE investment

	NPV inclusive rent	NPV exclusive rent+EE+IMC	Difference NPV	Welfare effect	Total welfare effect
Base scenario (A)					
- landlord income	20,000	18,814	1,186	(-)	+414
- tenant costs	24,000	22,400	1,600	(+)	
High energy price scenario (B)					
- landlord income	18,085	18,814	729	(+)	+1,180
- tenant costs	24,000	23,549	451	(+)	
High risk scenario (C)					
- landlord income	10,000	8,886	1,114	(-)	-314
- tenant costs	12,000	11,200	800	(+)	

In scenario A the landlord's NPV decreases with 1,186, due to capital and operation costs for IMC and energy efficiency improvement. The tenant however experiences a cost decrease of 1,600 thanks to the 40 percent decrease in energy consumption. The total welfare effect is positive since the tenant decrease in cost is bigger than the landlord decrease in income (1,600 > 1,186).

In scenario B the landlord actually experiences an NPV increase thanks to not having to pay for energy, despite the energy efficiency investment cost. The tenant also experiences a welfare increase thanks to the lower energy consumption. Note that this is different to the results for only introducing IMC in table 3 as the energy price increase in that example led to an increase in tenant costs and consequently the NPV. Here the total welfare effect is undividedly positive for both actors.

In the high risk scenario C the landlord's NPV decreases from 10,000 to 8,886, whereas the tenant experiences a welfare gain as the NPV of its costs decreases with 800. The total welfare effect is negative as the landlord's loss is bigger than the tenant's gain (1,114 > 800).

Summing up this last example it can be noted that total welfare is increased in the first two cases but not in the high risk case. Furthermore, in scenario B both the landlord and the tenant gains from installing IMC and improving energy efficiency, compared to the inclusive rent. Summing the welfare effects for the landlord and the tenant, the first energy price increase scenario results in a surplus of 997 (1,729-732), and the second energy price increase scenario in a surplus of 1,180 (729+451). Given the total welfare gain this shows that there are incentives to improve energy efficiency and installing IMC, and that the welfare surplus can be divided between the landlord and the tenants, e.g. a rent premium to finance the energy efficiency investment. This will be discussed further in the analysis.

5.4 Case III: Investing in energy efficiency after installing IMC

If IMC already has been installed in a building investing in energy efficiency will not be as profitable for the landlord since energy consumption in the beginning already is lower. Imagine a starting-point with exclusive rent and IMC installation, where energy consumption is 160, i.e. equal to the post-IMC consumption (80 percent of original 200). In the second stage investments in energy efficiency are undertaken at a cost of 1,000 lead to an energy consumption of 120 (75 percent of 160).

In this example the cash flows of the landlord include rent income and the operation cost for IMC, and the cash flows of the tenant are the rent cost and the energy cost. In table 5 the effect over a ten year period of an energy efficiency investment on behalf of the landlord can be seen, given the assumptions above.

Table 5 Total effects in NPV when having exclusive rent with IMC and making an EE investment

	NPV exclusive rent+IMC	NPV exclusive rent+IMC+EE	Difference NPV	Welfare effect	Total welfare effect
Base scenario (A)					
- landlord income	19,857	18,857	1,000	(-)	-200
- tenant costs	23,200	22,400	800	(+)	
High energy price scenario (B)					
- landlord income	19,857	18,857	1,000	(-)	+183
- tenant costs	24,732	23,549	1,183	(+)	
High risk scenario (C)					
- landlord income	9,929	8,929	1,000	(-)	-600
- tenant costs	11,600	11,200	400	(+)	

In scenario A the landlord´s incomes decrease because of the energy efficiency investment cost. At the same time the tenant's costs are reduced owing to the reduced energy consumption. Taken together the welfare effect is negative since the decrease in landlord income exceeds the decrease in tenant cost (1,000 > 800).

In scenario B the effect of an energy efficiency investment is the same as in the base case for the landlord, since landlord NOI is unaffected by energy prices. The tenant however experiences a bigger decrease in energy costs relative to that in the base case, as energy consumption is reduced. In this example the total welfare effect is positive since the decrease in tenant cost is bigger than the reduction of landlord income (1,000 < 1,183).

In scenario C – the high risk scenario - the income is lower in the starting-point due to the higher discount factor, but for the tenant the decrease in NPV from an energy efficiency investment is still 1,000. The tenant's costs are only reduced by 400 so the total welfare effect is negative (400 < 1,000).

