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ENERGY EFFICIENCY IN NON-RESIDENTIAL BUILDINGS

Motivation, Barriers and Strategies

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Preface

This paper is handed in as the final thesis for my master's degree in industrial ecology. The work is conducted at the Industrial Ecology Programme and the Department of Energy and Process Engineering at the Norwegian University of Science and Technology.

Academic supervisor has been Edgar Hertwich and his help is acknowledged. Inspiration, tips and comments from Harald Gether and Pål Næsje are also gratefully acknowledged. The information I have received for my case study has been essential, and all those who have contributed as informants, or through helping me establish contact with informants deserve thanks. Proofreading from Karen N. Byrhagen, Renate Haldsrud and Kjersti P.R. Øyen has been appreciated.

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Summary

In the thesis, causes of the energy efficiency gap, i.e. that seemingly attractive investments in energy efficiency are systematically passed over are explored, and policy instruments and business strategies that can be used to overcome this inefficiency are discussed. The economic literature of the efficiency gap focuses either on factors that are not included in the calculations of the gap, and that may explain why observed behaviour is actually efficient, or market failures that justifies policy intervention. In response to the economic literature, organizational and behavioural approaches have arisen, focusing on factors that preclude some of the assumptions made in economic theory.

A case study of four organizations has been carried out, investigating the decision processes, investment rules and motivation for energy efficiency measures. The main results are that all the organizations work systematically with energy observation and improving practices, while larger investments seem to be less prioritized. The building managers seem to cope with uncertainty by being conservative. Direct economic profitability is considered sufficient motivation for implementing energy-efficiency measures, while at the same time, the choice of investment objects is guided by strategic targets or general desirability. Capital-rationing occurs, but this competition among profitable projects is not considered a problem in the organizations. There is also some evidence of lack of incentives for energy conservation among occupants. A possible connection between emphasis on environmental results centrally in the organization and improvement in energy efficiency is established, and there are some indications that the start-up of an energy program depends on individuals.

The discussion of strategies to increase implementation of energy efficiency measures focuses on how to allow for technological change, and particularly diffusion of technologies. In this regard, looking for positive feed-back loops is important. A combination of market-based and behavioural instruments seems appropriate. Three specific strategies are explored: energy contracting, energy certificates and start-up help for arranging goals and routines for improvement.

Sammendrag

I denne oppgaven blir årsakene til at tilsynelatende attraktive investeringer i energieffektivitet systematisk blir latt være å gjennomføre, undersøkt. Videre blir mulige offentlige virkemidler og næringsstrategier for å bli kvitt dette effektivitetstapet diskutert. Den økonomiske litteraturen fokuserer enten på faktorer som ikke er inkludert i beregningene av hva som er lønnsomt, og som kan forklare hvorfor den atferden som observeres faktisk er optimal, eller på markedssvikt som kan gi grunn til offentlig inngripen i markedet. Som motsvar til den økonomiske teorien har det dukket opp studier som fokuserer på organisasjonsmessige og atferdsmessige faktorer, og som viser at faktisk atferd ikke nødvendigvis er i samsvar med de forutsetningene som ligger til grunn for økonomiske analyser.

Det er blitt gjennomført en case-studie av fire organisasjoner, hvor beslutningsprosesser, investeringsregler og motivasjon for energieffektiviserende tiltak er undersøkt. Hovedresultatene er at alle organisasjonene arbeider systematisk med energiobservasjon og forbedring av rutiner, mens tyngre investeringer virker å være mindre interessant. Det virker som eiendomsforvalterne forholder seg til usikkerhet ved å opptre konservativt. Direkte økonomisk profitt blir ansett som tilstrekkelig motivasjon for energieffektiviserende tiltak, men samtidig blir valget av investeringsobjekter bestemt av strategiske mål i organisasjonen eller generelle ideer om hva som er ønskelig. Alle lønnsomme investeringer kan ikke gjennomføres, men denne konkurransen mellom lønnsomme prosjekt anses ikke som et problem. Det er blitt observert manglende insentiver til energiøkonomisering blant brukere av bygningene. Det er blitt etablert en mulig sammenheng mellom fokus på miljømessige resultater sentralt i organisasjonen og forbedring av energibruken. Det er også visse indikasjoner på at oppstartsfasen i et energiprogram er individavhengig.

I diskusjonen av strategier for å øke gjennomføringen av energieffektiviserende tiltak blir det fokusert på hvordan å legge til rette for teknologisk endring, og spesielt for diffusjon av teknologi. I denne sammenheng er det å se etter positive tilbakekoblinger sentralt. En kombinasjon av markedsbaserte og atferdsbaserte virkemidler virker å være hensiktsmessig. Tre spesifikke strategier er blitt vurdert: energiytelseskontrakter, energisertifisering og oppstartshjelp for å etablere mål og rutiner.

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1 Introduction

Why do not organizations invest more in energy efficiency in their buildings? And what strategies can be used to make them do so? These are the main questions of this thesis.

1.1 Background

Consumption of electricity is presently increasing more rapidly than production. The import of electricity is increasing, and if current trends continue, we will approach the capacity for import in a ten year perspective. Because Norwegian electricity production consists almost exclusively of hydropower, the production is vulnerable to variation in precipitation. In this situation, a hydrological dry year will mean that import is not sufficient to cover the domestic under-balance, and consumption has to be reduced, possibly by disconnection (NVE 2002, NVE 2005).

Environmental concerns imply that increasing the energy production is not unproblematic. The potential for increasing the hydropower production is rather small due to the desire to protect unspoilt waters. Nature conservation is also used as an argument against other renewables, most relevant wind power. The use of fossil fuels has to be reduced to limit climate change. This gives reason to explore whether energy conservation can be part of the solution of how to achieve a sound energy balance. The national political goal with respect to energy conservation is to "limit the energy consumption considerably more than if it was left to itself" (St.meld. nr. 29 1998-99). This goal is part of the commission of Envoa which is a state enterprise working to promote energy conservation and new renewables.

Economic studies suggest that in many cases increasing energy efficiency can be economically profitable at today's price level. Not carrying through profitable projects inflicts an efficiency loss on the economy. In addition, the costs of new energy production will generally be higher than for existing production. At the same time, energy demand depends on long-living infrastructure, for example building styles. Changing this infrastructure takes time, and to avoid large efficiency losses and problems with the electricity balance in the future, these factors should be accounted for already today.

The possible problems of the electricity balance, the environmental consequences of the energy production and energy use, and the possibilities for economic gains constitute a strong argument to examine the possibilities of increased energy conservation. Hollander and Schneider (1996: 284) put it this way:

> "Clearly two major forces – economics and environmentalism – point towards energy efficiency as a desirable social objective. Efficiency can give society an inexpensive lunch (if not the proverbial free lunch) provided it results from technological advances that produce more goods and services with fewer inputs, lowering both the economic costs and the environmental impacts."
>
> Hollander and Schneider (1996: 284)

The energy use for operating Norwegian buildings is approximately 82 TWh, constituting 38 % of the total energy use (the energy sectors not included) (Enova 2006). Technically it is possible to reduce energy use in new constructions with a factor 3-4 per m^2 compared to today's practice (GRIP 2000). In existing buildings, the potential for improvements is less, but still substantial. Energy conservation in buildings therefore could constitute a considerable improvement of the energy situation.

1.2 Goal and scope

The aim of this project is to understand the causes that profitable energy conservation measures are not carried through, in order to be able to suggest policies and business strategies to overcome the problem. From the background material presented above, it is possible to argue that the energy conservation goal should be higher than just realising profitable projects. This would include making more projects profitable to the building owners, or alternatively forcing the building owners to implement more energy efficiency measures than are optimal for them. Not denying the relevance of this argument, I will not pursue this issue. I have limited the project to be about non-residential buildings, both public and private, but only existing structures. I focus on decision processes and motivation in organizations administering large masses of buildings. I focus particularly on the role of the building managers. Suppliers of energy conservation technologies are of course important, but to make the workload manageable, I have limited focus to concern the demand side of energy efficiency.

1.3 Outline of the thesis

To achieve understanding of what the efficiency gap is and what causes it, I start with presenting different theoretical approaches and previous empirical findings in chapter 2. The set subject states that the analysis should include an empirical study with the aim to identify and quantify the efficiency gap. Within the time span of the project it would not be possible to gather quantitative data. Therefore, the original plan was to calculate the efficiency gap for a few buildings in a case study. This would not allow for statistical estimation of the gap at the macro level. However, finding that estimations of the efficiency gap were available, I have chosen to present and comment on these calculations conducted by others. The quantification of the efficiency gap is presented in chapter 3. Based on the theory, I develop hypotheses regarding the causes of the energy paradox. These hypotheses and the methodology used to investigate them are presented in chapter 4. To understand the causes of the gap, I use a micro-level perspective, focusing on motivation and barriers from the individual building owner or administrator’s point of view. A case study of four organizations has been carried out, and the data from this study is presented in chapter 5. The data are analysed in chapter 6.

Because both the problem and the opportunities are most pronounced at the macro level, when it comes to discussing strategies to overcome the gap I change perspective and consider how external actors that may take a bird’s-eye view may approach the situation. Based on theory on innovation and policy design, together with the results from the case study, I derive general requirements for the preferred strategies in chapter 7. In chapter 8 I develop specific ideas for such strategies. Last, the application and limitations of the work are assessed, and conclusions are drawn in chapter 9.

2 Theory

In this chapter I first present the concepts of the energy paradox, energy efficiency and the efficiency gap. I then present the causes and policy responses of the paradox as interpreted by different theoretical schools.

2.1 The energy paradox

There is considerable concern about what has been termed the energy paradox: the seeming anomaly that very attractive investments in energy-efficient capital are routinely passed over by investors (Hassett and Metcalf 1993). An often cited example of the paradox is a study of purchases of refrigerators conducted by Meier and Whittier (1983). In this study, the sales figures of two refrigerators with identical consumer features, but different electricity consumption and price were compared. The extra cost of the more efficient model was compared with its lower operating costs to compute a rate of return on the investment. For example, if the more energy efficient model is NOK 1000 more expensive and the operating costs are NOK 200 lower for the next ten years, then the present value of the investment is: $PV = \sum_{t=1}^{10} \frac{200}{(1+r)^t} - 1000$

In this case, the present value is zero if the discount rate, r = 0,15. Because an investment is profitable if the present value is larger than zero, purchase of the less efficient model implies an implicit discount rate exceeding this rate of return. Meier and Whittier found that two-fifths of the consumers acted as though they had real discount rates larger than 60 % and another fifth between 35 and 60 %. For comparison the real rates of return prevailing in the capital markets are typically 4-12 % (Koomey and Sanstad 1994).

The energy paradox has been pointed to for a list of energy efficient technologies, for example compact fluorescent light bulbs, TV standby power, energy efficient appliances and improved thermal insulation materials (Jaffe and Stavins 1994a, Koomey and Sanstad 1994). The difference between the optimal and the actual level of energy efficiency has been termed the efficiency gap. A further discussion of the term requires an understanding of the concept of energy efficiency.

2.2 Energy efficiency

As we shall see, engineers and economists disagree on the size of the efficiency gap. This disagreement comes from different interpretations of the term energy efficiency. The engineering or technical perspective is based on the laws of thermodynamics and focuses on preserving the quality of the energy. Efficiency is defined as the minimum energy expenditure to perform a task relative to the actual energy consumed. The goal of energy conservation is then to accomplish the same task with the lowest possible amount of energy input (Shama 1983).

The economic perspective is based on profit maximization, or for a given production volume, cost minimization (Sanstad and Howarth 1994). Obviously, people do not demand energy per se, but rather the services it can provide. In other words, energy is regarded as an input to some other production. Economic efficiency is to accomplish the same task with the least costly combination of inputs. Economists normally assume decreasing marginal productivity of each input and substitution possibilities between inputs. The optimal level of energy efficiency is achieved when the marginal product of energy relative to the energy price is equal to the marginal product of other inputs relative to their prices.

The economically optimal level of energy efficiency is normally lower than, and never larger than, the technically optimal level. When a task is performed with the lowest possible input of energy, it is normally possible to substitute other inputs for energy and thereby reducing costs for a given production volume.

Following Shama (1983), I use a definition of energy efficiency in which the engineering and the economic perspectives are combined. Increasing energy efficiency is using less energy for a given task, by substitution when technical and capital improvements are possible, up to the economically optimal level. The act of increasing energy efficiency, i.e. to save money and energy without affecting comfort and convenience, is termed energy conservation. In contrast, energy saving is reducing energy use by lowering performance, an option which is not discussed in this thesis.

2.3 The efficiency gap

The term "efficiency gap" refers to the difference between the actual level of investment in energy efficiency and the higher level that would be cost-beneficial from the consumer's (i.e. the individual's or firm's) point of view (Brown 2001).

In the economic literature, the factors that account for the gap are called market barriers (Jaffe and Stavins 1994a). The market barriers are normally divided into market failures and non-market failures, a distinction that is important in the discussion of whether policy intervention is justified or not. The concept of a perfect market rests on a number of assumptions such as perfect competition, perfect information, no externalities, no transaction costs or entry barriers and economically rational actors (Koomey 1990). In reality these assumptions are never completely fulfilled. Market failures are conditions of a market that violate one or more of the neoclassical economic assumptions defining an ideal market (Brown 2001). A long list of market failures have been proposed as possible explanations of the efficiency gap. Market failures may occur, leading to inefficient markets and justifying policy intervention. On this background, the discussion of the efficiency gap concerns whether there are market failures in the market for energy efficiency or not. Non-market failure explanations of the energy paradox consist essentially of explaining why observed behaviour is indeed rational from the consumers' point of view. Unobserved costs and irreversibility are central aspects of this approach.

The difference between the engineering and the economic understanding of the efficiency gap, is that using the engineering approach, all barriers should be removed to achieve the least possible use of energy, while using the economic approach implies that only the market-barriers should be removed. In Figure 2-1, which shows different notions of the efficiency gap, removing those barriers that inhibit the market from achieving the correct equilibrium, releases the economist's economic potential. Removing in addition the barriers that are not market failures releases the technologist's economic potential. This level may still be below the hypothetical potential because both the economist's and the technologist's economic potential relates to actual energy prices. If the true cost of energy is higher, the potential is larger than the technologist's economic potential. The narrow social optimum is essentially the same as the economist's economic potential, only in this case, the costs of policy interventions to remove the market failures are included. If the cost of removing some market failures is higher than the benefit from removing them, it is optimal to refrain from these interventions. The figure also includes a true social optimum. This notion takes into account environmental externalities related to production and consumption of energy. Such externalities are arguments for increased energy efficiency, that are not related to the energy paradox.

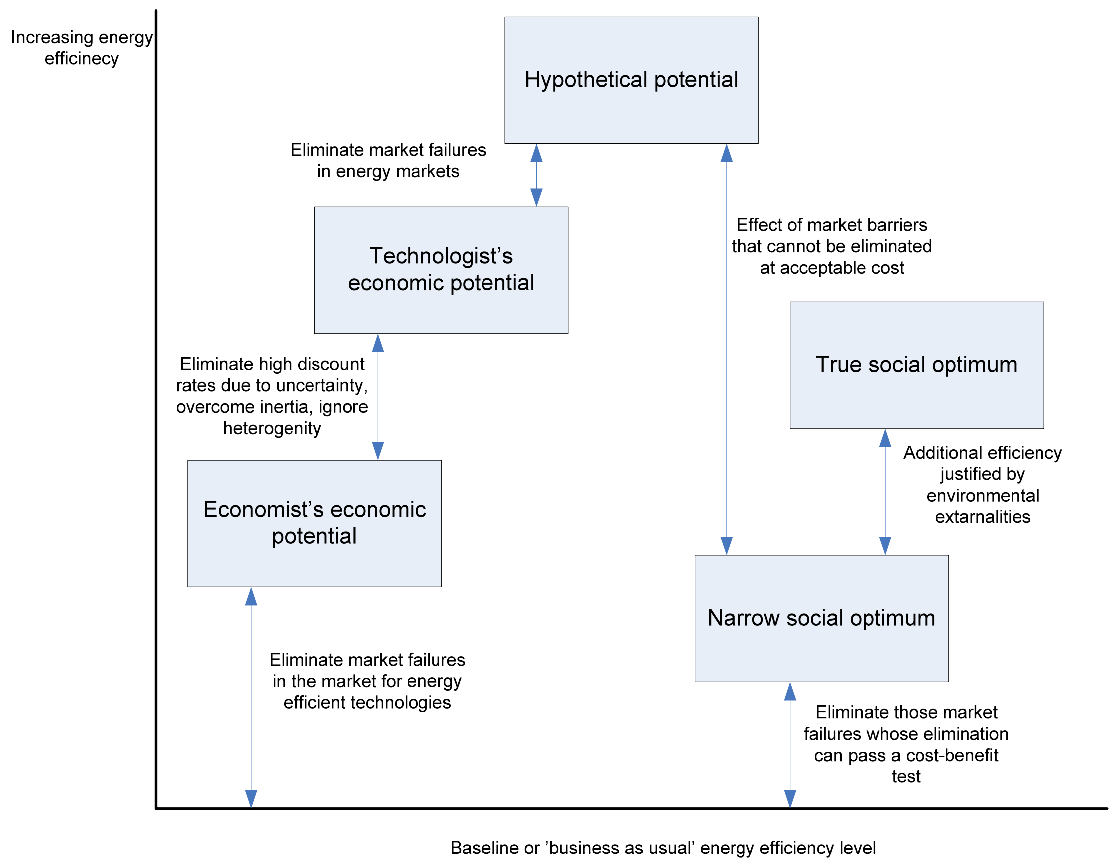

Figure 2-1: Different notions of the efficiency gap (Jaffe and Stavins 1994a).

