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Plan and Reality

– Municipal Energy Plans and Development of Local Energy Systems

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Sammanfattning

Enligt lagen om kommunal energiplanering ska varje svensk kommun ha en energiplan för tillförsel och användning av energi. Huruvida energiplanering är ett bra sätt att styra det kommunala energisystemet är dock omdebatterat. Denna avhandling studerar innehåll i, och implementering av, ett antal svenska kommunala energiplaner. Energiplanernas effektivitet studeras på två nivåer: uppfyllelse av mål och visioner i planerna, samt hur detta bidrar till att uppfylla de nationella energipolitiska målen.

Forskningen baseras på tre studier: en studie av innehållet i tolv energiplaner från Östergötland, en studie av mål och visioner i sju energiplaner och hur energisystem utvecklats efter energiplanerna antagits, samt en fallstudie av Kungälvs kommun där mål och måluppfyllelse studerats mer utförligt. Innehåll och målformuleringar i energiplanerna har analyserats med avseende på miljö, effektiv energianvändning och systemnivå. Mål och måluppfyllelse har även analyserats med avseende på aktörer.

Resultaten visar på att de studerade energiplanerna har smal systemsyn och att de miljöanalyser som finns i planerna är undermåliga. Energiplaneringen har varit effektiv till viss del. Bäst måluppfyllelse har kommunerna när det gäller mål på en relativt låg systemnivå och när det är kommunen själv som äger frågan, exempelvis fjärrvärmeutbyggnad och energieffektivisering av kommunens lokaler. När det gäller utvecklingens bidrag till de nationella energipolitiska målen är resultaten varierande: användning av biobränslen har ökat avsevärt, medan självförsörjningsgraden på el bara ökat något. Bäst är utvecklingen när det gäller minskade koldioxidutsläpp.

Baserat på bristerna som upptäckts i de studerade energiplanerna och dess implementering förs en diskussion kring möjligheter att öka energiplaneringens effektivitet och vidga systemsynen. Förbättringar som diskuteras är att stärka kopplingen till fysisk planering, och att inkludera medborgarmedverkan och miljöbedömningar. Om kopplingen till energifrågor stärks i översiktlig planering och om även privata aktörer kommer till tals under planeringsprocessen, skulle detta kunna underlätta implementering av energiplanerna. Miljöbedömningar i sin tur kan bidra med en vidare systemsyn om mer relevanta mål i planerna. Slutligen föreslås att ramverket för miljöbedömning av planer och program (2001/42/EC) kan användas vid energiplanering eftersom det framhåller vikten av breda analyser, samråd med privata aktörer och miljöbedömningar.

Abstract

Swedish municipalities are required to produce a municipal energy plan for energy supply and use. Whether energy planning is suitable to manage local energy systems, however, is subject to debate. This thesis explores municipal energy planning and development of local energy systems after energy plans were adopted to examine whether energy planning is effective. The effectiveness of energy planning is studied on two levels: in terms of whether goals in energy plans were implemented, and whether energy planning contributes to fulfilling national energy policy goals.

The research is based on three studies. In the first, the scope of twelve municipal energy plans from a Swedish region was assessed. In the second study, goals and visions in seven energy plans were analysed and compared to the development of the local energy systems. The third case involved Kungälv municipality, where the implementation of goals in its energy plan was studied more thoroughly. Scopes and goals in the energy plans were analysed from three perspectives: the environment, energy efficiency and the systems level. Goals and development were also analysed from an actor's perspective.

The results show that the scopes of the studied energy plans have narrow systems boundaries, and that the environmental analyses presented in the plans are very basic. Energy planning was found to have been fairly effective in terms of fulfilment of goals in energy plans. Most positive developments are for goals on a relatively low systems level when the local authority owns the issue, for example district heating expansion and energy efficiency measures in public buildings. When it comes to contributing to national energy policy goals, results vary; use of biomass has increased, but self-sufficiency in electricity supply has increased only slightly. The most favourable development when it comes to energy-related emissions is the reduction of carbon dioxide.

Based on shortcomings identified in the studied energy plans and implementation, possibilities to increase the effectiveness and widen the scope of energy planning are discussed. Improvements are discussed in terms of urban planning as well as participative planning, and with respect to the environmental assessment of plans. If energy issues are included in urban planning and a participatory planning approach is used, this could facilitate the implementation of energy plans. Including environmental assessment could facilitate wide scopes and more relevant goals. It is also proposed that the EU framework for environmental assessment of plans and programmes (2001/42/EC) can be used for energy planning, since it includes a comprehensive approach, public participation, and environmental assessment.