To sum up it can be noted that additional investments in energy efficiency improvements compared to only installing IMC in a new building result in a total welfare gain if energy prices increase more than inflation, given the above assumptions. In this case the welfare gain is enjoyed only by the tenant.

6 Analysis

In these simple examples it has been showed that, depending on the circumstances, IMC can imply a gain for both landlord and tenant. In this section it is looked more into detail on the different circumstances, and the implications in relation to contract design will be discussed.

6.1 Maximum investment cost

According to the assumptions the maximum possible investment that would have a positive net present value in the base case scenario is 1,000. Translating this to SEK, it is hard to imagine an investment in energy efficiency improvements that costs at most 1,000 per square meter while at the same time reducing energy consumption by 25 percent. Given that the simulations correspond fairly to real world conditions, it is questionable that there are a lot of profitable energy efficiency measures that are ignored by real estate owners. What is more, these calculations are based on the energy consumption before IMC has been installed. If IMC was installed first, subsequently reducing energy consumption, the 25 percent in energy savings brought about by the energy efficiency measures would be based on the lower energy consumption (as in case IIii), meaning the maximum energy efficiency investment cost would be even lower than 1,000.

6.2 Case specific implications

Case I: Energy efficiency investment without IMC

If the one who pays the energy bills and finances investment in energy efficiency is one and the same there are incentives to improve energy efficiency through investments, given the stated conditions. The maximum investment in scenario A is 1,000, at which energy savings (25 percent) offsets the capital cost. With the stated calculation assumptions energy efficiency investment is profitable for the landlord only if energy prices are expected to increase at a rate significantly higher than inflation. Hence, if scenario B would be describing reality, there could be a social gain if investment cost for energy efficiency measures could be shared.

Case II: IMC installation with and without prior energy efficiency investment

i) Going from inclusive rent to exclusive rent with IMC without improving energy efficiency

Under the given assumptions, all three of the scenarios have a positive welfare net effect. The landlord gains from installing IMC in the high energy price increase scenario but experiences a loss from the two other, whereas the tenant experiences gains and losses in the opposite cases.

In this example it can therefore be shown that installing IMC isn´t necessarily the obvious choice. Costs of installing and operating IMC also play a role in determining how attractive it is as a means of reducing energy (costs), which also has been put forward in commissioned reports (Boverket 2008) and policy recommendations. However, it is naïve to think that the landlord would introduce IMC facing a loss and not transfer (part of this) to the tenant. As was seen among the example contracts in section 2.3, there are even companies who have raised rents instead of reducing them when excluding the energy cost from the rent, motivating it precisely by the installation cost.

However, it can also be seen in this case that the landlord has incentives for installing IMC when energy price increases are high, but in the other two cases the tenant has an incentive to split the gains from installing IMC with the landlord, in order to get at higher welfare. In other words, if negotiations between landlord and tenants could be arranged (for example stipulated in rent contracts) the result should be a social gain.

ii) Improving energy efficiency before going from inclusive to exclusive rent with IMC

In this example, the base scenario A induces a loss for the landlord but a net welfare increase. Scenario B implies a gain for both landlord and tenant and in the high risk scenario C the tenant experiences a gain but the overall effect is a net welfare loss. Interestingly, in the high energy price increase scenario, the welfare gain from improving energy efficiency and installing IMC would mean a higher welfare gain than the total welfare gain for only installing IMC (case IIi). The gain is distributed a little differently though, for the landlord it is higher (1,729) in the IMC only scenario than when doing both (729). Again, there are good conditions for improving energy efficiency, installing IMC and split the surplus after compensating the landlord for the loss, and this should be acted upon if only the possibility to negotiate exists.

Case III: Installing IMC before improving energy efficiency

In this case, where IMC was installed first, the landlord can choose to further improve energy efficiency, the landlord will always loose. The investment in energy efficiency is nothing but increased costs to her, none of the energy savings will add a positive value to her calculation. The tenant on the other hand experiences welfare increase under all of the three circumstances, the most when energy prices are increasing faster than inflation (scenario B). The tenant clearly has an incentive for more energy efficiency measures to be carried out. In scenario B the welfare gain is also large enough to make the total welfare effect positive, a net gain of 183. If this gain could be split between the tenant and the landlord, i.e. first by compensating the landlord for the loss and then sharing the surplus, there would be incentives to improve energy efficiency even if the landlord in the starting-point only loses from the investment.