The difference between the economist's and the technologist's notion of the efficiency gap coincides with the difference between the top-down and the bottom-up approach. Bottom-up analysts argue that a certain number of investments in energy efficiency is technically possible, a part of which is profitable (Koopmans and te Velde 2001). This approach relies heavily on cost and performance characteristics of specific technologies, and recognizes that many decision makers might behave suboptimally. In contrast, the top-down approach, favoured by many economists, focuses on general market forces

(Huntington 1994). A part of this movement seeks to explain why seemingly irrational behaviour is indeed rational from the decision maker's point of view. This approach is given attention in chapters 2.5.1 and 2.5.2 below.

2.4 Theoretical notions

Above I presented different notions of the size of the efficiency gap. However, the existence of a gap is not accepted by all researchers and there is considerable discussion on the causes of the energy paradox. A distinction between four theoretical approaches is helpful for following the arguments, although most empirical research includes elements from several approaches.

In neoclassical economic theory, the equilibrium that a perfect market will yield is in accordance with the efficient situation. Firms purchase energy efficiency as long as the marginal benefit of conservation exceeds the marginal cost. Thus, almost by definition the efficient amount of conservation measures is implemented (Kulakowski 1999). Neoclassical economists are the ones who most often deny the efficiency gap arguing that there are some unobserved aspects that make the consumers behaviour rational. The existence of market failures is recognized, but only in a few well-defined cases, such as environmental externalities, public goods or imperfect markets.

As neoclassical economics has been widely criticised, economic researchers have tried to develop more realistic models. The neo-institutional economic approach retains the core elements of neoclassical economics, such as rational choice and equilibriums of markets, but it also stresses heavily barriers such as information and transaction costs (Kulakowski 1999).

By assuming rational actors and optimizing behaviour, the economic literature is sometimes criticised for not capturing essential features of how individuals and organizations act. The organizational approach focuses on the firm as a body composed of several sub-units. These units may have different goals, views, attitudes, interests and constraints. The sub-division of the firm often intrudes incentives, and because of this, investments may be inefficiently large or small (Kulakowski 1999). Rather than maximizing profits, firms satisfice; they aim at producing enough profits to survive.

The behavioural approach focuses on individuals within institutions and how they act to fulfil their own values and needs in an organizational setting (Kulakowski 1999). Actions which do not seem rational from an external perspective may be understood from studying technical, personal, social and political circumstances in the organization.

2.5 Causes and proposed policy responses

The proposed causes of the energy paradox are numerous. In the first two parts of this section, I present arguments that essentially explain why the analyses used when finding an efficiency gap are imperfect, i.e. why there is no efficiency gap. I then present market failure explanations and contributions from organizational and behavioural approaches. The policy responses deduced from the respective approaches are also described.

2.5.1 The value of postponing decisions

An attempt to explain why the consumer's behaviour is indeed rational, involves calculation of options. High discount rates are found from simple cost-benefit calculations saying that it is optimal to invest if the energy savings exceed the annualized costs of the investment. However, since the energy price varies, the future benefit is uncertain. In a cost-benefit analysis one assumes a probability distribution for the future energy prices. The expected future savings are the savings that arise from the average of the distribution. When uncertainty is low, this assumption may work well, but when uncertainty is high, the probability distribution is wide and the difference between the lowest and the highest probable price may significantly affect the outcome of the cost-benefit calculation.

Uncertainty in energy prices can be modelled through the concept of random walks (see for example Metcalf 1994). The energy price in one period is assumed to be equal to the energy price in the previous period plus (or minus) a stochastic element. While the cost-benefit analysis simply calculates from the above the average savings, the options based analysis includes the possibility of delaying the decision. If, at the present, there is large uncertainty whether the investment will be profitable or not, waiting one period may decrease the uncertainty: if the price increases, the probability distribution moves upwards, while if the price decreases, the probability distribution moves downwards. In other words, if the price next year is lower than this year, the probability that the average future price will be lower than the price this year, increases. It may therefore be optimal to delay the decision. To modify the decision rule from cost-benefit analysis, an additional cost of killing the option is included. This means that it is not the consumer's discount rate that is high, but the cost of investing that is higher than normally calculated.

The options theory builds on the insight that investments have some sunk costs: once the investment is done, there is no possibility of undoing it. On the contrary, if you decide not to invest in the present, you may still have the possibility to do the investment in the future. In other words, prior to making the investment, the investor holds an option not to invest, but this option is lost when the investment is done. The option is more valuable the more uncertain future energy costs are (Hassett and Metcalf 1993).

In a study of alternative heat sources for Norwegian buildings, Grandal Lånke (2005) has compared net present value and real option values for seven projects. The study reveals discrepancies between the two measures of profitability. In two of the cases net present value is positive while the option calculations show that it is optimal to postpone investments.

2.5.2 Other non-market failure arguments

In general, non-market failure proponents argue that if the observed rate of diffusion of a technology is less than the calculated optimal rate, there must be some unobserved adoption costs that would modify our calculations of what is optimal. For example there may be qualitative differences between new and existing technologies that make the new technology relatively less attractive. In addition, there typically are adoption costs in addition to the monetary costs. These are not necessarily market failures, but are nevertheless not accounted for in traditional present value calculations. Finally, calculations are often based on the average user, but while the technology in question may be cost-effective on the average, there will still be some individuals or some firms to whom it is not profitable (Jaffe and Stavins 1994a, Koomey 1990).

Arguing along the same lines, Sutherland (1991) found that investments in energy efficiency required high rates of return because they were illiquid and it was not possible to diversify away the risk. The decision rules were the same as for other investments. He concluded that the only market failures that justified government support of conservation policies were external costs of energy production and consumption, and the lack of aggregate insurance against risk.

Researchers that do not find any efficiency gap, conclude that no policy is necessary. Actually, regulating a market that works properly, is not only a waste of resources, but distorts the market and makes it inefficient. Among those most critical to the efficiency gap is Sutherland (1991) who finds that a correct energy price would provide adequate incentive to invest in the optimum level of energy efficiency. If we keep to efficiency given the prevailing prices, no action would be needed.

2.5.3 Market failures

A number of market failures have been proposed as explanations of the efficiency gap. *Imperfect information* is a term that covers a number of market failures. In its' simplest form, this is a matter of lack of information. Koomey (1990) asserts that lack of current and credible information on the latest and most cost-effective conservation technologies is one of the most important obstacles that designers and builders face. Sometimes there may also be a case of misinformation; some developers and tenants believe that there is little scope for improving energy efficiency.

When parties to a transaction have access to different levels of information, we have a case of asymmetric information. Producers of energy efficient equipment will in general be better informed about the characteristics and performance of the equipment than prospective buyers (Sanstad and Howarth 1994). Similarly, developers know more about a building than do prospective tenants or buyers. Tenants and buyers are therefore at a disadvantage in negotiations, and they must either take the developer's word that the building is energy efficient, which means added risk, or they must hire someone to analyze the building, which means added cost (Koomey 1990). Energy labelling is an attempt to make up for imperfect information.

Lack of information and misinformation is often linked to information costs. These are costs of collecting information about technologies or the credibility and reliability of new suppliers and subcontractors, of calculating the costs and benefits of different efficiency levels and of passing this information on to prospective tenants or purchasers (Koomey 1990). Information costs are special forms of *transaction costs*. Sanstad and Howarth (1994) argues that transaction costs often are misinterpreted as "hidden costs", a concept that implies that there may not be an efficiency gap after all because the real cost of the investment is larger than the price. Incorporating hidden costs may cause the savings from increased energy efficiency to disappear. However, only costs that are private and indivisible should be interpreted as hidden costs. Many of the transaction costs, for example parts of the information costs, are both public and divisible and could be overcome by policy interventions.

Connected to imperfect information and transaction costs is the problem of *bounded rationality and satisficing*. Because we can only process limited amounts of information, we often compensate by acting by rules of thumb. In contrast to finding the optimal solution, this confines to finding a satisfactory solution (Koomey 1990). Satisficing behaviour may approximate the optimal outcome when change is slow, but during rapid change, as is the situation with energy efficiency technologies, rules of thumb may not keep pace and large disparities may develop between optimality and decisions actually made. For the actors in the building market, energy costs may constitute a small fraction of the total costs. Under such conditions satisficing behaviour is common. Moreover, in the real estate industry there is often a preference for revenue-enhancing measures over cost-reduction measures to increase profits (Koomey 1990).

In a case study of two large American organizations, Kulakowski (1999) found that energy-efficiency retrofit projects had a different capital budgeting request procedure and faced a higher hurdle rate than capital improvement projects of comparable risk. In one organization, building energy retrofits were treated as expenses rather than capital projects. In the other organization, energy retrofit projects were treated as capital projects, but had to go through a stricter funding procedure than other building improvements. She also found that managers rely on simple measures, such as payback period, to make their decisions. Morch and Gjøen (2001) found that for office and industrial buildings, investments should be repaid within 2-3 years. Investments with a payback period of more than 4 years were less prioritized. One of the participants in the study revealed that much longer payback periods could be accepted for investments in production facilities.

Misplaced incentives occur when an agent has the authority to act on behalf of a consumer, but does not fully reflect the consumer’s best interest (Brown 2001). This is often called a principal-agent problem. When there are tenants, the owner often does not want to invest in energy efficiency because the cost of energy applies to the tenants, while the tenants may want to reduce their energy bills, but do not have the possibility to invest. Morch and Gjøen (2001) collected data from 28 enterprises in Oslo and found significant differences between owner occupied buildings and buildings with tenants. In the sample all the enterprises that were owner occupied wanted to implement energy efficiency measures, while 35 % of the enterprises that had tenants did not want to take measures. They also found that when there were short contracts, even the tenants might not be interested in the investment because they did not know whether they would still use the building in a year. In addition short contracts complicated the planning for building owners because the situation was unpredictable. Planning was particularly hard when it needed to be coordinated with several tenants. Kulakowski (1999) found some evidence that split incentives affected decisions in a negative way when the groups who received the benefits of energy cost reduction were financially separated from those who bore the cost of the investment.

Public regulations define the bounds within which the market is constrained to operate. When these bounds inhibit efficient outcomes, we speak of *regulatory distortions*. Examples may be obsolete building codes that inhibit innovation and cost-effective conservation, subsidies for established energy technologies or taxes that shift the relative prices of energy and energy saving (Koomey 1990). Electricity prices are often set equal to average rather than marginal costs. This means that the price is too low, and the consumption too high at peak times, while the opposite situation occurs at off-peak periods (Koomey 1990, Brown 2001).

Risk aversion is another problem. Trying out new energy saving technology involves some risk; that the technology does not work as advertised, that energy prices does not rise as expected or that the real estate market becomes depressed which may make potential buyers more wary of increased initial cost. For the society as a whole, the profit from the successful investments will cover the costs of the unsuccessful investments and in total the result will be a positive economic return. However, the risk for the individual economic actor may be greater than the aggregate risk and investments may therefore be lower than optimal (Koomey 1990). In the construction industry, adopting new technologies or changing suppliers entails risk of delay.

Imperfections in capital markets may inhibit market efficiency. Efficient allocation of resources requires all actors to have uniform access to financial capital at the same rate of interest. This is not the case, as energy suppliers normally can obtain capital at lower interest rates than can the consumers, and low-income households must pay more to obtain credit than must high-income households (Brown 2001, Sanstad and Howarth 1994). These interest rate gaps inhibit efficiency because the most efficient projects are not necessarily carried through. Theoretically a reallocation of the investments could release more efficient projects at the same cost.

As mentioned above, externalities cannot explain why consumers do not invest in energy efficiency that is profitable with current prices, but when taking society's view of energy efficiency into account, discussing externalities is inevitable. In the presence of negative externalities there will be some *unpriced costs*. An obvious example is the environmental impacts of extraction, production and distribution of power. This implies that the market price of power is lower than the real costs to society, and this lower price disfavours investment in energy conservation. There may also be cases of *unpriced goods*. Typically, knowledge, competence and R&D have an aspect of public goods; investment in these goods benefits not only the firm that invests, but also competitors and other firms. The extent of such investment is therefore often too low. The fragmentation of the building and construction industry, where design and engineering of buildings is split between many small firms, makes this problem particularly pronounced (Brown 2001).

Those who find that market failures cause the efficiency gap, argue that information problems should be met by public institutions gathering and distributing information (DeCanio 1993), negative externalities should be internalized by taxes, incentives should be improved by making consumers pay for what they actually use etc. Howarth and Sanstad (1995) argues that direct regulation of equipment standards may be required and may side-step problems of asymmetric information, transaction costs and bounded rationality because consumers are not forced to make unguided choices between alternative technologies.

2.5.4 Organizational barriers

Ross (1986) found that underinvestment in energy efficiency can arise from the capital budgeting practices of firms. For large projects, the firms studied used discounted cash flow methods, often including sensitivity analyses as a basis for investment decisions. For smaller projects, however, many firms had an essentially fixed sum for which many projects competed. In this case the actual hurdle rates were very high (35-60 %), and investment was considerably lower than what would be justified by conventional analysis. The different results for large and small projects came from different decision practices. While large projects were considered centrally in the organization, smaller projects were considered at division or plant level. The information and decision costs were relatively higher for small projects.

Ross' study also revealed that cost-cutting investments were mostly financed by the firms' earnings, and that the earnings rarely would be sufficient to allow implementation of all profitable projects. Moreover, it would be potentially damaging for the firms to attempt to raise large loans, independent of the profitability of the investments. Competition among profitable projects therefore seems hard to avoid, but Ross underlines that capital-rationing is not a rational way of focusing investment on the most profitable investments, because less profitable large projects that goes through another decision process are still carried through.

The decision making process and the way institutions are organized, is also studied by Cebon (1992). Cebon focuses on the acquisition and analysis of information. Decisions depend on technical information on potential solutions, contextual information on space use, characteristics of the building and the equipment etc, and connected information which comes from people joined institutionally or geographically to the sites of the project. Cebon finds that decentralization of decisions increases incentives to act and the availability of contextual information, but decreases skills and access to technical information. This is constraining because any structural change that increases an organization's capability in one domain, penalizes it in another.

Morch and Gjøen (2001) found that enterprises with a flat organization and a decentralized decision-making process require large profit and quick repayment, but they can relatively easy and quickly fix the financing. In contrast, enterprises with a hierarchical organization and a centralized decision-making process are more focused on the financing while profit and repayment period is less important. Decisions concerning financing may take long, and they often need to be related to a new budget period. This applies to most public institutions, but also to private companies where decisions are taken centrally.

Cebon argues that policies should be based not only on economic and engineering arguments, but also on organizational considerations. Policies should therefore aim to match technologies to the organizations they penetrate. This can be done by selecting technologies that fit existing organizations, or when needed, reconfiguring technologies to fit organizations. Alternatively, the opposite approach could be taken; to select organizations likely to be receptive to target technologies. A last option is to modify organizations so they can select the technology. Kulakowski (1999) proposes government-sponsored training on how to set up "energy management profit centers" to overcome structural barriers in organizational decision-making.