Acknowledgements

Without guidance and support from a number of people, this thesis would never have been finished – I owe you all great gratitude. First of all, I am very grateful to my tutors, Anders Mårtensson and Olof Hjelm. Anders' extensive knowledge about energy systems and scientific writing has been fundamental to my work, and Olof's intelligent and patient support during the writing process has been invaluable. Of course, I am also thankful to all my colleagues at Environmental Technology and Management for all their ideas and advice. I also would like to thank Kristina Holmgren, Karin Westerberg and Jenny Palm for feedback and ideas.

I am very thankful for financial support from the Swedish National Energy Administration and the Swedish Environmental Protection Agency, as well as the opportunities to participate in the research programmes "Utsläpp och Luftkvalitet" (Emissions and Air Quality) and "Miljöstrategiska verktyg", MiSt (Tools for Environmental Assesment and Decision Making), respectively. Seminars and discussions in these programmes have been very enlightening.

I would like to thank my family and friends for their support, whether you have a clue about what I am "studying" or not ;-). I want to especially thank Mats, Jenny, and Johan for being the best of friends. I don't have words for how much you mean to me!

Last, but not least, I thank Anders for bringing sunshine back into my life again.

List of papers

This thesis is based on the following papers and appendices[1]:

Papers

Paper I — Nilsson, J. and A. Mårtensson (2003) Municipal Energy Planning and Development of Local Energy Systems, *Applied Energy* **76**, 1-3, 179-187.

Paper II — Nilsson, J. and A. Mårtensson (2002) Municipal Energy Planning and Energy Efficiency, *Proceedings of the 2002 ACEEE Summer study on Energy Efficiency in Buildings*, Pacific Grove, CA, USA.

Paper III — Stenlund, J. and A. Mårtensson (submitted) *Municipal energy planning - An effective tool for managing local energy systems?*

Appendices

Appendix I — Study on energy plans and energy system's development

Appendix II — Study of development of energy systems development in terms of national indicators

Related papers

Papers not included in this thesis with relevant information for interested readers:

Nilsson, J. and A. Mårtensson (2002) Municipal Energy Planning and Renewable Energy, in Sayigh, A. A. M. (ed.) (2002) *Proceedings of the World Renewable Energy Congress VII, 29 June - 5 July 2002,* Cologne, Germany.

Stenlund Nilsson, J and Tyskeng, S (2003) The scope of municipal energy plans in a Swedish region. A review of energy and environmental issues in the plans. Linköping, Linköping University: LiTH-IKP-R-1274

Stenlund Nilsson, J, Tyskeng, S et al (2004) Strategisk miljöbedömning av lokala energisystem. Projekt nr P12615-1. Slutrapport 2004-03-31 från ett projekt i Energimyndighetens program Utsläpp och luftkvalitet.

[1] The author changed names in 2003 and 2005, which means that Stenlund (2005-), Stenlund Nilsson (2003-2005), and Nilsson (-2003) refer to the same author.

Word list

Term	**Explanation**	**Swedish**
Alternative vehicle fuels	For example biogas, ethanol, biodiesel	Alternativa fordonsbränslen: biogas, etanol, RME (rapsmetylester)
Ash, flue ash	Solid combustion residue, solid combustion residues that are filtered from exhaust gas	Aska, flygaska
Biogas	Gas for energy purposes. Methane (CH_4) from fermentation of biological waste products or sludge	Biogas
Boiler	General term for combustion devices	Panna
CHP, combined heat and power	Combined heat and power plant where combustion, often biomass based, is used for both power generation and district heating	Kraftvärme
Comprehensive plan	Municipal over-all plan	Översiktsplan
District heating and local district heating	Centralised heating systems for buildings, based on a hot water distributions system	Fjärrvärme, närvärme
Exhaust gas cleaning	For example catalytic converters or electrical filters	Rökgasrening
Flue gas	Exhaust gas from combustion	Förbränningsavgaser
HVAC	Heating, Ventilating, and Air-Conditioning	Värme, ventilation och komfortkyla – som “VVS utan sanitet”
Local authority	The administrative body within the municipality	Kommunen som myndighet
Local government	The political (decisive) body within the municipality	Kommunfullmäktige
Municipality	Geographical area as well as decisive and administrative body	Kommun