7 Conclusions

Following the last years' increased interest in reducing energy consumption, IMC has been brought forward as an easy and effective means of achieving this. However, just as inclusive rents reduce tenants' incentives to use energy economically, IMC reduces the landlord's incentives to improve the building performance.

This paper has described the split incentives problem related to IMC and showed through simulations that actions for saving energy that are socially profitable may be neglected if the responsibility for the investment lies on someone different from who reaps the benefits of the improvements. Hence, once again it can be established that split incentives may hinder improvements in energy efficiency.

However, given that the example figures are accepted as fairly realistic it was also shown that it should be hard to find energy efficiency measures that actually are profitable, considering how low the maximum energy efficiency investment cost was.

Disregarding this and returning to the basic conditions – a measure should be carried out if total energy cost savings exceed investment cost for an energy efficiency measure, and if total welfare gain is possible to achieve it should also be possible to split this net gain between the actors involved. When transiting from inclusive rent to exclusive rent with IMC this should be considered and rental contracts should be designed accordingly – in a way that gives both landlord and tenant incentives to save energy and thereby costs.

It also has to be recognized that simultaneously introducing these two types of measures alters the calculation conditions. For example, since the profitability of energy efficiency measures is calculated based on the savings in energy that will be made, energy consumption reductions following IMC will make potential savings smaller and thus fewer measures profitable. For that reason it is important that both IMC and energy efficiency measures are considered simultaneously so that the landlord does not over-invest

So far in Sweden the more commonly used IMC is for hot water, which is seen as fairly easy to measure and distribute correctly to the tenants. IMC of heating is still rather unusual since the technical problems connected to the measuring systems are making a fair and correct measuring and distribution hard. However, the techniques are likely to improve which may make it more common to install IMC also for heating in the future. If heating IMC spreads and results in reduced energy consumption, this level is what calculations of potential savings from energy efficiency measures should be based on. Energy should be saved until the marginal cost of reducing energy consumption equals the marginal gain from the reduction. Basing calculations on the higher pre-IMC level would lead to overinvestment and too big energy saving investments from society´s point of view.

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Appendix A

Table A1 Clause conditions as described in Bohman (1995)

Type of contract	Energy cost included in ground rent	Final rent (tenant perspective) according to clause depends on:		Incentives for savings
		Size of energy consumption	Variations in energy prices	
Inclusive rent	Yes	No	No	Landlord
Semi-inclusive rent "Inclusive clause" ("normal" consumption based on average energy prices, included in rent; markup varying with price increases)	Partly	No	Yes	Landlord
Semi-inclusive rent "Additional cost clause" (some consumption included in rent; markup varying with price *and* actual consumption)	Partly	Yes	Yes	Landlord and tenant
Exclusive rent	No	Yes	Yes	Tenant

Contract principles in the five example contracts

1. Completely cost adapted price setting *for heating* and *hot water*, where a standardized consumption is based on the actual consumption at zero price. Consumption equal to the standardized consumption renders total costs equal to the inclusive rent, whereas deviations from the standardized consumption are charged/compensated for in retrospect. Variable price calculated as the average cost per cubic meter/kWh. Fixed costs are also charged, included in the base rent based on apartment size.

2. Same principle as above for *electricity* and *hot water* but price is here calculated through negotiations by landlord and tenant (the SUT). Landlord has the right to initiate new price negotiations if actual prices change more than 10 percent from negotiated prices.

3. A) IMC for *water*, details are unclear; stated but not motivated/explained price for water.

   B) IMC for *water*, details are unclear; stated but not motivated/ explained reduction of rents.

4. Partially cost adapted price setting for *heating*. A specified indoor temperature given by the landlord is included in the rent. Tenants are allowed to vary temperature within an interval, and each deviating degree is charged/compensated at a pre-specified cost per square meter. Rent is raised monthly or per square meter to compensate for installation of IMC equipment. Both parties agree to evaluate the deal and adapt parameters if necessary.

5. Completely cost adapted price setting for *electricity* and *hot water*, charged directly by the electricity/energy company. Rent reductions are negotiated by landlord and tenant (the SUT) and for electricity reductions include fixed costs.