2.5.5 Behavioural barriers

A study of behavioural determinants of energy use has been conducted by Komor and Katzev (1988). They found that owners and managers of small commercial buildings were poorly informed about their energy use and energy costs, and that they (wrongly) believed that there was nothing they could do about their energy use or that reduced energy use would entail reduced comfort. Moreover, responsibility for energy-related decisions was diffuse and energy costs were considered unimportant because they were only a small fraction of gross sales.

Based on these results, Komor and Katzev concluded that common instruments to affect energy use do not work appropriately. For example, energy audits or specified bills are useless when many managers never even see the bill, or they notice only the total cost and throw away all other information. It is also commonly argued that individual metering would increase energy efficiency because users then pay for what they use.

However, the study compared routines in buildings that used both electricity and natural gas and were billed for actual electricity use, but paid a fixed sum for natural gas use, and found that the managers controlling energy use were equally careful with electricity and natural gas consumption.

Kulakowski (1999) found that improvements in for example lighting quality may be a just as important driver of energy-efficiency investments as are cost reductions. This finding is supported by the results of Aune and Morch (2001). In a case study of three enterprises they found that although the direct economic benefit of an investment was important, the main motivating factor might as well be better indoor climate or improved environmental profile. To understand why, or why not, an energy efficient investment is attractive, profitability therefore should be seen in a larger context that includes also the indirect benefits.

The importance of enthusiastic individuals should also be mentioned. At one of the organizations in Kulakowski's study, a manager created a separate fund for energy retrofits and allocated $1 million a year for this. By change of the person in charge, the money allocated to the fund was halved. Hagen et al. (2004) studied six enterprises which had received free energy efficiency consulting, but did not carry through any measures. This study focused on what had happened to the energy efficiency reports and where (if at all) the responsibility for energy efficiency is placed. They found that in some of the organizations there was no clear addressee for the report, or it was considered "another document to consider". Some of the organizations studied were characterized by the lack of a body responsible for energy efficiency. Organization and individual commitment was found important for the destiny of proposed energy efficiency measures.

Proponents of behavioural approaches conclude that when designing future energy conservation programs, it should be recognized that money is not the only determinant of behaviour. Although less well-defined, other factors need to be addressed to influence behaviour. In particular, possibilities of increasing the comfort and attractiveness of the building should be stressed. Moreover, Komor and Katzev (1988) stress the importance of timing interventions at relevant times, for example during planning of retrofits, and of targeting actual, rather than formal, decision makers. The organizational and behavioural approaches provide the insight that correcting market failures may not be sufficient because individuals and organizations do not always behave the way the economists assume.

3 Quantification of the efficiency potential

The standard method for calculating the efficiency potential is using net present value calculations. The net present value can be expressed as in the equation below, where S_t is the expected energy conservation at time t, P_t is the expected price of energy at time t, r is the discount rate and I_0 is the initial investment cost.

$$PV = \sum_{t=0}^{\infty} \frac{S_t * P_t}{(1+r)^t} - I_0$$

In a report by Energidata (1997) the energy efficiency potential of Norwegian buildings has been calculated from a random sample of 2000 dwellings and 300 commercial buildings. For all buildings, technically and economically feasible measures were identified. The buildings were divided into sectors and the efficiency potential of each sector was scaled up in accordance with the size of the sector. The result was a total energy efficiency potential of 14,2 TWh, of which 6,8 TWh was in non-residential buildings. Table 3-1 shows the efficiency potential and total energy use for categories of non-residential buildings. The table is based on 1995 numbers and the total energy use in non-residential buildings was calculated to 30 TWh.

Table 3-1: Energy efficiency potential by building category (1995) (Energidata 1997, NOU 1998:11).

Building category	Energy efficiency potential (TWh/ year)			Total energy use (TWh)	Percentage efficiency potential
	Electricity	Petroleum	Total		
Offices	1,6	0,4	2,0	15	26
Commodity trade	1,4	0,5	1,9		
Education, sport centers and culture buildings	0,7	0,3	1,0	5	20
Health	0,3	0,0	0,3	4	17,5
Hotels and restaurants	0,2	0,2	0,4		
Industrial buildings and warehouses	0,9	0,3	1,2	6	20
Total	5,1	1,7	6,8	30	22,7

There is of course large uncertainty in this kind of analysis, because it is based on a sample of buildings, because knowing exactly how large reduction in energy use an investment will induce is impossible, and because future prices are unknown.

The results above are based on an electricity price of 40,9 øre/kWh, an oil price of 24,9 øre/kWh (excluding VAT) and a discount rate of 7 %. A 25 % increase in energy prices would increase the potential to 7,6 TWh and a 50 % price increase would result in a potential of 8 TWh. A discount rate of 15 % would decrease the potential from 6,8 TWh to 6,0 TWh and a discount rate of 30 % would decrease the potential to 4,6 TWh. According to Energidata (1997) the efficiency potential does not seem to be reduced by time. Rather, as some projects are realized, other profitable projects emerge.

Enova (2006a) calculated the total energy use in 2001, and found that it was approximately 35 TWh. According to Enova (2006b) the energy efficiency potential in the total mass of Norwegian buildings is approximately 5 TWh within 10 years and 6-8 TWh within 20 years. In contrast to the estimates of Energidata, these estimates may include some considerations of what part of the profitable potential that realistically may be realized, so the two estimations are not necessarily contradictory.

For American buildings, there are estimates that give possible energy savings up to 45 % with technology available in the early 90s (Kulakowski 1999). More moderate estimates imply for example that a technical potential of 25 % reduction in energy use with no sacrifice of comfort or productivity is possible in US federal buildings (DeCanio 1993). Actual reductions in energy use from retrofits aimed at energy conservation seem to be lower. Several studies have found average reductions of approximately 15 % (Goldman et al. 1988, Cohen et al. 1991). The numbers are not directly comparable, but it is not unlikely that some profitable projects are not realized even in retrofits aimed at energy conservation.

Table 3-2: Energy efficiency potential by barriers (1995) (Energidata 1997)

Barrier	TWh	Percentage
To be realized within 1 year	0,1	2
Owner-tenant-problems	1,8	26
Lack of information/ knowledge	3,4	50
Profitability/ prioritizations	0,9	13
Financing	0,2	3
Other barriers	0,4	6
Total	6,8	100

When calculating the efficiency potential, Energidata also investigated the reasons that the potential was not realized. The results are presented in Table 3-2. Although presented in this tabular form, removal of one barrier does not necessarily release projects. Rather the table presents the immediate barrier while removing this barrier may reveal more barriers. For example, removing information problems, a project may still be held back by owner-tenant-structures and lack of finance capital

Assuming that the analysis of Energidata gives a good estimate, the profitable energy savings in non-residential buildings are in the same order of magnitude as the gas power plant planned at Tjeldbergodden, which is expected to deliver 7 TWh of electricity per year (NVE 2006). To give an idea of the economic potential of energy conservation, we can use the gas power plant for comparison. The expected investments in the power plant are of NOK 5,5 billion, including expansion of the methanol plant at Tjeldbergodden, but excluding investments in new line of force and switching stations (Statoil 2006). Theoretically, the earnings of the power plant and utilization of the efficiency potential in non-residential buildings should be the same (given that the electricity price is not affected), i.e. the energy price multiplied with the amount of energy produced or conserved. The implication is that if investment in the power plant is profitable, equally large investments in energy efficiency would also be profitable. The comparison is of course extremely simplified. It does not take into account different lifetimes of the investment objects or additional earnings that may arise in relation to the production or conservation of energy.

4 Research focus and methodology

The theory is ambiguous with respect to the existence of an efficiency gap and presents a variety of possible explanations for its potential existence. The findings presented in the previous chapter justify a further investigation of causes and possible responses to the inefficiency. In this chapter I first present hypotheses regarding the decision making, motivation and barriers in organizations, that may help explain the existence of the efficiency paradox. Then I present the methodology used to investigate the hypotheses and some information on the data material.

4.1 Hypotheses

The aim of the case study is to obtain understanding of the decision processes, the factors that motivate the building managers and the barriers to energy efficiency that causes the efficiency gap. Based on the theory presented in chapter 2 a large number of hypotheses could be formulated, but focusing mostly on decision making, investment rules and motivation, I have reduced the number of hypotheses to a manageable number. Hypotheses 1-3 below concern motivation and drivers for starting or implementing energy efficiency measures. Hypotheses 4-8 concern decision making and the foundations for investment decisions.

1. a) Direct economic profitability is sufficient as motivation for implementing energy efficiency measures, or

   b) factors other than direct economic profitability are equally or more important for motivation.
2. Personal commitment is necessary to initiate and implement energy efficiency measures.
3. If the costs and the benefits of energy efficiency apply to different actors, this reduces motivation.
4. a) Decisions on energy efficiency investments are made based on comprehensive analyses including calculations of net present value and considerations of uncertainty and risk, or

b) decisions are made based on a single parameter such as payback time, other limited analyses or rules of thumb.

5. a) Every project is compared to a general rule of profitability, or
   b) profitable projects compete on a fixed budget sum.
6. a) Cost-cutting investments in "peripheral" inputs are equally interesting as investment in production equipment, investments that increase income etc., or
   b) cost-cutting investments are less interesting than other investments.
7. Uncertainty regarding future energy prices makes it attractive to postpone decisions.
8. In organizations with decentralized decision making financing is easy, but quick repayment is required. In organizations with centralized decision making financing is complicated, but pay-back periods may be relatively long.

4.2 Methodology

To answer the hypotheses developed above require quite a lot of information on each of the organizations studied. The reasons for choosing a qualitative approach are both theoretical and pragmatic. Qualitative methodology is suited for exploratory studies and when we want to study something in depth. When previous research is not exhaustive, it is hard to pronounce exact research questions. The flexibility of qualitative methodology is therefore valuable. The researcher may be open to new perspectives introduced by the informants and follow up interesting points of view as they appear (Thagaard 2002). For this study, the starting point was one of which the field seemed quite unclear and it would be hard to be sure to catch the important features through a quantitative survey. Moreover, data for a sufficiently large number of buildings were not available and would have been unmanageable to gather within the scope of this work.

Focusing on organizations rather than individual decision makers, a case study may be suitable. According to Yin (1994: 13) a case study is "*an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident*". The study analyzes one or a few cases, of which a large amount of information is collected, normally from multiple sources. Prior theoretical propositions guide data collection and analysis. In other words, the case study is appropriate when we want to understand a phenomenon, an organization etc. in detail and when this phenomenon cannot be understood isolated from its context.

Because based on few cases, qualitative studies do not allow for statistical generalization. Rather, the goal is *analytic* generalization; to support or weaken previously developed theory (Yin 1994), but also to generalize to other cases based on detailed understanding of the most important factors explaining the object of research (Thagaard 2002). The aim is to understand something in depth, an understanding that may lead to improvements in theory and, if relevant, hypotheses that later may be explored through quantitative studies.

To assess the quality of an empirical study, we consider the reliability and the validity of the research. The interpretation of these terms is somewhat different in qualitative than in quantitative methodology (Thagaard 2002). Reliability implies that the research should inspire confidence. The researcher should account for the way data have been developed throughout the research process, and make clear distinctions between primary information from the fieldwork and assessments of this information. The way data have been developed is described in chapter 4.3 below. The primary information and assessments of this information are presented separately in chapters 5 and 6.

While reliability concerns the way data are developed, validity concerns the interpretation of the results. The researcher should critically discuss his or her interpretations and accentuate the conditions under which the results are valid. The validity is also increased if the results are confirmed when compared to other studies. The validity is sought ensured by the way the information is discussed in chapter 6 and in the conclusion chapter.

4.3 The data material

Because several of the hypotheses concern potential problems when decision making and implementation involves several actors, it was desirable to study large organizations. It was also desirable to have both cases that had implemented energy efficiency measures and cases that had not. This was based on the assumption that it would be easier to study motivation in organizations that had implemented energy efficiency measures, while studying barriers would be easier in organizations that had not. Studying both kinds of organizations would also give a possibility to reveal differences. Originally I also wanted to have energy efficiency analyses from all cases to be able to follow the process in a specific building. I assumed this would give specific information that would enable me to point out exactly how decisions where taken and where something potentially "went wrong". I planned to study only office buildings to keep the data material more homogenous.

Four organizations have been studied; two municipalities, a state enterprise and a private real estate company. They are all relatively large organizations with hierarchical structures that involve a central decision making body, a real estate section, other sub-units and occupants. The state enterprise has made investments that have led to large improvements in energy efficiency, while the other organizations have made only moderate improvements. My attempts to find case organizations that had energy efficiency analyses, but had not carried through the proposed measures failed, except for one case. However, the report in this case was fifteen years old and it proved impossible to find out what actually happened to the proposed measures. I therefore had to rely on cases for which it did not make sense to follow a process for a specific building. Rather I have been focusing on the general decision processes in the organizations. Focusing on the general processes rather than the specific buildings, it did no longer seem important to limit the study to office buildings. The kind of organizations I wanted to study, administered both office and other kinds of non-residential buildings, and the decision making and investment processes were the same.

To establish contact with informants I asked for tips. Organizations A and D were contacted after tips from Enova and organization B after tips from my supervisor. Contact with organization C was established through an energy efficiency consultant agency. The cases are of course not representative, but they are typical for their kind of organization in the sense that they do not differ systematically from other municipalities, real estate companies or state enterprises.

Most of the data have been developed from semi-structured interviews with building managers. The advantages of qualitative interviews are that the questions may be adjusted to the different informants and that there is a possibility of following up interesting information from the interviewees. Therefore, all the interviews were touching the same themes, but some questions were followed up more closely and some questions were left out in each interview according to how the interview developed. The interviews were mainly about decision making procedures, investment rules and motivation. Some questions regarding barriers and preferred public policies were also included. A general interview guide is presented in appendix 1.

There has only been one interview for each case. All the interviewees were the persons in the real estate section of the organization working with energy efficiency. In addition to the interviews some quantitative information has been used. This information I received from the interviewees, from an energy efficiency consultancy agency and the organizations' web pages. A list of the information used for each case is given in appendix 2.

As noted in the methodology part above, a case study should build on a large amount of data from different sources. The data collected is not as extensive and varied as would have been desirable. For many issues, I have only the interview data, i.e. only one information source from each organization. Because the views of the interviewees do not necessarily give a good picture of the organization as a whole, the information should be interpreted carefully. Some of the hypotheses concern issues that require mainly descriptive information. It is reasonable to assume that this information would look the same if I got it from another informant in the organization. I consider this to hold for hypotheses 4, 5, 7 and 8. For these hypotheses, the results apply to the organizations. For the other hypotheses, I consider the information used too dependent on the individuals interviewed to be able to generalize to the organizations. In stead, the results are interpreted as implications based on the building managers view.

5 Description of the cases

In this chapter the empirical data is presented. I have emphasized presenting the information from the interviews as objective as possible. All assessments of the information are coming in chapter 6.

5.1 Case A: small municipality

The municipality owns approximately 50.000 m^2 of building area, dwellings for rent not included. The buildings are administered by the division for real estate. The following section describes the way energy efficiency is treated in the municipality, exemplified by an administration building for the purpose of specific investment analyses.

5.1.1 Decision process

The division for real estate is responsible for energy efficiency in the municipal buildings. Every year the energy use in each building is compared to a standard (Norsk Standard 3032)[1]. This serves as the starting point for potential energy efficiency measures. For buildings with particularly high energy use, a consultancy firm may be contacted for assessing potential improvements. In some cases net present value is calculated and payback time is an important economic indicator. Payback periods should not be more than 7-8 years. For the division for real estate, the most important considerations are security for people and maintaining the value of the buildings.

The division for real estate proposes measures for the investment budget. The investment budget is separated from the operation budget, and both are prepared by the deputy major and the economy division, and discussed and adopted by the municipal council. Traditionally investments have often passed without considerations of the consequences in the operation budget. Because the administration has not analyzed future operation costs related to a purchase, my informant expresses that the politicians have

[1] The standards are guiding values for energy use and effect need after profitable energy efficiency projects have been carried through (Enova 2004). The standards are differentiated with respect to climate, building use and age. The NS 3032 standards are divided into low medium and high energy use. The municipality refers to the highest standards.

made decisions on a tottering foundation. Recently the municipalities have been instructed to consider life cycle costs, an instruction which has caused increased focus on the connection between investments and operation costs. According to my informant, the decisions of which projects that will be taken into the budget are guided by acute needs and political prioritizations. The real estate section implements the investments, and the daily operation is done by the suborganizations. Figure 5-1 illustrates the decision process.