Municipal administration	The administrative part of the local authority	Kommunala administrationen
Private estates	Small houses: villas, terrace houses	Småhus
Purchasing	Swedish local authorities must follow a special procedure when purchasing. This provides possibilities to select the most favourable alternative according to specified requirements	(Offentlig) upphandling
Self sufficiency in energy supply	Energy policy goal for more domestic energy sources	Självförsörjning
Sewage sludge	Rest product from sewage treatment	Avloppsslam
Small scale solid fuel combustion	Combustion for heating purposes in small private houses, usually wood or wood pellet based	Uppvärmning med villapanna, baserat på fasta bränslen, oftast ved eller pellets
Sulphur emissions	The most common is SO_2	Svavelutsläpp
Transition	Shift, change (of the energy system)	Omställning

Table of contents

1 Introduction

This introductory chapter introduces municipal energy planning as a means for improving local energy systems. Thereafter, a description of how this thesis contributes knowledge to the research field is presented, along with the research questions.

1.1 Energy, environment and means to manage local energy systems

Energy use affects the environment. Impacts on the environment are caused during the entire lifecycle, from fuel extraction to conversion into heat and electricity to waste product treatment and disposal. There are two ways to reduce environmental impacts from energy: using less energy (energy conservation) and using renewable energy resources (RE) instead of fossil fuels. Implementing these strategies would mean matching energy use and supply using a systems perspective, as well as a transition to RE energy systems.

There are several international initiatives underway to decrease environmental impacts from energy use, for example the Kyoto protocol that emphasises reduction of greenhouse gas emissions (United Nations, 1997), and the Local Agenda 21 (LA21) that presents a more general approach towards sustainable development. Within LA21, the local level is especially emphasised to play “a vital role in environmental management” (United Nations, 1992). The local perspective is also seen as important in the European Union action plan to improve energy efficiency, where it is stated that “there is a large savings potential which can be realised by greater decentralisation of energy management” (Commission of the European Communities, 2000). Local initiatives that combine energy and environmental issues are therefore of interest to study.

One such approach is local energy management, which aims at directing the development of local energy systems when it comes to energy supply and use issues. Supply issues can include electricity generation, choices about energy carriers in incineration plants, or district heating expansion strategies. Use issues can include saving potentials in buildings, energy-efficient equipment or information campaigns to change user behaviour. Local energy management can also address energy issues in infrastructure planning, such as spatial planning or transport systems design.

Three examples of approaches to manage local energy systems are: Integrated Resources Planning (IRP), Community Energy Management (CEM) and Municipal Energy Planning (MEP). IRP has been used, for example, in the evaluation of choices about buildings and equipment from both the utility (supply) and customer (use) perspectives. The aim is to supply energy service at lowest cost to society (Bakken, 1996). CEM is an approach to include energy issues in urban and infrastructure design from the perspective of the local community (Jaccard, Failing et al., 1997). In Sweden, energy management is represented by MEP. Swedish MEP has its roots in Swedish energy policy aimed towards securing energy supply and reducing oil dependence

(Swedish National Audit Office, 1991) and is a legal requirement (SFS 1977:439). Swedish MEPs have had an emphasis on details and technical solutions, with a focus on energy supply (Stenlund Nilsson and Tyskeng, 2003) rather than minimizing costs (as with IRP) or urban design (as with CEM).

Whether or not energy planning is a suitable way to manage local energy systems is subject to argument. There are no broad national (or international) evaluations about whether energy planning has a beneficial impact on local energy systems or not, but energy planning is nonetheless both promoted and criticised. Several organisations and institutes describe potential benefits from energy planning. According to the California Energy Commission (1997) "a well-thought-out energy plan can (---) provide a focal point for some of the most difficult local government issues including land use planning, transportation system design, affordable housing and air quality management". The Joanneum research group (2000) highlights possibilities to learn about synergy effects and connections between different parts of the energy system as well as possibilities to find cost-effective solutions. There are also Swedish handbooks that describe benefits from energy planning (Johansson, 2001; Swedish National Energy Administration, 2001c; Swedish National Energy Administration, 2001a). Gains with energy planning described in these books include, for example, that an overall energy strategy can grasp several activities and that planning itself raises awareness of energy issues.