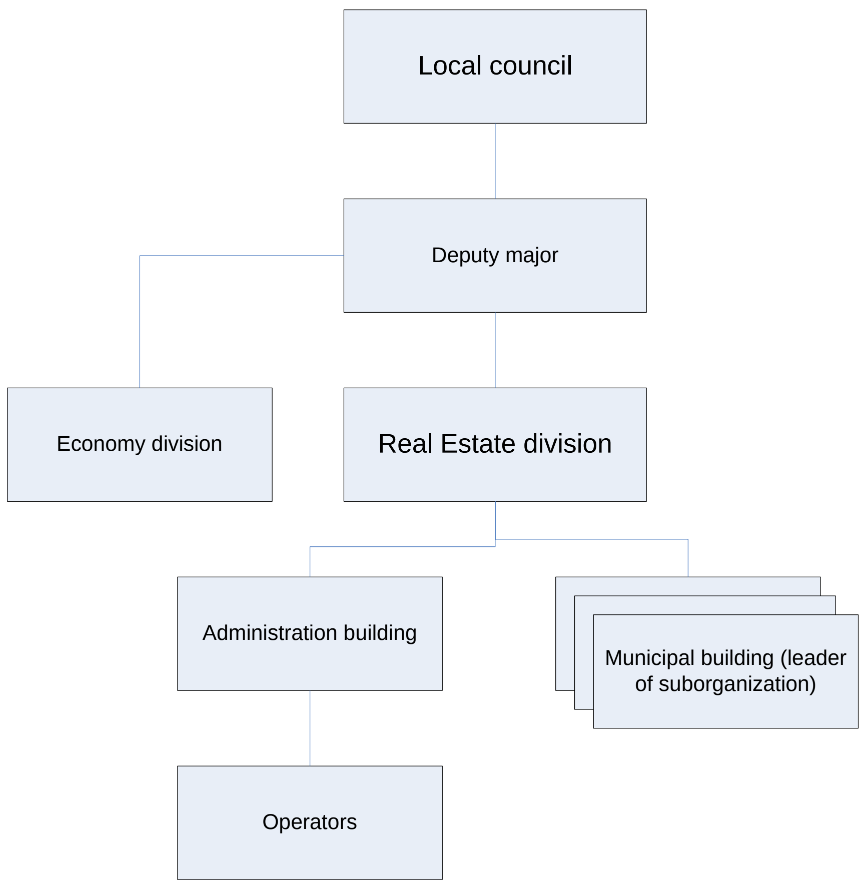

Figure 5-1: Decision tree for case A, small municipality.

5.1.2 Motivation and barriers

According to my informant, the view of reduced costs is a good motivation for doing energy efficiency measures. This applies both to the division for real estate and for the politicians. A connection between energy efficiency and indoor climate has not been articulated.

The barriers that are considered most important are the economic situation of the municipality and lack of motivation among the users of the buildings. As for many Norwegian municipalities, the economy is so bad that the municipality is put under control of the County Governor. This means that the municipality is not allowed to raise loans. In this situation, the municipality simply cannot afford all investments that could be profitable; the informant expresses that being poor is expensive.

Up to date, the users of the buildings have not had any real economic incentive to be concerned with energy efficiency. In cases of energy conservation, the benefit of the reduced costs applies not directly to the sub-organization that saved energy, but to the municipality centrally. For example, this was the case at the nursing home were energy conserving measures were taken recently. However, this is about to change because there are plans of establishing a municipal enterprise to which the sub-organizations pay rent and energy costs. When the users pay the energy bills themselves, my informant thinks they may be more interested in energy conservation.

5.1.3 Policies and strategies

The municipality takes part in a program administered by Enova. Through this program, the municipality is a part of a network of municipalities. The network develops strategies, and the ambition is a reduction in energy use of 10 % within 2009 relative to 2004. During 2005 weekly observations of energy use were introduced in all buildings. The caretakers are responsible for this, and using ET-curves[2], they may reveal systemic errors that lead to excess consumption.

Regarding public instruments to increase energy efficiency, my informant would prefer direct subsidies. According to him, the system that Enova uses, does not suit municipalities well because it requires large volume of the projects. In addition, Enova requires a lot of reporting both during and after the projects. My informant says: "*I dread applying for support because it brings me such a lot of work*" (my translation). He does

[2] An ET-curve shows how the energy use in the building should vary with outdoor temperature given optimal operation of the building. Actual energy use is plotted towards the curve to reveal discrepancies. If actual energy use is outside a bound of for example 10 % above or below the curve, action should be taken to reveal the causes and potentially rectify errors.

not find it worth to spend a lot of time on reporting when he can only receive subsidies of approximately 10 % of the investment.

Concerning firms providing energy services, my informant says that the municipality cannot afford buying those services. Even if the deal is meant to divide the investment costs over a longer period of time, he thinks it will be impossible to keep the total costs for the first years at the same level as today. The first years the costs will be larger than what they pay for energy today, and the investment therefore requires increased budget which is difficult to achieve.

5.1.4 Example: Administration building

The building studied is one of several municipal administration buildings. The building mainly contains offices. In 1991 an extensive energy efficiency analysis was conducted. Fifteen possible energy efficiency measures were considered, of which six were found feasible. The others were refused of either technical or economic reasons, or they were set aside because they were already decided implemented of reasons other than energy efficiency. Three of the measures considered had internal rates of return over 100 % and the other three had rates of return from 15 – 45 %. The present value of all the investments was approximately NOK 120.000, and throughout the lifetime of the technologies, the calculated energy saving would be 800 MWh.

The energy efficiency analysis did not include considerations of risk or uncertainty, but regarding the high internal rates of return, even with some uncertainty, most of the measures would probably be profitable. None of the measures influenced the profitability of the others, so from an economic perspective all should be implemented. In reality none of the proposed measures have been carried through. Because the analysis is fifteen years old, it is hard to find information on what happened to the report and why no efficiency measures were taken. The energy use in the administration building is still far above the highest of the standards the municipality refers to.

5.2 Case B: large municipality

The municipality owns 775.000 m^2 of building area which is administered by the real estate section. The following section describes the way energy efficiency is treated in the municipality.

5.2.1 Decision process

The real estate section is responsible for energy efficiency in the municipal buildings. At their budget, NOK 5 million a year are earmarked for energy efficiency measures. These resources are allocated based on present value. Having NOK 5 million a year, my informant expresses that the real estate section is able to make the investments that are interesting to them. Further investments would be at the margin of profitability. This decision process does not include any other actors.

The real estate section actively makes use of Enova. Applications including present value calculations are prepared by the municipal servants themselves. Previously, hiring consultants to prepare the applications has been tried, but the costs could arise to NOK 250.000 and servants at the real estate section found that they could do this cheaper and faster themselves. The informant expresses that the municipality is better off doing their energy efficiency analyses themselves than hiring consultants, because the consultants overestimate the benefits.

When the projects have been considered by Enova, they are presented to the budgetary procedure. My informant have experienced that achieving funding is easier if support from Enova is already guaranteed.

Figure 5-2 illustrates the general decision process. The real estate section initiates and plans investment projects and demand funding from the deputy major. The deputy major and the financial administration division prepare the budget. The city council makes decisions on which areas that are prioritized, guiding the budgeting at the administrative level, and passing the final budget. The real estate section implements measures and guides the staff at the buildings. The operators are instructed by the local leaders.

Present value calculations are conducted assuming that the energy prices will stay unchanged. My informant considers the uncertainties in the analyses to be small and to not constitute a problem in the decision making. The municipality is directed to use a discount rate (presently 7 %). My informant finds this somewhat paradoxical because in reality it is not an alternative to invest the money. Instead the money should have been placed where the profit is largest, even if this means negative profit.

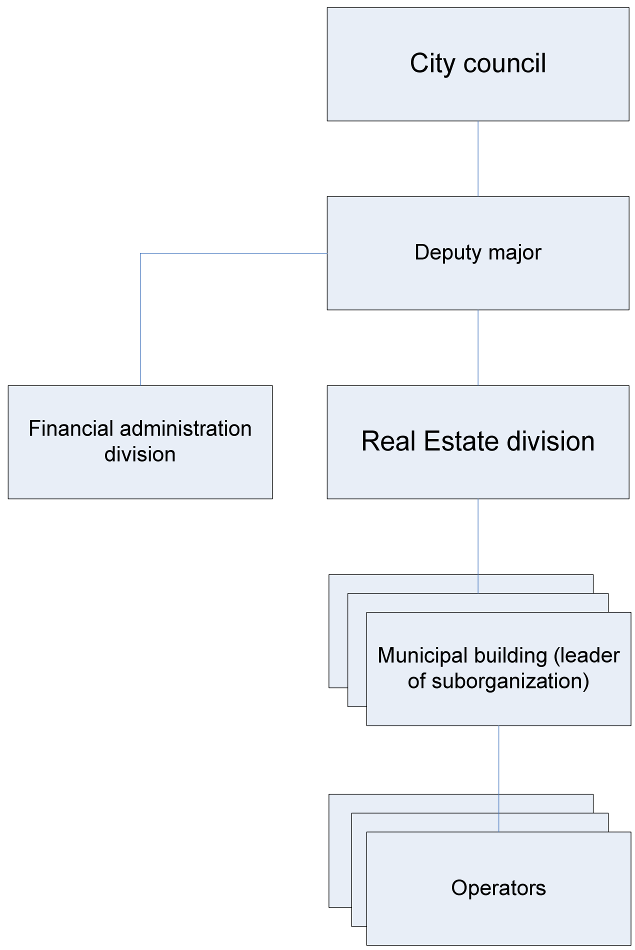

Figure 5-2: Decision tree for case B, large municipality.

Concerning pay-back periods, there are no general rules other than pay-back during the life-time of the measure, i.e. positive present value. According to the interviewee, even projects with pay-back periods of more than 20 years may therefore be considered. However, my informant thinks that in the political process, projects with short pay-back time are preferred as the politicians generally would like to see results within the period they are elected for, i.e. maximum four years. Nevertheless, in general there is no check that the investments actually entail the expected rate of return.

In competition among projects within different areas, political will is of importance. Emphasizing that this is not his field, my informant assumes that projects in for example the health sector may be accepted at lower profitability than energy efficiency projects. He finds that the comparison is complicated because cost-benefit-analyses cannot be made at all areas[3].

5.2.2 Motivation and barriers

According to my informant, the main motivation to increase energy efficiency is the economic profit, but the environmental benefits are also present in the arguments for energy efficiency. Improved indoor climate is not normally used as an argument, but in some cases energy efficiency measures with a low, or even a small negative present value may be carried through if there are additional benefits such as improved indoor climate.

The institutions occupying the buildings pay the energy bills themselves. However, reduced spending at energy leads to a lower budget for the institution the next year. My informant tells that this lack of economic incentive has been used as an argument against putting an effort into saving among the institutions. Furthermore, my informant finds it hard to achieve focus on energy efficiency at the institutions because the costs of energy are small compared to the total costs. For example, a school may typically have energy costs of NOK 700.000 a year which corresponds to the labour costs of two man-labour years. The real estate section controls heating and ventilation of the buildings based on demand from the institutions, while lighting and fixtures are controlled directly by the institutions. The real estate servants sometimes encourage the occupants to for example turning off computers at night, by pointing to the economic savings this brings along.

[3] Strictly speaking a cost-benefit analysis may include valuation of non-economic costs and benefits, however controversial the methods to calculate these may be. This was not an issue during the interview, and I believe the informant used the term cost-benefit analysis as synonymous to present value analysis.

5.2.3 Policies and strategies

The municipality takes part in two Enova programs, but according to the interviewee, the municipality has come too far to benefit from taking part in an Enova network. One of the programs the municipality takes part in, is for energy management for larger building owners. Through this program, the goal is to achieve a 15 % reduction in energy use at an area of 400.000 m^2. The total energy use in this area was originally 80 GWh, so the amount to save is 12,7 GWh. NOK 6 million is allocated for this, of which NOK 2 million is support from Enova. The goal should be achieved through training of users and operators, and through taking out the benefits of increased focus on energy use. Major investments are not part of the program.

In the other project that includes Enova support, the goal is a 17 GWh transition from electricity to district heating and bio-fuel heating and conservation of 2,5 GWh in a total of 24 buildings. In this case, the real estate section made use of the municipal energy and greenhouse gas plan of action to argue for funding. According to my informant, referring to politically adopted documents is generally effective when demanding funding.

My informant refers a general belief that through simple measures, such as focus on energy use, a 10 % reduction in energy use can be achieved. This is the potential that my informant thinks should be realized. First and foremost this includes optimization of operation. An electronic system that shows the hourly energy use for all municipal buildings has been installed. From this, both the local building operators and the real estate section can supervise the energy use and reveal waste. For the present, energy use can only be compared to previous use, but there are plans of going through the buildings, check the settings and drive them optimally, so that there will be an optimum that can be used for comparison later on. There are also plans of modelling a school building designed for minimum energy use (with respect to the shell of the building, i.e. cubical form, few/small windows, not low-energy) for comparison. The schools are also encouraged to make their pupils utilize the electronic system to learn about energy use.

A large degree of automatic control of ventilation and heating is emphasized as desirable by the informant. This is to avoid depending on the operators, because regardless of training, the informant expresses that there will always be good and bad operators. Measures at the shell of the building, for example insulation or changing windows are, of economic reasons, not interesting as stand-alone projects. Concerning public instruments, my informant consider money the most desirable means.

5.2.4 The real estate section as a tenant

The municipality has sold out most administration buildings, and the real estate section now hires offices from a private real estate company. The municipality has a long-term contract, probably of ten years or more. There is a joint electric meter for the tenants in the building, and energy costs are distributed according to area. It may be the case that all the tenants in that share the meter are municipal. This has not been checked. As a tenant, the real estate section has not initiated energy efficiency analyses or measures. Some individuals that are occupied with energy use have put up posters to encourage their colleagues to save energy.

5.3 Case C: State enterprise

Case C is a large state enterprise with a large number of buildings for different purposes. In a segment of the buildings, including 23 buildings with a heated area of 220.000 m^2, there is a goal of 20 % reduction in energy use relative to 1999-2001.

5.3.1 The energy program

In 2001 the top management set a goal of 20 % reduction in energy use in a segment of the buildings relative to the period 1999-2001. The project was initiated by an electrical engineer in the real estate division who found that the energy use in general was too high. Similar initiatives had been taken earlier, but because the initiators quit their jobs before the projects were thoroughly established, these initiatives did not lead anywhere. This time, however, an energy consultancy firm was contacted. The consultants estimated that 15 % reduction was realistic. The results from the energy efficiency analyses were presented to the top management who wanted to go for the project. However, they wanted to set the goal at 20 % rather than 15 % to have something to strive for. This is, according to my informant, a general characteristic of the company; they do not want to be too content with what they achieve, rather they want to set ambitious targets and work for them. The real estate division was given the responsibility and the necessary economic resources to carry through the project.

By now NOK 25 million have been invested in the project, and the annual savings are NOK 11 million a year. The energy use is reduced by 27 %. Expected reduction when all planned measures are carried through is 28-29 %, and my informant hopes to pass 30 % by time. The enterprise recently won a national environmental price for the energy program.

5.3.2 Decision process

The top management of the enterprise has decided that investments should have a hurdle rate of 20 %. Earlier the rate was 12 %, but experiencing that many servants underestimated costs and overestimated benefits to make their projects pass, the requirement was increased. Originally it was increased to 25 %, but having established better budgeting practices, it was decreased to 20 %.

My informant uses as a general rule that investments in energy efficiency should have pay-back periods of maximum three years. There is one exception: energy observation systems may have longer pay-back periods, but are implemented anyway. My informant prefers the three-year rule because it includes a buffer; if it actually takes four years to pay back the investment, the rate of return is still acceptable.

Receiving an energy efficiency report from the consultancy agency, the enterprise calls for tenders for all measures that are expected to have pay-pack periods of five years or less. A package of energy efficiency measures are constructed and presented to the economy division. The technical staff at the relevant building are consulted for assessing the feasibility of different measures, but the decisions are taken centrally, not including anyone from the buildings. Figure 5-3 illustrates the decision process.

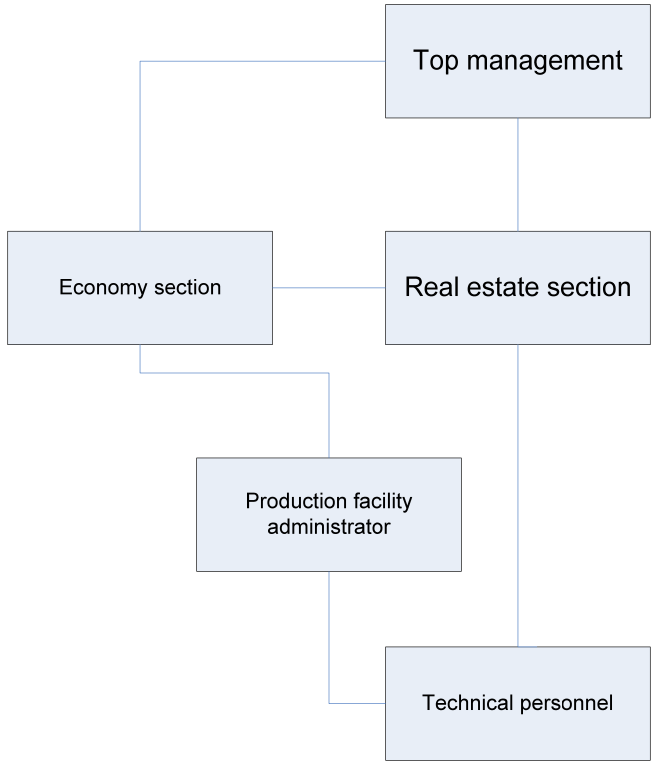

Figure 5-3: Decision tree for case C, state enterprise.

5.3.3 Motivation and barriers

Economic profit is first priority for the enterprise, and a prerequisite to take measures. According to my informant, environmental considerations are a second driver. The enterprise has an environmental account and my informant thinks good environmental results help them get customers. He gives a concrete example that a large customer chose them rather than a competitor because of their concern for the environment.

My informant emphasizes that the enthusiasm of the top management is important for the success of the energy program. The fact that this is a prioritized area is essential for the financing and helps creating focus at the production places. The top manager was happy when winning the environmental prize and expressed that she would like to win the prize again.

There is a fixed sum for investments each year. Both the profitability and the content of the projects are considered. Projects should be part of the strategy of the firm.

Having an energy program as part of the strategy is therefore considered by the informant to be essential for achieving financing.

Some investments in production equipment are accepted at considerably lower rates of return than energy efficiency investments. These are investments that are necessary to support the production. An example is a machine that should be exchanged, but because the enterprise had to continue the production during the exchange period, a provisional solution had to be established. This included renting a building area of 5000 m^2, installing production equipment and moving the production. The costs amounted to NOK 72 million. For this investment, the regular requirements regarding pay-back and rates of return could not be applied.

My informant thinks local effort has been necessary to make the energy program a success. The administrators of the buildings do not have incentives to conserve energy through the energy bill. Investments and economic gains are placed centrally. To achieve focus among local administrators and servants, energy use has been included as one of the key figures that the subunits regularly report on. Good results in the key figures have benefits.

The enterprise depends on an effective logistic system, and it is in a process of more or less continuous moving of the production. When selling a building, only the shell of the building is interesting to potential buyers. This means that most investments cannot be compensated for by increased price. Existing buildings are often changed to adapt to production changes. No energy efficiency investments are made in buildings that are not expected to be in use for more than three years. Nevertheless there are examples of buildings where improvements have been done, and decisions of closing down have been made shortly after.

In the energy efficiency analyses, calculations of present value is based on an electricity price of NOK 0,55 per kWh. My informant finds this a conservative estimate of the future price. He prefers to be a bit conservative to be sure not to carry through any projects that are not profitable. Nevertheless, too conservative is not good, and it is being considered to increase the price estimate to NOK 0,70 per kWh. In that case, projects that originally were refused will be reconsidered.

5.3.4 Policies and strategies

The enterprise has an energy observation system which is administered through a web service produced by an energy consultancy firm. The consultancy firm gives general assistance in energy-related matters and they produce yearly reports for the enterprise. An example of assistance is figuring out what is wrong when energy use differs from expected based on the ET-curve. At one facility, energy use is presently 15 % higher than for the same period last year. In this case the real estate servant and an energy consultant are going to the facility to examine the technical systems. The enterprise has established networks for the technical personnel in which they may exchange experiences.

In an early phase of the energy program, the enterprise was in contact with Enova. It was offered NOK 1 million in support, but refused the offer. The administration costs would be so large that receiving support would not pay off. Regarding public instruments, my informant proposes some kind of reward based on achieved results and economic and financial assistance to get started.

My informant is sceptical to energy contracting. He emphasizes the vulnerability that comes with depending on someone else. Not having control over their own technical systems, he imagines the harmful effects that would result if the systems do not work. Potentially, the whole production could be hindered. The enterprise has competent technical personnel that can handle their systems and are curious about new things. In addition, losing economic control of their buildings is undesirable. The energy contractor could potentially be bought up, and the enterprise could end up with its competitor owning parts of their buildings or production equipment.

5.3.5 Example building

The building studied is a combined office and production building. In the production facilities there is a large heat loss through the entrances because there is a lot of transportation in and out of the building. Before the start of the energy program, the specific energy use was 330 kWh/ m^2/ year. Estimated energy use after implementation of profitable projects is 273 kWh/ m^2/ year. This is a 17 % reduction and corresponds to reduced energy costs by NOK 521.000 per year. The energy efficiency analysis includes 19 potential projects. The internal rates of return are between 11% and 623 %, but some rates are reduced when other projects are carried through. 15 or 16 of the projects have been realized. The energy use has decreased gradually after 2002. In 2005 specific energy use was 271 kWh/ m^2, i.e. at practically the level prescribed.

5.4 Case D: Real estate company

Case D is a large, privately owned company with business activities within several fields, of which real estate is one. The company has real estate sections in several Norwegian cities. The section studied administers 140.000 m^2 of area for rent, distributed among 25 office buildings. All the buildings have an energy observation system. This is a web service bought from a consultancy firm. It is hard to measure actual changes in energy use because of continuous change of tenants and building use, but it is assumed energy conservation of 5-10 % because of the system.

5.4.1 Decision process

Energy efficiency measures are practically never taken separately, but are considered in relation to maintenance and retrofits. The tenants should not be disturbed by work during the contract periods, so generally measures are taken when there are new tenants or at renewal of contracts.

The informant tells that initiative to energy efficiency improvements normally come from the operation engineers at the company. Once or twice tenants have initiated improvements, but this is not usual. The real estate section has a maintenance budget in which most energy efficiency measures are included. Decisions within the maintenance budget are taken internally in the local real estate section. New building projects and large retrofits are considered individually and decisions are taken centrally in the real estate part of the company. Measures may be discussed with an electrician and the operators. Decisions are implemented by the real estate section. The decision processes are illustrated in Figure 5-4.

The informant tells that present value analyses are generally not used. Investments are considered from a qualitative approach. When a building needs maintenance, the engineers decide what quality they want on the renewals, and ask suppliers for a price. The company wants the buildings to be in as good condition as possible, and energy efficiency is part of this. They go for the solutions of highest quality within what is economically justifiable. The cost of energy efficiency is not considered separated from other costs, but as a part of the total maintenance costs. It is therefore hard to distinguish actual costs and benefits of energy efficiency.

The company has to prioritize among profitable projects. However, if there was more capital, my informant expresses that the company might still not be able to carry through more projects because it would run short of time. Investments in energy efficiency are always conducted at specific points in time, so there may be more profitable projects that are not considered because it is out of question to make investments in the relevant buildings.

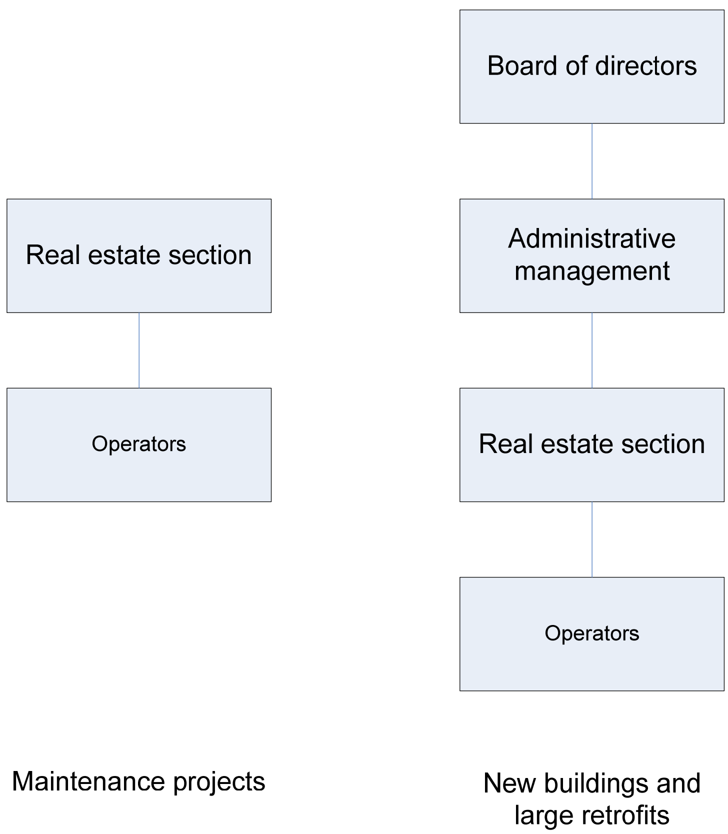

Figure 5-4: Decison tree for case D, real estate company.

5.4.2 Motivation and barriers

In all buildings, the tenants pay the energy costs. According to my informant, the company's motivation for energy efficiency is to keep their buildings in as good condition as possible. The direct economic benefit applies to the tenants. The informant's experience is that small tenants generally are not interested in energy costs while some large tenants (more than 400-500 m^2 and 20-40 employees) are interested. With large tenants, larger investments are discussed with the tenants, and they may accept higher rent after the investments.

There is only one electric meter in each building, so when there are several tenants, electricity costs are distributed by area. This is mostly the case for small tenants. Because there are fixed costs of electricity, my informant thinks that they probably would get higher electricity costs with individual metering.

The fixed costs of electricity are recognized by the informant as a barrier to energy efficiency because dividing the electricity costs into a fixed and a use-dependant part lowers the price that may be used for calculating profitability.

The company does not normally receive proposals or alternatives for investments neither from tenants nor suppliers. The technical solutions that they present for tenants or demand from suppliers are normally accepted without presenting alternatives. My informant therefore finds it important that the company's engineers are updated with respect to available technical solutions.

When the EU directive on energy efficiency is implemented, the informant expects that the company will have to post their buildings' energy use at the walls[4]. My informant finds this an incentive to focus on energy efficiency. My informant does not welcome a system of A,B,C etc.; he would rather see the specific energy use. He is certain that energy labelling will increase focus on energy use among tenants.

[4] The EU directive on the energy performance of buildings is accepted by Norwegian government and will be implemented into Norwegian law. The implementation will mean that the real estate company will have to get energy certificates for their buildings before they are let out. However, the requirement that the energy label should be posted at the wall, will probably only apply to public building owners. The directive is described in chapter 8.2.

5.4.3 Policies and strategies

The company has been in contact with Enova at several occasions. In one project of a new building they are receiving support, while in at least two cases they have considered taking part in a program, but have left it off. My informant finds that the instruments Enova uses for new buildings are good, but points to that there are no subsidies for measures in existing buildings[5]. He thinks that the instruments could not really be designed better than what Enova has done. The crux of the matter is consciousness regarding energy use. Nevertheless, he misses the energy efficiency seminars for operators that used to be held by the Department for Energy and Petroleum.

The company has considered offers for third party financing at a few occasions, but have ended up doing the financing themselves. Third party financing is considered interesting by the informant because it might ease negotiations with the tenants. Using third party financing, the tenants would pay the costs of the investment to the external actor, while if the firm makes the investment itself, the costs may be harder to distinguish from other costs, and the tenants may not accept higher rent.

[5] Actually, Enova has a subsidy program for existing buildings (Enova 2006c). The interviewee may not have been aware of this, or I may have misunderstood him.

6 Analysis and results

The aim of the case study has been to obtain understanding of the decision processes, the motivation factors and the causes of the energy paradox. In this chapter I give an assessment of the cases in elucidation of the theory and hypotheses presented earlier.

6.1 General impressions of the cases

The small municipality in case A has started focusing on energy efficiency by taking part in an Enova network. The real estate section works systematically with gathering data on energy use, comparing the data to standards and picking out buildings with particularly high energy use for further investigation. Energy use is on average higher than the standards. The ambition is a 10 % reduction, which implies getting approximately down to the highest standards. The municipality is in a difficult economic situation, administered by the County Governor. In this situation a large part of the municipal spending goes to cover acute needs, and my informant emphasizes that achieving budget allocations for energy efficiency investments is hard. The informant gives the impression that he thinks financing is the main barrier for being energy efficient.

The large municipality in case B has not formulated a target for energy reduction, but the ambition level seems to be the same as in case A: approximately 10 % reduction. Focus is on optimizing operation to avoid waste of energy. As in case A, the municipality works systematically with respect to registering energy use and reveal excess use. My informant stresses that the real estate section has the competence and resources to make the improvements that are interesting, and that they are on their way, but they have some problems engaging the occupants and the operators.

Case C is the “success story” of this study in the sense that it this organization has established an energy program and have achieved large reductions in energy use. Although case C is presented as the more ambitious organization in this study, we cannot know whether their performance actually is “better” than the other organizations, i.e., if it was possible to compare investment projects, we cannot know whether organization C would have invested more in energy efficiency than would the other organizations. Because the organizations differ with respect to production, values and competence, and their buildings are of different quality and are used for different purposes, the cases are not directly comparable. Nevertheless, being aware of this, it makes sense to look for success factors that possibly may be transferred to other organizations.

The important factors for the success seem to be the commitment of the top management and including the energy program in the strategy of the firm. Interestingly, in this case improved environmental profile seems to be a motivation factor, and the indirect economic benefits of good environmental results are emphasized. The start-up of the energy program seems to have depended on engaged individuals in the real estate section. The fact that several similar initiatives were taken before a decision was made in the top management, implies that the start-up process have taken some time and may not have been straight-forward. In the phase before the decision in the top management, it seems like the project depended on individuals.

In case D, the real estate company, energy efficiency measures are never considered as stand-alone projects, but is, according to my informant, a natural part of maintenance and retrofits. In the interview, the importance of maintaining the value of the buildings was repeatedly emphasized. The importance of not disturbing tenants was also stressed. This case shows that timing of measures both with respect to tenants and to other work that has to be done in the building, is important. The informant expresses that the knowledge, prioritizations and commitment of the building managers is essential because most decisions are taken locally, and tenants and suppliers normally do not propose other solutions than the ones the building managers propose.

The cases studied are varied with respect to production and economic situations. It is interesting to find that the building managers all seem to experience that their position is important regarding energy efficiency, and that they can make many decisions locally even in big organizations. At the same time, it is clear that the respective organizations' values and main activities are decisive for the way they think about energy efficiency.

6.2 Ambitions and perceptions of the efficiency potential

All the informants emphasize that they work with energy efficiency and that they do as much as they can. All the organizations have systems for energy observation and work systematically with revealing waste. Larger investments, on the other hand, seem to be less interesting. Energidata (1997) found that the efficiency potential in all commercial buildings was 23 %. This study also revealed that 50 % of the potential arose because of lack of information. Energy efficiency analyses were conducted for all the buildings, and the building owners were asked if they knew that profitable investments could be made in their buildings. A similar comparison of technical and economic analyses, and the building managers' perceptions of the potential, has not been possible within the scope of this study. However, knowing that there is no indication that the buildings in the cases are particularly energy efficient, there is a possibility that the informants do not know the full potential in their buildings. In other words: the building managers seem to *believe* that they do a good job on energy efficiency, while they may actually be concerned with only a part of the potential. This interpretation is in accordance with the results of Komor and Katzev (1988) who found that many building managers wrongly believed that there was nothing to do about their energy use (cf. chapter 2.5.5).