Several studies also note potential benefits from energy planning. Vince Quirk et al. (1993) discuss energy planning potential from an integrated resource planning (IRP) perspective, and highlight advantages when it comes to selecting among alternative strategies. Butera (1998) describes a situation in Italy where energy planning is a legal requirement for larger cities (>50,000), but note that very few have complied with this obligation. No direct explanations for the shortcoming are given, but Butera emphasises the need for energy planning to cope with rising energy demand and sub-optimisation such as simultaneous heating and cooling. Jaccard and Failing et al. (1997) state that "CEM appears likely to offer various benefits to individuals and society as a whole", even if costs for the process seem high. Witness of successful local CEM in terms of accomplished projects and use of new technologies has also been presented (Anderson and Doig, 2000)

However, there are those who are sceptical to energy planning as an approach to managing local energy systems. Guy and Marvin (1996) declare that different kinds of technical approaches to energy (supply) management have been made without analysis of the roles of institutions. They state that technical approaches to energy management may lead to better knowledge about the energy system, but are badly suited to deal with competitive institutions for energy supply and companies developing their own visions for future energy supply and use. However, Guy and Marvin highlight demand side management, a user-oriented approach to energy efficiency, as a potential way to reshape energy use.

When it comes to Swedish MEP, the National Audit Office (1991) states that the effects of municipal energy planning are uncertain. Lindquist (2000), Olerup (2000), and Palm (2004) note in separate studies that local authorities have limited influence on the local energy systems, even when it comes to the municipality-owned energy companies.

An analysis of available literature has found no studies on energy management initiatives and the actual development that included several municipalities and changes in environmental impacts associated to energy use. The contribution of this thesis is to add these dimensions by comparing planning and reality in municipalities that have adopted energy plans. It also assesses the effectiveness of energy planning as a means to manage local energy systems.

1.2 Objective

The overall aim of this thesis was to investigate whether energy planning was effective on two levels. The first level concerned the implementation of energy plans in terms of fulfilment of goals and visions stated in the plans; the second if the development in the studied municipalities corresponded to national energy policy goals. The research was based on three studies: an initial study on the scope of energy plans and two studies on how the development in the municipalities related to goals and visions in the energy plans. Based on the results from the three studies, correspondence to national energy policy goals was investigated.

This thesis is based on three main research questions: RQA – what is the scope of Swedish municipal energy planning? RQB – How well were the energy plans implemented? RQC – how does energy planning and development correspond to Swedish energy policy? Each research question was divided into a number of sub-questions.

RQA – what is the scope of Swedish municipal energy planning?

What were the contents of MEPs in terms of:

- Stated goals?
- Technical descriptions?
- Environmental assessments?
- Measures to follow up the plan?
- How they relate to municipal comprehensive planning?

RQB – How well were the energy plans implemented?

- Were goals and visions stated in the energy plans fulfilled?
- What happened to energy-related emissions?

RQC – how does energy planning and development correspond to national energy policy?

- How was energy policy reflected in the scopes of the energy plans?
- How did the development correspond to national energy policy goals?

This thesis focuses on the content of energy plans and what in fact happened in reality in terms of technical development and environmental pressure. Neither the energy planning processes nor implementation were studied. This limits the scope of the thesis from organisational and social aspects of energy planning, which of course are interesting and relevant to study if the research questions asked are “how” and “why” energy planning is effective or not. The scope is also limited to Swedish conditions, and to some extent to the chosen objects of study. However, this focus provides knowledge concerning what kinds of goals and visions were successfully implemented. Furthermore, the results reveal in what senses municipal energy plans are effective, and the concluding discussion suggests how energy plans can be developed, which could be seen as valid even in an international context.

2 Theoretical framework

This second chapter presents the theoretical background for the research. First, a brief introduction to systems is made, as well as discussion of the black box model as a way of studying systems. Thereafter, a framework of the assumptions on which this research is based – environmental impacts from energy and how these can be reduced – is presented.