When the informants give the impression that they find energy efficiency important and that they do everything they can, it may partly be a result of the interview situation. Knowing that the interview is about energy efficiency, they may consciously or unconsciously, present themselves and their organizations in a biased manner by focusing a lot on what they achieve and reject that they could do more.

6.3 Decision making and the basis for decisions

In cases A, B and C present value analyses are used, and in cases A and C pay-back time is an important criterion when considering investment projects. In the small municipality pay-back periods of up to 7-8 years are accepted, while in the state enterprise investments should be paid back within three years. In cases B and D pay-back period is not used as an indicator of the attractiveness of an investment, according to the informants. In the real estate company projects are given a qualitative rather than a quantitative assessment. None of the informants emphasize analysis of uncertainty or risk. Regarding hypothesis 4, no clear conclusion can be drawn. The public organizations are of course subject to rules regarding how to make investment decisions, and this requires some documentation of expected results. Nevertheless, the servants in the organizations may behave differently with respect to how the required analyses are conducted and assessed. In cases

A and C decisions seem to be based on quite extensive material. At the same time, the informant in case C is quite rigid on pay-back time. In case D only qualitative judgments are made.

In all the organizations there is a more or less fixed sum for investments every year and taking up loans for energy efficiency investments does not seem interesting. This supports the hypothesis that there is competition among profitable projects within the organizations. In the small municipality taking up loans is impossible because of its administrative situation. In the other three organizations the informants seem to find that even though not all profitable projects can be carried through, the sum available for investments is large enough. While part of the theory focus on imperfections in capital markets that make it difficult to achieve financing, the case study implies that the organizations may not be interested. The interviewee in case D expresses that the company would not have capacity to make more investments even if they had more capital, while the interviewee in case C focuses on certain profit and prefers having a buffer towards uncertainty. These results are in accordance with Ross' (1986) findings presented in chapter 2.5.4.

The choice of investment projects is guided not only by profitability, but by the prioritized fields in the organizations. In the municipalities, the budget allocations naturally are guided by political prioritizations. The informants imply that other fields, for example health and social services, may have higher priority than energy efficiency. This is particularly noticeable in case A. This municipality is in a difficult economic situation, and a large part of the spending seems to be guided by acute needs. In such a situation it seems like energy efficiency is given less priority. In the state enterprise some investments that are essential to the production are accepted at considerably lower profitability than the general rules.

In the state enterprise, projects need to relate to the strategic areas that the top management wants to concentrate on to achieve funding. The importance of relating to general goals is also mentioned in the large municipality. Here, the real estate section point to politically approved documents to argue for funding. The conclusion with respect to hypothesis 6 is that some investments are prioritized because of their content. However, energy efficiency investments do not seem to be systematically less prioritized.

An important factor deciding which kinds of investments receive funding seems to be the relation to strategic targets. Following economic theory, rational behaviour would be to consider all investments by the same rules. However, the behaviour of the state enterprise that needed new production equipment can hardly be seen as irrational. The wisdom is maybe that the border between investments and one-time operation costs is indistinct.

The informants do not seem to find that uncertainty of future pay-off is a problem. In case B the informant expresses that there is practically no uncertainty in their analyses. Present value is always calculated using today's energy prices. My informant expresses the position that present value is the value of an investment with present prices and that uncertainty arises when using other estimates of the energy prices. The theoretic definition of present value, or "expected present discounted value" as is the correct term, is "*the value today of an expected sequence of future payments*" (Blanchard 2000). The term "present" points to the discounting of future payments to give them a value today. The term "expected" is used because these future payments normally are uncertain. In other words, my informant's understanding of the present value concept is not in accordance with economic theory. This is an interesting result which reveals that although the decision maker makes decisions based on present value analyses, the potential he sees may differ from what economists see, because the inputs into the analyses are different. A possible interpretation, is that the informant considers it unlikely that energy prices will fall, but he does not want to guess if energy prices will increase, or how much. By using today's energy prices in calculations, he therefore feels at the safe side, not experiencing uncertainty.

In case C, uncertainty of future energy-prices is recognized. It is met by using conservative estimates of the prices and to take additional benefits as an extra surplus. If the energy price increases, projects that were originally rejected may be reconsidered. At a specific point in time, however, the variation in possible future energy prices is not considered and taken into account. For the cases studied, thinking in terms of option values is not explicit. However, future electricity prices ranging from NOK 0,20 to NOK 0,70 per kWh have been mentioned in the interviews, and even though the informants do not stress uncertainty, they are touching the issue. A possible interpretation is that the building managers do not experience uncertainty as an issue because they have a way to deal with it; to use conservative estimates. In other words, we cannot draw clear conclusions regarding the option value hypothesis. If the interpretations above are correct, risk aversion may be a problem, c.f. chapter 2.5.3.

The last hypothesis concerns centralized versus decentralized decision-making. In case A decision-making is centralized, financing relatively complicated and quite long pay-back periods are accepted. In case B decision-making is centralized, financing is easy within certain limits and very long pay-back periods may be accepted. In case C decision-making is centralized, financing is a little complicated and quick repayment is required. Last, in case D decision-making is mainly decentralized, financing is easy and pay-back periods are not emphasized. The systematic correlation that hypothesis 8 proposed based on the work of Morch and Gjøen (2001), is not found.

6.4 Motivation

The first hypothesis concerns economic vs. non-economic benefits as motivation factors. In the two municipalities and in the state enterprise, direct economic benefits are considered the most important motivation factor. In the state enterprise, the indirect benefits that arise from improved environmental results are also emphasized. In the large municipality additional benefits that cannot be measured may be used as arguments for carrying through energy efficiency measures that are not profitable enough by themselves. In the real estate company there is motivation in maintaining the buildings' quality; to keep the buildings in as good condition as possible. This point is mentioned in case A too. Good indoor climate seems important in all the cases, but the informants stress that improved indoor climate in general is not compatible with reduced energy use. Only in buildings that are in very poor condition to begin with, they find that the two may be compatible.

With respect to the hypothesis, these results may be interpreted in several ways. Firstly, direct economic benefits are a precondition and seem to be considered by the informants as sufficient motivation. Maintaining the building value is also considered important. An interesting observation is that case C differs from the other cases in three ways: the ambition level, the emphasis on the benefits of good environmental results, and the inclusion of the energy reduction target in the strategy of the enterprise.

Focusing on the connection between ambitions and emphasis on environmental results, we may wonder if emphasizing environmental results is a precondition for targeting beyond avoiding obvious waste of energy. If this connection holds, it is an interesting find because in case C environmental benefits are not seen as an alternative to direct economic profits, but rather as an addition. Possibly, including targets in the business strategy is the connection point between the two above; emphasis on environmental results induces concrete programs and targets, which releases action. This idea may be used as a hypothesis for empirical investigation. If the observation is correct, it supports the hypothesis that other factors than economic are equally important as motivation factors.

In case C the start-up of the energy program depended on engaged individuals. This gives some support to the hypothesis that individual commitment is necessary. However, it does not seem like the energy program in case C has depended on individuals after if was well-established. Maybe individual initiative is needed to establish targets and routines for addressing energy efficiency, but that once a system has been established, this is less vulnerable. However, in Kulakowkski's (1999) study, an energy efficiency system was vulnerable to changes in person in charge even after establishment (c.f. chapter 2.5.5).

Both the municipalities have problems engaging the users of the buildings. The real estate sections make the investments and the benefits accrue centrally. In the municipalities, they focus on taking out the potential that lies in optimizing operation, i.e. projects that do not necessarily include large investments, but that require the involvement of users and operators. In case B some of the users have argued towards the real estate section that they do not have incentives to conserve energy. In the state enterprise too, both investments and benefits accrue centrally. To engage the users of the buildings, energy use has been included in the key figures that the sub-units report on.

In the real estate company, the company makes the investments while the tenants receive the direct economic benefits through their energy bills. In a few cases it is possible to discuss investments with tenants and make them accept higher rent. According to the informant, only large tenants are interested in this. Generally, the tenants are not interested in energy efficiency. In most cases it is hard to specify exactly the costs and benefits of an energy efficiency investment. This makes it difficult to convince the tenants to accept higher rent. The building managers seem to experience that lack of economic incentives is a problem regarding occupants. Regarding themselves, they give the impression that economic benefits for the organizations as a whole is sufficient incentive for action. Problems because of lack of incentives among occupants have been found in many studies, for example the study of Morch and Gjøen (2001) referred in chapter 2.5.3.

6.5 Policies and strategies

When being asked about preferred policies, all the informants emphasized that they had not been thinking about this issue. Direct subsidies were mentioned and also professional stat-up help. Not denying that this may be preferable from the building owners' point of view, it should not be given too much attention because coming up with other ideas offhand may be difficult. Two of the informants seemed to be dissatisfied with the workload that receiving support from Enova would lead to.

There were different views on energy contracting. The two most interesting opinions is the fear that it will make the organization more vulnerable and that it will lose control, and that it might help distinguishing costs and benefits of energy conservation and by this help overcome landlord-tenant problems.

With reference to the discussion of theoretical notions and explanations of the energy paradox in chapter 2, the results of the case study indicates that both organizational and behavioural barriers, and market-failures are relevant explanations of the paradox. There are no indications that additional private adoption costs are very important. However, this issue has not been focused much upon, except for the discussion of option values, so the idea should not be completely rejected. The results of the case study nevertheless provide enough evidence of inefficient behaviour to justify a discussion of strategies to induce change.

7 Closing the gap

The distribution of buildings by energy use naturally takes a bell-shaped form, biased towards high energy use. This variation will always persist, due to a number of factors, including different use of the buildings, different preferences, economic considerations and changing standards through time. Improving energy efficiency performance involves moving the distribution as a whole towards lower energy use. This change of (informal) standards may require broad changes, sometimes termed a paradigm shift:

> "The full transition to a more energy efficient building stock, incorporating developments in services, design, component technologies, materials and practices as well as organizational changes can be constructed in terms of a paradigm shift. The notion of a paradigm is seen here not only to encompass the fundamental technological principles which promote and constrain directions of technological development but also the organizational context in which technological development takes place, thus paradigm change involves not only the development, diffusion and adoption of new technological principles, but also changes in the structure of the industry in which technological change takes place, in networks of communication and co-operation, in strategic reorientation, and in the boundaries of the industry."

Bodin (1996: 492).

Obviously, a paradigm shift involves numerous actors, notably the construction industry, building owners and managers, occupants, and building and environmental authorities. The construction industry is very heterogeneous both with respect to variety in occupations and with respect to organization. The industry consists of many small firms, organized in a large number of trade associations (STEP 2003). Improving the innovation power of the construction industry, including changing habits of contraction and cooperation, will be an important part of the challenge. However, within the scope of this project, a thorough analysis of all the actors and all the aspects of a paradigm shift as noted in the quotation above, is impossible. As the case study has focused on the building managers, I find it natural to continue having the main focus at the demand side. Not neglecting that the issue is broad, I will focus the discussion below on a few themes.

Bodin (1996) argues that a paradigm shift may emerge from interaction between environmental policy and technological change, and I will present some theory on both these themes. Norwegian innovation policy is based on the principle that innovation policy should be integrated into and coordinated with other policy areas (NHD 2003), i.e. innovation policy should be integrated into for example energy policy. This principle is guiding for the discussion in the way that I focus on an energy conservation policy that stimulates technological change.

7.1 Technological change

Technological change is the creation, development and spreading of something new, be it a product, a service, a production process or an organization form (Kline and Rosenberg 1986). The process of technological change can be divided into three stages: invention, innovation or commercialization[6] and diffusion, a distinction deduced from the work of Schumpeter (Jaffe et al. 2002). Invention is the development of a new product or process. Commercialization is the process in which this product is made available on the market. Diffusion is the process where the invention becomes widely available and is adopted and taken into regular use by consumers. For this thesis, I will focus on diffusion, but first a short comment on the relevance of the first two stages.

Given continued economic growth, the demand for goods and services that require energy both in production and consumption will increase. To counteract an increase in energy demand, further technological development is required. Today it is possible to build houses using only a quarter of the energy of a house built with conventional practices (GRIP 2000). To make this profitable and widespread requires both cost-cutting technological change and change of industry practices. Part of this work will be revealing and dealing with possible lock-in situations. This kind of situation may arise if the invention has a learning curve that depends on cumulative production. The initial costs of the invention may be higher than the costs of the existing dominant

[6] I prefer to use the term commercialization, rather than innovation to avoid confusion. The term innovation is often used as a collective term for technological change, and it will be used in this denotation elsewhere in the thesis.

technology, while the costs given learning can be lower than for the existing technology (Arthur 1989).

Hollander and Schneider (1996: 285) argue that further technological development itself will increase the rate of adoption:

> "in real world situations there is always a gap between average practice and best practice (…) The size of the gap is a major driving force for technological change; the larger the gap, the greater will be the financial incentive for change and the more rapid will be the general adoption of newer, more efficient technologies. To assure continual improvements requires continual advances in best practice."

Given the results of the previous case study, this approach is unsatisfactory. Organizations do not automatically adopt new technology to approach the best practice in the field. Addressing the barriers that are neither technological nor economic is a prerequisite to be able to utilize both the existing economic potential and the increased potential that may arise from further technological development and cost reductions.

7.2 Diffusion theories

While the economic theory suggests that adoption of new technologies should happen instantaneously for all potential adopters when the benefits exceed the costs, the theories of technological change find it natural that adoption happens gradually. The diffusion process is often modelled as S-shaped, as illustrated in Figure 7-1. This illustrates that diffusion is slow at first, then increases rapidly before it slows down when it approaches a saturation level. This pattern has been shown for a number of different technologies, including the electric service, the refrigerator and the washing machine (Hall 2005).

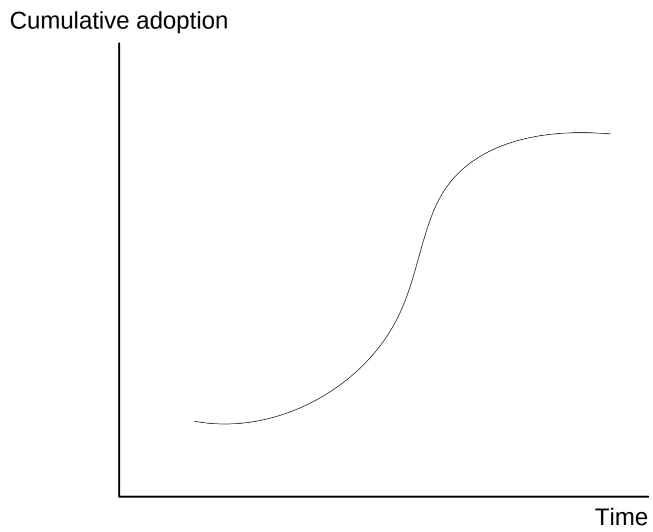

Figure 7-1: S-curve.

There are two main explanations of the S-shape. In the *probit model* it is assumed that potential adopters have different returns from the new technology. At a given point in time, those who have benefits marginally higher than the costs of adopting, will adopt the invention. Because costs tend to decrease with time, cumulative adoption increases. If the distribution of potential adopters is normal, or another single-peaked distribution with similar shape, the cumulative adoption as the cost falls, gets the familiar S-shape. This model is in accordance with economic theory, and the energy paradox is actually an observation that adoption of technologies does not necessarily follow the reduction in costs.

In the *epidemic model*, focus is on getting information about the new technology. It is assumed that the most important source of information is people or firms who have tried the technology. The diffusion is a function of how many of the potential adopters that have tried it and how many that are left. When only a few have experience with the technology, it spreads slowly, but as more people or firms get experience, the rate of adoption increases. When many of the potential adopters have got the technology, few are left to be informed, and the diffusion levels off (Jaffe et al. 2002). In this model, adoption may be profitable for all potential adopters, but adoption depends on “infection by the epidemic”. This idea may for example be relevant regarding the building managers focusing on maintaining the building value. Both the total effort and the kinds of investments needed to maintain the building value will depend on the building market. If energy efficiency is considered more important in the building market, then this may be an “epidemic” that influences building managers to improve on energy efficiency.

As the epidemic model explains, the S-curve consists of a positive and a negative feedback loop (Sterman 2000). The positive feedback loop which dominates at first, is actually a case of exponential growth, in which a change in the system is reinforced by the system itself. This is the case with the information spreading in the epidemic model described above. The negative feedback loop which dominates at the top of the S-curve, is a mechanism in which a change in the system is balanced out through a change in the opposite direction. This it what happens when adoption by some consumers decreases the number of future potential adopters. This is also the way equilibriums are achieved in a market; if demand for a product increases, the price increases and in response demand decreases. While the positive feedback loop generates continually larger effects of an initial change, the negative feedback loop generates smaller effects every time it is repeated, and eventually there is no more effect of the loop unless there are other forces changing the system.

Because using policy instruments is costly, the best policies are those that stimulate positive feedback loops. Managing to create positive feedback, the instruments might be removed and the system will continue to move towards a better state. In contrast, using policy instruments that create only balancing loops, the system will stop changing soon after the external force is removed. In reality there are of course a variety of positive and negative feedback loops influencing the dependent variable, making the interaction between variables a lot more complex. Nevertheless, what we are looking for is mechanisms that set off an exponential growth process.

The process of technological change is iterative, and creating autonomous demand would potentially increase the rate of invention and commercialization as well as diffusion, thus increasing the potential, and this would constitute a positive feedback loop itself.

7.3 Promoting diffusion

The above description of the diffusion path may seem deterministic, but in reality it is not so. The part of the diffusion literature that is occupied with how to encourage consumers to purchase new technologies, tends to focus on media information, the role of social networks and characteristics of the product itself, i.e. factors that presumably might be affected. Factors that are harder to affect, such as characteristics of the individual adopters are left untouched (Hall 2005).

7.3.1 The Bass model

When focusing on media information and social networks, the Bass model is central. In this model it is assumed that mass media are important early in the diffusion process, but as some consumers achieve experience with the new technology, interpersonal contact takes over as the important factor driving diffusion (Bass 1969). The model has been tested for a number of consumer durables, and in these cases interpersonal communication was far more important than mass media for diffusion (Rogers 2003).

The model can be connected to a common classification of adopters. The categories include innovators, early adopters, early majority, late majority and laggards (Bass 1969). The innovative are curious about new ideas, actively seek information from a range of sources and find interest in risk. They are the first to adopt new technologies, but they have limited capacity to influence other potential adopters because they are considered too different from the majority. In contrast early adopters are more moderately interested in innovations, but in return they are a more integrated part of the local social system. Thereby they are respected and often work as opinion leaders. The early adopters are considered by many to be “the ones to check with” before adopting a new idea. The early majority and the late majority are, as the terms denote the majority of the adopters. The early majority are deliberately positive, while the late majority are sceptical and their adoption depends on system norms that must favour the innovation. The laggards are the counterparts of the innovators; they are quite isolated in the social system and they often make decisions based on what has been done previously.

The classification is interesting because it can be used to point out target actors. To achieve large scale change, the majority has to adopt the innovations, but they are not necessarily the ones a strategy for diffusion should target. Change agents who seek a "local missionary" for speeding up adoption, often target the potential early adopters (Rogers 2003).

Rogers (2003) also found that mass media and interpersonal contact are important at different stages in the decision process. Mass media information is important for achieving knowledge of the existence and functions of an innovation, but when it comes to considering whether the innovation is advantageous for the specific adopter, interpersonal contact is decisive. This is equivalent to the two-step hypothesis of how people form opinions.

The Bass model and the classification of adopters are developed using individuals as the unit of analyses. For the following, I will assume that the general findings can be transferred to organizations.

7.3.2 Organizations and attributes of innovations

Rogers (2003) distinguishes five important characteristics of the innovations. Firstly, the greater the perception of the relative advantage of the innovation compared to its' alternatives, the faster is adoption. Note that it is not the "objective" advantage that counts, but the advantage that the potential adopters take in. The second characteristic is compatibility. The more consistent with existing values, past experiences and needs of potential adopters the innovation is, the easier is adoption. The third point is complexity. An innovation that is perceived as difficult to understand and use diffuses more slowly than one which is considered simple. Fourth, new ideas that can be tried at the instalment plan for a shorter period of time or for a part of the business, have an advantage. Last, innovations that are easily observable diffuse more rapidly than others. Visibility stimulates discussion of the new idea, which again stimulates adoption.

The points above shed some new light on some of the results of the case study. At the general level, energy efficient technologies would probably not receive high scores at any of the points listed. Specifically, the point concerning compatibility is consistent with the finding that strategic goals guide investment decisions.

In this connection, the propositions of Cebon (1992) referred in chapter 2.5.4, should also be taken into account. Changing the perceived attributes of the technologies is by no means a straight-forward task, and the important issue is actually that technologies and organizations match each others, regardless of which one that has to change. When Rogers (2003) focuses on the attributes of the technologies, it is from an assumption that this part is the easier to change. However, as Bodin (1996) notes in the quotation at the beginning of this chapter, large scale change requires not only technological change, but change in the organizations involved in the process of change.

The last point may be relevant in relation to the case study results that capital-rationing is widespread and generally not considered a problem, and that the choice of investment projects is guided by strategic goals and desirability. To sum up, when developing strategies for increased energy efficiency, the following implications of the theory of technological change should be emphasized:

- The strategy should preferably create positive feedback loops.
- Promoting spreading of information through interpersonal contact may be effective.
- Targeting potential early adopters that may work as opinion leaders may be effective.
- The strategy should seek to adjust technologies and organizations to each others.

7.4 Environmental policies

When discussing environmental policies at a general level, it is useful to distinguish between some categories of instruments. A usual distinction is between direct regulation, market-based instruments and voluntary agreements. In addition, some instruments are meant to affect the choices of the actors without directly affecting the markets. For simplicity, we may call these instruments behavioural instruments, and they typically include information and awareness drives.

The advantages of regulatory instruments are that the government can formulate the instruments in a way that affects all relevant parties and that the results, to a relatively large degree can be controlled by the authorities. However, because normally all actors are given equal shares of the burden, targets tend to be set low to avoid incurring heavy burdens on the organizations affected. Direct regulation therefore is effective in achieving minimum standards, but impose few incentives to exceed the standards. For example, there are clear indications that building energy codes are not sufficient to lead industry towards higher standards (Lee and Yik 2004). Dividing the burden equally among actors is generally not cost-effective, because there is no mechanism ensuring that environmental improvements are made where the cost of a given improvement is lowest.

Direct regulation is traditionally considered incompatible with promoting technological change. This applies particularly to technology standards that instruct the regulated parties to use a specific technology, because this creates a lock-in situation. Performance standards setting targets for performance, leaving it to the market actors to decide how to reach them, have a somewhat better reputation (Gann et al. 1998).

The most usual market-based instruments are taxes, subsidies and tradable permits. The incentives to adopt new technologies have been found to be larger under market-based instruments than under direct regulation (Jaffe et al. 2002). Newell et al. (1999) compared changes in energy prices and changes in energy efficiency standards. They found that while changed prices induced both elimination of old models and commercialisation of new models, regulation induced only elimination of the old.

Although the effect of a tax on energy and an equivalent subsidy for energy conservation technologies theoretically should give the same result, it has been shown for energy conservation technologies that a subsidy has larger effect (Jaffe and Stavins 1995). In other words, it seems like lower adoption costs are preferred to higher future earnings. However, subsidies have the disadvantages that they favour certain technologies and do not provide incentive to reduce energy consumption per se, they are expensive to society and they normally do not distinguish between adopters who depend on the subsidy and adopters who would have made the investments anyway. In the case of energy conservation technologies that are already profitable to the adopters, it is also hard to argue that subsidies are justified. The informants in the case study, embraced the idea of subsidies. Of course, from their point of view, subsidies are preferable because it is a positive stimulus.

Generally, attempts are made to limit public intervention in markets because according to neoclassical economic theory it reduces the profits of the regulated actors. In the case of market failures, the theory suggests that overall profit to society is increased, but this happens at the sacrifice of the regulated parties. Evolutionary economic theory, embracing the idea of satisficing, suggests that it is possible to create “win-win” situations in which both the environment and the regulated parties profit (Jaffe et al. 2002). This is a logical consequence of the assumption that firms do not optimise; facing regulation, the firm may simply change its’ strategy, possibly increasing, possibly decreasing its’ profits. The case study did not give clear indications regarding satisficing behaviour, but the idea of double profits is of course attractive and this possibility should be considered when arranging policies.

Voluntary agreements are arrangements where organizations make commitments to improve their environmental performance. The agreements may be unilateral, in which the polluters are the only parties involved, they may be negotiated agreements between industry and public authorities or they may be voluntary programs developed by public authorities (Lee and Yik 2004). Unilateral agreements are relatively rare. Negotiated agreements usually mean that the authorities refrain from direct regulation given that the organizations themselves take measures to achieve certain targets. Examples of voluntary programs are certain energy efficiency labelling schemes which aim to provide indirect incentives to exceed the mandatory requirements and common practices.

In contrast, voluntary agreements offer greater flexibility in how to reach the targets, and giving responsibility to the industry itself, it may encourage innovative solutions. However, there is a chance for free riders and that the industry is unable to make arrangements and improve performance. Lee and Yik (2004) suggest that mandatory standards and voluntary energy labeling should be used together to achieve both minimum standards and incentives to exceed these standards. Because voluntary agreements require that private organizations take responsibility, they are most suitable for pro-active industries, small number of participants, mature sectors with limited competition and given long term targets (Worrel and Price 2001). As noted in the introduction of this chapter, the construction industry is heterogeneous and not-well-organized. Competition is hard, and most actors are only occupied with profit and meeting government regulations. In this situation, voluntary agreements are probably hard to arrange.

Referring to the discussion of positive and negative feedback loops in chapter 7.1 above, the government’s response to technological changes should be taken into account.

Because diffusion of a superior technology for energy conservation decreases the aggregate costs of energy conservation, the efficient level of control changes. If both the marginal costs of energy conservation and the marginal costs to society of energy use (the damage costs) are increasing, then a reduction in the costs of energy conservation increases the optimal level of conservation and lowers the "conservation price", as illustrated in Figure 7-2.

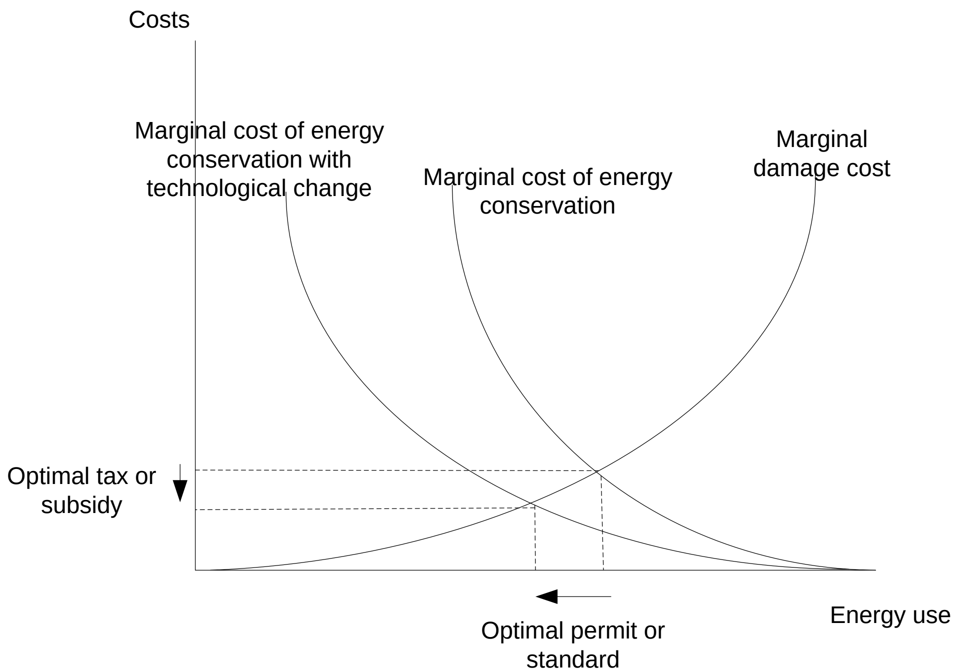

Figure 7-2: Government response to technological change.

The logical response from the government would be to decrease the number of permits, to set the standards at lower levels of energy use, to decrease the subsidies or to decrease the tax rate. Only under a tax scheme are the regulated parties' interests compatible with the governments'. Under the other arrangements, the industry may restrain technological change because they expect that it will result in stronger regulation. Under voluntary agreements, the benefits apply to the parties of the agreements. In the case of negotiated agreements, successful performance in one period, may lead the authorities to require further improvements for the next period.

Several of the case study findings correspond to the behavioural approach. The importance of individuals is central within this approach, as is non-economic motivation factors. The possible result that actors may not form rational expectations in the economic sense, is supported by behavioural theory. This theory proposes strategies that for example increase the attractiveness of the building. This seems relevant in relation to the focus on maintaining building value. The importance of the timing of interventions is also relevant, particularly in relation to the case where energy efficiency measures never are considered isolated.

Concerning the choice of policy instruments, there are clear indications that direct regulation should be used to set minimum standards, and it seems very likely that other instruments are preferable for achieving progress and technological change. Recognising that the actors involved in the building sector, i.e. building owners and managers, occupants and the construction industry is a very heterogeneous and not well-organized group, voluntary agreements are probably hard to arrange, at least in the short run. The case study revealed that relevant actors do not necessarily behave the way economists assume, and a combination of instruments inspired by the behavioural and organizational theory, and market-based instruments therefore may be appropriate.

8 Examples of strategies

A large number of strategies have been proposed and tried in order to increase energy efficiency in buildings. Some examples are voluntary energy labelling, public procurement of certain technologies, favourable financing, and information and awareness drives. To give a thorough analysis of all the possibilities has not been the objective of this project. Rather, a few alternatives that are particularly relevant given the focus of thesis until here, has been explored. The ones that are presented here, are energy contracting, energy certifying and start-up help for establishing goals and routines.

Energy contracting has been chosen because it provides a possibility that the potential may be utilized by commercial actors without public spending. In addition this service is relatively widespread abroad, which gives reason to explore if there is a potential in Norway as well. Energy certification has been chosen because this instrument will be implemented shortly, and is interesting to consider in elucidation of the case study and the general discussion of strategies above. The start-up help is an idea that is generated directly from the case study.

8.1 Energy contracting

Some firms have made energy conservation a business through energy contracting. This means that the firm, sometimes called an energy investor, proposes an investment to a building owner and guarantees that the building owner will profit. The arrangement of the contract may of course vary. Normally the firm makes an energy efficiency analysis and proposes investments based on this. The building owner may make the investment himself or the energy service firm may make the investment. In the first case the energy investor still guarantees that the saved energy costs are sufficient to pay back the investment, and in case this does not hold, he will have to pay the difference. In the latter case, called third party financing, the building owner pays back the investment over a given period of time. When the investment is paid back, the building owner takes over the equipment and may take the full benefit of the savings. In both cases the energy investor is responsible for planning and implementation. Often, service, maintenance and training are also included in the contract and performed by the energy investor.

8.1.1 Advantages and disadvantages

Energy contracting may contribute to overcoming some of the possible barriers to energy efficiency investments. Firstly, the problem of poor information and competence is strongly reduced because neither the building owner nor the operator needs to feel sure about the technology introduced. Sandvei (2004) found that caretakers were more willing to go for an installation if the energy investor provided service and maintenance. The caretakers felt safer about taking charge of the equipment after running-in that being responsible from the start. This is obviously not the case for all organizations. The informant in organization C of the case study emphasized that he would be afraid to let external actors be responsible for the enterprise's equipment.

Secondly, financing is made easier because the building owner may make use of third party financing if providing capital for a large investment is hard. In principle it is possible to arrange contracts that keep the total costs of the building owner at the level of expected energy costs in absence of the improvement, of which a fraction covers energy costs while the rest is pay-back for the investment. The results of Energidata (1997) presented in chapter 3 suggest that financing is not among the most important barriers. The case study also revealed that although the organizations do not have enough finance capital to make all profitable investments, this is not necessarily considered a problem.