2.1 Systems and the black box model

The systems analysis approach has been highlighted as well-suited to address the complex issues of energy (McIntyre and Padhan, 2003). In systems analysis, the study objects are systems. A system is defined as components with connections between them so that they form a unit. The system is distinguished from its surroundings by system boundaries, and can consist of smaller sub-systems (Ingelstam, 2002). Energy systems referred to in this thesis are of different sizes, as seen in Figure 1. In this thesis, the smallest, least complex technical systems are referred to as “detailed systems” or systems at a “detailed systems level”. These are, for example, HVAC systems or single energy plants. Detailed systems are part of bigger systems – “technical systems”. HVAC systems are, for example, parts of buildings and incineration plants are parts of district heating systems. If all parts of an energy system in a municipality – the “municipal energy system” – are considered, it is referred to here for example as a “large technical system” (LTS). The LTS, therefore, embraces all parts of the energy system, including its actors. Actors are people acting in the energy system such as suppliers, users or maintainers. The system boundary for the municipal energy system is the geographical boundary of the municipal territory.

Energy systems are very complex to study, not least when it comes to the LTS level. A way to facilitate analyses of processes that change energy systems is to use a “black box” model (see Figure 2). This simplified approach to study change in system properties focuses on the system’s state before (input) and after (output) the process (the black box), and not the process in itself. The black box approach is suitable to apply if the aim is to study a system’s properties without knowing every detail of the system (Ingelstam, 2002). Application of the black box model in this thesis is further described in Chapter 4.

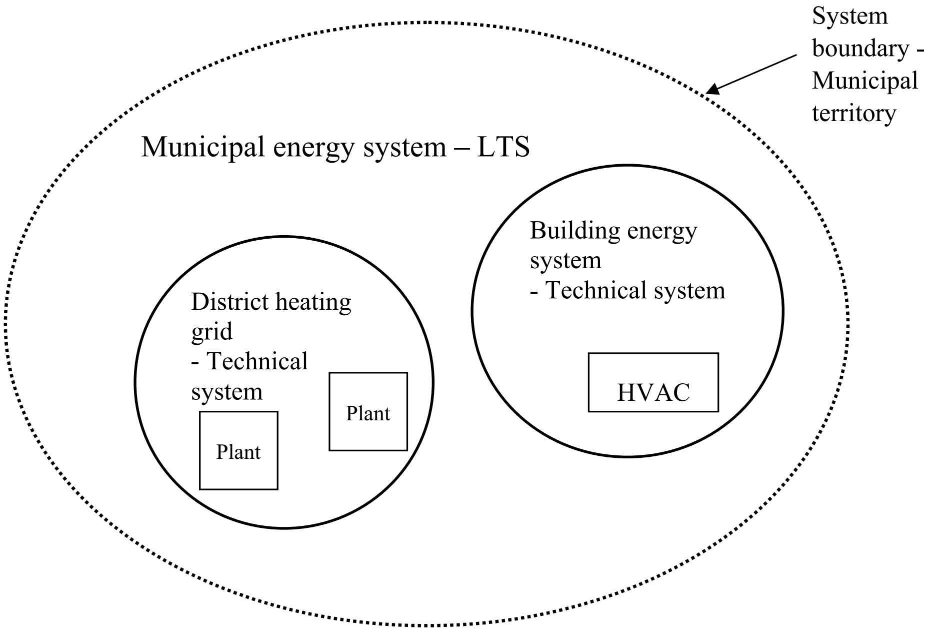

Figure 1. A municipal energy system with part systems on detailed level (boxes) and technical systems level (circles).

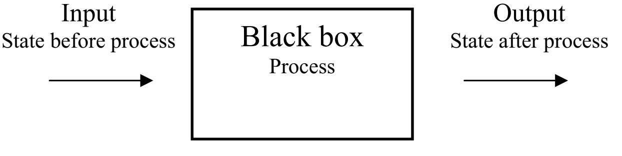

Figure 2. Black box model of a process that changes the properties of a system.

2.2 Theoretical approach to describe and analyse energy plans and development of energy systems

The theoretical base for this thesis can be described as a framework to analytically categorise and describe energy plans, and to assess effectiveness in terms of goal fulfilment. This framework is based on the three main assumptions seen in Figure 3:

- Energy conversion leads to environmental impacts
- Environmental impacts from energy can be decreased by efficient energy use and use of renewable energy sources
- Energy planning can facilitate improvement of local energy systems and scopes of energy plans affect the outcome of energy planning:
    - Systems approach – system level of goals and visions presented in energy plans are important factors when it comes to success in implementation
    - Actors – whether the local authority or private actors own the issues is important when it comes to success in implementation

The framework can be viewed as the "spectacles" for this research, through which energy plans and development in the municipalities that adopted them have been studied. This framework influenced, for example: how the contents of energy plans were analysed and categorised (RQA); measured effectiveness of energy plans in terms of fulfilment of goals stated in energy plans (RQB); and evaluated correspondence to national energy policy goals (RQC).

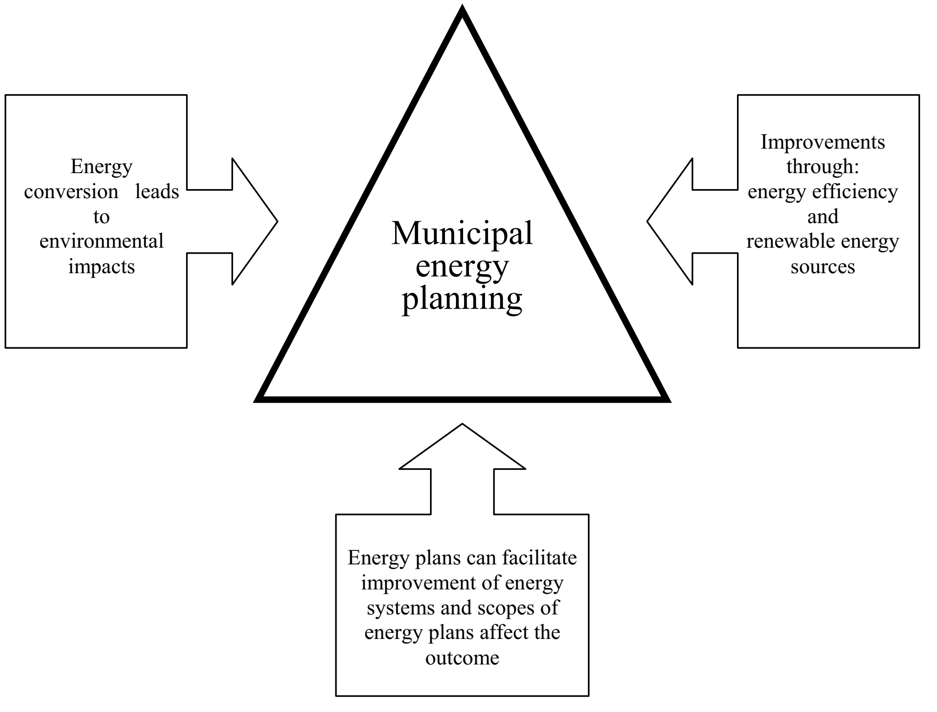

Figure 3. Theoretical framework applied to describe energy plans and assess their effectiveness. Boxes with arrows symbolise that these are views applied to the study object.

2.3 Environmental impacts from energy

As mentioned in the introduction, energy use affects the environment in all phases – from source extraction to waste product disposal. This is one of the three basic views that are applied in this thesis (see Figure 3). In addition to making energy resources scarcer, resource extraction also leads to local environmental impacts in terms of land use. During conversion from fuel to heat (or mechanical work), there are emissions of volatile organic compounds (VOC), polycyclic aromatic hydrocarbons (PAH), sulphur (SO_2), nitrogen (NO_x), and green house gases (GHG). Fuels also leave ash as combustion residue. The environmental effects from energy are complex in the way that they differ in space and time. Table 1 shows examples of environmental effects during a fuel lifecycle.

Table 1. Examples of environmental effects during a fuel lifecycle (see for example Svensson, Roth et al. (2006)).

Activity	**Example of environmental impact**	**Example of environmental pressure**	**Time horizon**	**Space**
Fuel extraction	Land use	Loss of biodiversity	Short – long	Local
Combustion	Emissions of:			
	VOC	Photo-oxidant	Short – long	Regional
		Toxicity		
	PAH	Acidification	Short – long	Regional
	SO_2	Eutrophication	Short – long	Regional
	NO_x	Climate change	Short – long	Regional
	CO_2		Long	Global
Residue treatment	Leakage	Toxicity	Long term	Local
	Waste of resources	Resource issues	Long term	N/A

2.4 Reducing environmental impacts from energy

According to the first law of thermodynamics energy can not be destroyed, only take another form. However, this does not mean that energy, useful for society, is abundant. On the contrary, it what kind of energy, and how it is used, that is important.

2.4.1 Energy efficiency

Energy efficiency can be viewed from two angles, efficient energy supply and efficient energy use.