Thirdly, the risk of the building owner may be reduced or completely removed. The energy contractor may be better suited to carry the risk because aggregated over a number of projects, risk is lower than for an individual investment. The building manager in case D added an interesting point of view. He suggested that including an external actor possibly could make tenants more willing to pay the cost of the investment because of the separation of the energy efficiency cost from other costs.

Because energy contracting involves some extra costs, the present value of an investment is lower than without contracting, and the energy savings need to be larger to ensure profitability. Therefore, contracting is most relevant for buildings where the energy use is large to begin with. In effect, for energy contracting to be profitable, yearly energy use normally needs to be 1,5 GWh or more, corresponding to 6000 m^2 of heated area in an office building (Zsak 2005). It is, however, possible to achieve the necessary volume by arranging a common contract for several buildings. Experience from other

European countries implies that the energy savings potential should be at least 30 % to make a contract profitable. Energy contracting is not widespread in Norway, but some consultancy agencies offer this service. See Zsak (2005) for examples.

8.1.2 How to promote energy contracting

Energy contracting may be provided by new or existing firms. The advantage of existing firms is normally larger equities and better credit among external investors. Electric utilities may be motivated by the prospect of avoiding expansions of the electricity grid. This motivation is of course limited because the main interest of the utility is to sell electricity. Responsibility for energy saving has been removed from the utilities of this reason, and electric utilities should probably not be target for a potential campaign to promote energy contracting. Suppliers of equipment have the advantage of detailed knowledge of operation, service etc. of their own products. With respect to optimizing energy and monetary savings, there is of course the disadvantage that these firms will favour their own products even if other alternatives may be better. A third alternative is suppliers of services. Their advantage, which also may apply to suppliers of equipment, is the possibility of providing outsourcing not only for energy, but for other functions as well. The possibility of making several cost-cutting investments with the same contractor may be attractive to building owners. Suppliers of services may need to hire competence on energy technology. Last, energy consultancy firms may provide contracting. They have the necessary knowledge and are objective with respect to the choice of technology. Their disadvantage is normally low equities and thereby not good conditions for taking up loans (Zsak 2005).

Because there is a business potential in providing energy services, we should expect firms to take advantage of this possibility. When this does not automatically happen, government intervention may be justified to "help firms help themselves". For example, in Germany the Government has promoted energy contracting by stimulating development of standardized contracts (NOU 1998:11). In St.meld nr 29 (1998-99) energy contracting is presented as desirable, but other instruments in the energy policy, such as the building regulations and efforts to make electricity costs more visible, are considered sufficient to promote energy contracting.

8.2 The EU directive on the energy performance of buildings

The EU directive on the energy performance of buildings[7] includes stipulations of a standardised method for calculating the energy use of buildings, minimum standards for energy efficiency in new buildings and large buildings that are renovated, energy labelling, and requirements of visible energy labelling in large public buildings. The directive is approved by Norwegian authorities and will be implemented into Norwegian law. Probably, the implementation will happen gradually through 2007 and 2008, and full implementation will come in 2009 (NVE 2006b).

The effect of the directive is that all new buildings, large buildings that are renovated, large public buildings and buildings that are sold or let, need an energy certificate. The certification will be conducted by an external consultant, and it will include information on the energy performance of the building, assessed by an energy label on a scale from A to G, and a list of possible measures for improvement, including economic considerations. The minimum standards in the building regulation are also being changed, and the standards and the certification scheme are supposed to be compatible.

The aim of the arrangement is both to make energy use visible for owners and occupants and to propose specific actions for improvement. The arrangement can therefore be characterised as an information strategy. Remembering that Energidata (1997) found that lack of information was the cause that 50 % of the efficiency potential was not realised, the arrangement seems justified.

The direct effect of the system would constitute a negative feedback loop. The list of profitable measures that comes with the certificate includes a finite number of measures. The more projects that are carried through, the less is the remaining potential. However, there is a possibility that increased demand for energy efficiency stimulates suppliers and induces technological change. Positive feedback loops may arise this way. With reference to chapter 7.4, the government’s logical response to technological improvements would be to strengthen the standards for the certification. This will presumably not constitute a problem because the individual building owners are too small

[7] Directive 2002/92/EC

to recognise the connection between their performance and the level of the standards. In addition, the actors at the supply side would gain from stronger standards if they are able to come up with technological solutions.

8.3 Start-up help

The case study results indicated that having centrally defined goals regarding energy efficiency is important. It also showed that the path until defining goals may be a challenge, i.e. initiative seems incidental, and the idea is vulnerable in the process of realizing initiatives into decided goals. A strategy that initiates goal setting and supports the organization until goals have been established therefore may be useful.

The start-up help could be inspired by environmental management systems. Establishing an environmental management system involves setting up a structure for how to improve one's environmental performance. Important aspects are creating an environmental policy, mapping the organizations environmental impacts, defining targets and programmes and implementation and operation. To secure continual improvement, the actions taken should be revised and corrected, and the management should review the results. The process is illustrated in Figure 8-1. For this purpose, the top three boxes of the figure are most important; i.e. how do we make the wheel start rolling?

There are a number of environmental certificates (for example ISO 14000, EMAS, Miljøfyrtån) that organizations can achieve if they fulfill certain requirements of an environmental managements system. The certifying agencies provide guidelines and help in the process of establishing systems that fulfill the requirements. For the organizations, the incentive to achieve a certificate can be both cost-saving and that some customers demand it. In contrast to the energy certificates described in chapter 8.2 above, that describe performance, environmental management certificates guarantee that the organization has a system for improving, regardless of their level of performance and that they committed themselves to strive for continual improvement.

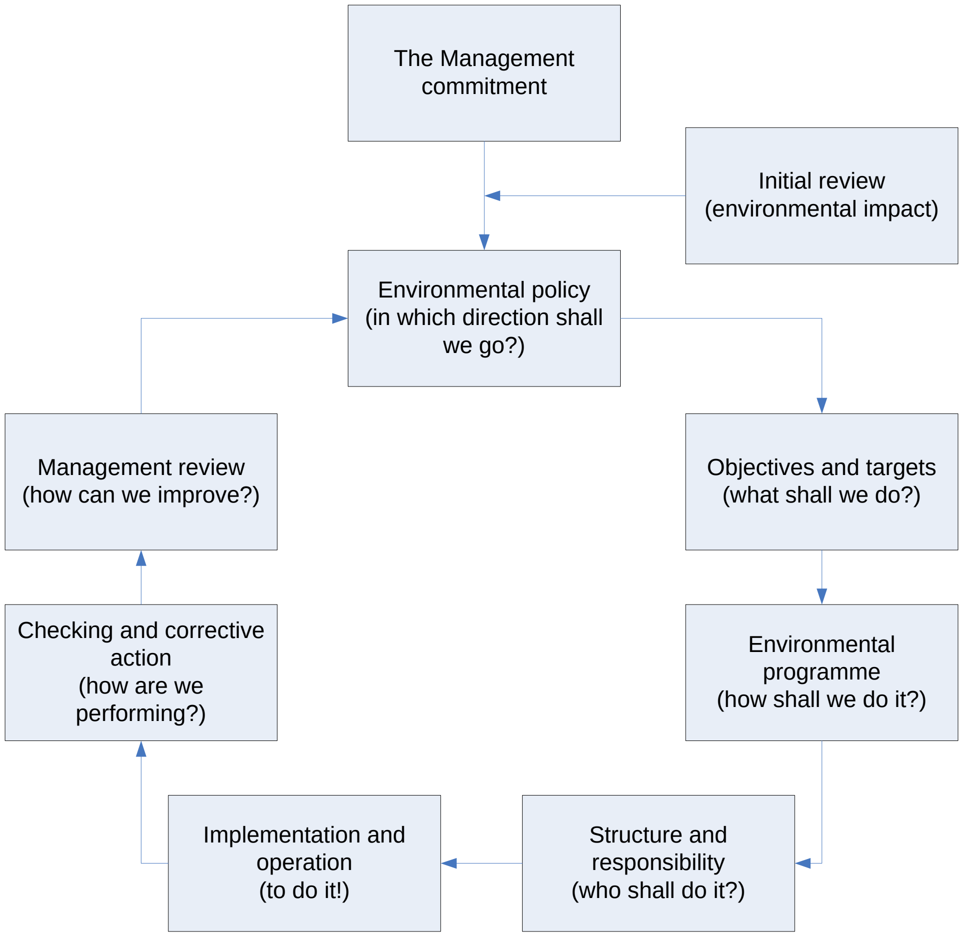

Figure 8-1: Environmental management system (Fet 2003).

The start-up help would involve encouraging organizations to start establishing an environmental or energy management system. This would presumably be in the interest of certifying agencies and could possibly be done without subsidizing. Of course, more certifying will not come be itself, and public effort could be needed to start the process. For example, the government could promote certification by first requiring that public organizations can document energy management systems, and next demand similar documentation from suppliers of goods and services for public organizations. The encouraging of organizations could happen through general information and publicity about management systems, or through outreach activity. Because part of the objective is to make up for lacking initiative in the organizations, looking up organizations and propose ideas to them would probably be more effective. The choice of strategy for recruiting customers would of course be a trade-off between costs and results.

Referring to the Bass model (cf. chapter 7.3.1) the organizations that achieve start-up help should be encouraged to communicate their programmes, for example by demanding similar efforts by their suppliers and contractors. Including the certificate logo at stationary and advertising articles could be positive to the organization and by increasing observability, increasing the awareness of the system.

Energy management could be established separately or as a part of a broader environmental management programme. The last option would probably be most beneficial for most organizations because cost-cutting could be possible at other areas and the brand mark of the certificate would be more acknowledged. The danger in this context, is that focus could be only on the direct production processes and energy use in buildings therefore would disappear from the agenda. It could possibly be a task for the certifying agency to encourage focus on this part, for example by demanding energy labeling and follow-up of proposed measures in energy certificates.

9 Conclusions

The aim of the project has been to understand why profitable investments in energy efficiency are not realised, in order to suggest policies and business strategies to take advantage of the opportunities. The literature on the efficiency gap is extensive, and the review given in this thesis is by no means complete. Nevertheless, by approaching the issue from different theoretical notions, it provides a broad understanding of the aspects that are dominating the debate of the causes of the energy paradox. Quantitative measures of the efficiency potential in non-residential buildings have been referred. The estimated value of the technical and economic potential is approximately 7 TWh. The uncertainty of the estimate is large, but a better estimate could not have been made within the scope of the project. Some of the aspects described in the theory part have been investigated through the case study. Using a qualitative approach has resulted in valuable insight into decision processes and motivation. Because the data material gathered for each case has been less extensive than desirable, in some respects we need to be careful about drawing conclusions about the organizations as wholes. The results of the case study can be summarized as follows:

1. All the organizations work systematically with energy observation and improving practices. Larger investments seem to be less prioritized.
2. The building managers do not seem to experience that uncertainty about future energy prices is a problem. A possible explanation is that they deal with uncertainty by being conservative.
3. Direct economic profitability is the main driver for implementing energy-efficiency measures. Maintaining the building value is also important.
4. The indirect economic benefits of a good environmental profile may possibly be an important driver for being ambitious.
5. The start-up and establishment of an energy efficiency program may depend on individuals.
6. The users of the buildings often lack incentives to care about energy efficiency and the real estate servants experience problems engaging the users.

7. Competition among profitable projects is not considered a problem in the organizations.
8. The choice of investment objects is guided by strategic targets or general desirability.
9. The building managers consider themselves good at energy efficiency and communicate the perception that they utilize the potential for efficiency gains.

Some of the results may actually be used as hypotheses to be investigated further. This applies particularly to point 2, 4 and 5 above, but also the other results provide additions to the theory that may help articulate clearer research questions in the future.

The discussion of strategies to increase implementation of energy efficiency measures focuses on the importance of arranging policies that allows for technological change, and how to promote diffusion of energy conservation technologies. The most important results of this discussion is that one should look for strategies that create positive feedback loops and that one possibly may try to utilize interpersonal communication for spreading of ideas and technologies. With respect to policy instruments, it seems like market-based instruments are better suited than regulations and voluntary agreements for the building sector, particularly with respect to promoting technological change. Because the analysis has shown that non-economic aspects are important in explaining the existence of the efficiency gap, policy instruments based on the behavioural and organizational approaches should probably also be used.

The results regarding strategies are indeed general, but to give exact recommendations based on the data material presented in this thesis would be neither possible nor justifiable. A thorough discussion of strategies should take into account the supply side of the market for energy efficiency technologies and be based on a broader understanding of the demand side than the one presented here. The strategies for new and existing constructions should be seen together, and a review and assessment of policy instruments and business strategies that have been tried, both in Norway and abroad, would be appropriate.

Nevertheless, a few examples of strategies have been presented. Based on the theory, the case study results and the discussion of strategies, it seems like the planned energy certification scheme is justified. The results regarding energy contracting are not exclusively positive; there are implications that the barriers that contracting help overcome, are not the most important barriers. However, energy contracting is relatively widespread abroad and it may turn out a success in Norway as well. Given that having environmental or energy reduction goals as part of the organization's overall strategy is important for performance, some kind of general or specific start-up help for establishing goals and routines may be justified.

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Appendix 1: Interview guide

General questions

Have energy efficiency analyses been carried through?

Have energy efficiency measures been carried through? What kind of measures?

Has the profit (in terms of energy and money) been as expected?

At what level is the specific energy use in your buildings?

Decision processes

Where does the initiative to an investment normally come from?

What kinds of analyses are made before the decisions (present value analyses?)?

How long pay-back periods are acceptable?

Are the requirements regarding pay-back the same for investments in energy efficiency and investments in for example production equipment?

Is it possible to carry through all profitable investments or is there competition between profitable investments? Is there a fixed sum for investments?

Is taking up loans a possibility?

Which sub-organizations are involved in the decision making? How is the budgeting procedure?

Which decisions do you make locally and which decisions are taken centrally in the organization?

Are non-economic criterions important in deciding which investments to make? Which?

How large are the energy costs relative to the total budget or operation costs?

Motivation

Who receives the benefit from reduced energy costs? Do the sub-units/ occupants have incentives to conserve energy (do they pay the energy costs?)?

Can the rent be increased when energy efficiency improvements are made?

Are there differences regarding which tenants propose investments? Are there differences to which degree the tenants are heard? (Long time contracts vs. short time contracts, large vs. small tenants).

Is reduced costs sufficient motivation for considering energy efficiency investments?

Is improved indoor climate a possible motivation factor? Will improved indoor climate lower the requirements regarding pay-back?

Can improved environmental profile work as motivation?

Barriers

What do you consider the largest impediments for implementation of energy efficiency measures?

If there is uncertainty whether an investment is profitable, for example because of uncertain future energy prices, would the decision be postponed? Do you have examples?

Strategies and public instruments

Have you been in contact with Enova? In what way? Have you received support? How do you experience the instruments?

Which public instruments do you think would have most effect on your organization?

Some companies offer energy services (energy contracting). Could this be interesting to the organization? Advantages and disadvantages?

Appendix 2: Information sources for case study

Case A: Small municipality

- Interview with leader of the real estate section, responsible for administration, operation and maintenance.
- Energy efficiency of administration building.
- Report on energy use in municipal buildings.
- Organization chart of the municipality.

Case B: Large municipality

- Interview with servant at the real estate section working with energy efficiency.
- Data on energy use from the web system of the municipality.
- Organization chart of the municipality.

Case C: State enterprise

- Interview with servant responsible for real estate (this person is actually the only person working at the real estate “section”).
- Energy efficiency analyses of office/ production building.
- Energy observation system on web (information on energy use in all buildings over time).
- Web page (general information on the enterprise).

Case D: Real estate company

- Interview with operation engineer, administering and planning maintenance and operation.
- Data on energy use from the web system of the company.
- Web page (general information on the company).

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The Industrial Ecology Programme (IndEcol) is a multidisciplinary university programme established at the Norwegian University of Science and Technology (NTNU) in 1998 for a period of minimum ten years. It includes a comprehensive educational curriculum launched in 1999 and a significant number of doctoral students as well as research projects geared towards Norwegian manufacturing, energy and building industries. The activities at IndEcol have a strong attention to interdisciplinary research and teaching, bridging technology, natural and social sciences in the search for sustainable solutions for production and consumption of energy and resources.

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