Efficient energy supply – using suitable kinds of energy

One way to describe the importance of what kind of energy is used is the term "exergy". According to the theory of exergetics, as energy is always conserved, exergy is always consumed during a process (Wall, 1977; Wall, 1997; Wall, 2002). This means that exergy is a measure of the value of energy, or its usefulness (Wall, 2002). Table 2 lists a relative value for the usefulness of different energy sources.

Table 2. Exergy factors – relative values of usefulness – for some energy forms (based on Wall (1997)).

Energy form	**Exergy factor**
Mechanical energy	1.0
Electrical energy	1.0
Chemical energy about	1.0[a]
Nuclear energy	0.95
Sunlight	0.93
Hot steam (600°C)	0.6
District heat (90°C)	0.2 - 0.3[b]
Heat at room temperature (20°C)	0 -0.2[b]
Thermal radiation from earth	0

a. May also exceed 1 (due to choice of system boundaries)
b. This values depends strongly on the outdoor temperature

As Table 2 indicates, electricity is high-quality energy. Simplified, this is the case since electricity can be converted into all kinds of energy: mechanical work in a motor, sound in a speaker, or heat in an electrical radiator. Warm water, on the other hand, is low-quality energy, and can only be used in the last of the three examples above – heating a radiator.

When reading this thesis, it is important to have the exergy concept in mind. The analyses are based on the assumption that if energy is used, it should be of as low quality as possible. This means that electrical energy should not be used for purposes where other energy sources can be used. In Sweden, this would be applicable to for example space and tap water heating.

Efficient energy use – using energy more efficiently

"Energy efficiency" means providing the same energy service with less energy input. This service could be, for instance, to "transport a person from point A to point B". In this example, several ways of moving a person would suffice: by car, bus, bicycle, or on foot. In this case, walking or going by bicycle would be the most energy efficient, requiring virtually no energy input for the transport. However, if the energy service were defined as "transport a person from point A to point B within half an hour", or "transport a person within the same period of time as that a car would require and with no additional effort", energy efficiency would take on a different meaning.

This discussion suggests two different kinds of energy efficiencies: one that includes behavioural change and perhaps additional effort, and one that means energy efficient technologies, for example a car that uses less petrol but is as fast and comfortable as any other car. The first kind is not necessarily easy to follow up. Even if energy use has decreased, that does not necessarily imply that energy efficiency has improved; demand for a certain service, for example, might as well have changed. Therefore are various indicators commonly used to monitor energy efficiency (Swedish National Energy Administration, 2002c). An indicator can be defined as "energy used for a certain energy service". In this thesis, energy efficiency will be measured with Swedish national indicators (see section 4.4.2).

2.4.2 Renewable energy resources

Swedish energy policy is directed towards more use of renewable energy resources (RE) (Government bill 1996/97:84, 1997). There are a number of different kinds of renewable energy resources (RE), for example biomass for combustion, solar heat and power, wind power, and hydropower. Even though not based on finite resources, RE also affect the environment (World Energy Assessment, United Nations Development Programme et al., 2000). Biomass can replace fossil fuels in incineration power plants, be processed as vehicle fuels, and used for small scale combustion for heating buildings. Biomass fuels lead to environmental impacts during upgrade and combustion, but only marginally contribute anthropogenic carbon to the atmosphere (Uppenberg, Almemark et al., 2001a; Uppenberg, Almemark et al., 2001b), and the residual waste products are to some extent suited to recycle as fertiliser (Jacobson, 2003). Sun collectors for heating purposes or electricity do contain scarce metals: however, these are possible to recycle. Both hydro- and wind power plants mean impact on the local environment, although the effects to some extent disappear as the plants are taken out of use and removed.

Analyses in this thesis are based on the assumption that RE is preferable to fossil fuels and nuclear power. If the environmental impacts described in Table 2 are considered, the greatest advantages of RE are that if carefully used, they are not finite as oil, coal and uranium, and that the contribution of CO_2 to the atmosphere is much lower than for fossil fuels.

2.5 Energy planning can facilitate improvement of local energy systems

The last of the three main assumptions in this thesis is based on rational planning theory. Planning is a way to enforce political goals, and the connection between goals and means are logical and predictable (Sager, 1994). This, simplified, means that in an ideal case goals are set on a political level, planners write plans, and then what is planned for happens. Based on this rational view of planning, the assumption of this thesis is that energy planning is a way to change local energy systems. Based on this rational planning theory, it is also assumed that contents of energy plans affect the development in the municipality. The choice has been made in this thesis to focus on two theoretical levels when it comes to following up goals for energy plans: a systems approach and an actors level (those who own the issues that are set goals for).

2.5.1 Importance of a wide system approach

It is important to set up system boundaries around the studied system to make analysis possible; to effectively draw boundaries however, one must find a balance between the system becoming too complicated to study, and closing out what is interesting (Ingelstam, 2002). When it comes to analysing energy systems, a wide systems approach is emphasised to avoid sub-optimisation (Gebremedhin, 2003) and to include different sectors and issues (McIntyre and Padhan, 2003). Gebremedhin (2003) shows in his thesis that there are great potentials for integrated and more efficient heat supply systems. If systems boundaries during analyses are widened to include both municipal and industrial energy systems, cooperation potentials would be revealed. Gebremedhin means that integrated systems can help to reduce the share of fossil fuels and electricity used for heat generation, thereby reducing environmental impact from the energy systems. McIntyre and Padhan (2003) note that since energy is linked to complex problems, energy issues have to be tackled in such a way that other problems are not "aggravated". They also state that a holistic approach to energy issues, where the focus is not solely on supply or demand, can help to solve other problems linked to energy. One example is transport issues, where more efficient public transports can lead to reduced energy use, improved mobility and reduced emissions.

As mentioned at the beginning of this Chapter, municipal energy systems are viewed here in three system levels: LTS, technical and detailed. The assumption is that a systems approach for energy plans affects the actual development of the municipal energy systems both when it comes to effectiveness of the plan and whether the energy system develops toward more energy efficiency and renewable energy use.

2.5.2 Actors – importance of who owns the issue

The last assumption is that which actor or actors own the issue is important when it comes to success in implementation. This assumption is based on criticism regarding energy planning that the LA has limited or little influence over the local energy system (Olerup, 2000; Palm, 2004). When analysing goals and implementation, the assumption is also made that another important issue for success is whether or not the LA or another actor naturally owns the issues. Here, actions included in municipal responsibilities and activities performed by municipality-owned companies are regarded as issues owned by the LA. Goals and actions that would represent more or less effort from actors outside the LA are regarded as owned by "both" or by "private" actors.

3 Background to Swedish energy planning

This chapter aims at facilitating the understanding of the role of Swedish energy planning and how it has changed over time. First, a summary of events in energy policy leading to the current energy situation is presented. Following this, the roles of Swedish municipalities and their responsibilities when it comes to energy planning are introduced.

3.1 Swedish energy policy

From hydropower expansion to energy crisis

Since the first half of the twentieth century, hydropower for electricity generation gradually expanded,, and totally dominated the Swedish electricity supply until the 1960s (Kaijser, 2001; Radetzki, 2004). During the 1950s, nuclear power was developed, and complemented hydropower. Oil use for heating and transport purposes increased rapidly between 1965 and 1970 as well; in 1970, 66% of the total energy supply (including electricity) in Sweden came from oil (Radetzki, 2004). When the six-day-war between Israel and The Arabic states broke out in 1967 and oil transports through the Suez Canal were disrupted, Sweden's oil vulnerability due to heavy dependence became apparent (Moberg, 1987). Furthermore, the former (almost) political unity for hydropower expansion was now broken, and the expansion debated because of environmental concerns. This led to a political decision in 1970 where one third of the potential hydropower projects were stopped and turned into "protected rivers" (Radetzki, 2004).

Entering the 1970s, Sweden faced major challenges for its energy system: energy demand increased rapidly, oil dependence was heavy, and hydropower expansion was halted. Prognoses foretold that the energy demand would continue to grow rapidly. Nuclear power was proposed as an option for secure electricity supply with "low" environmental effects, but the safety aspects were also debated (Radetzki, 2004). It was only in 1973 that energy issues were first prominent in the political agenda before a Swedish election (Moberg, 1987); this was also about the time the term "energy policy" entered into common usage (Vedung, 2001).

In 1975, a whole new energy policy was established – the government aimed to give the state command of the development (Moberg, 1987). The 1975 policy was based on three major parts: oil reduction, energy conservation, and international cooperation (Radetzki, 2004). The oil reduction part was supposed to be based on development of domestic energy resources, increased use of natural gas and coal. The intention was to reduce vulnerability and environmental effects from oil use, and to preserve resources for future generations (Radetzki, 2004). The energy conservation part meant reduction of the historical increase in energy use from 4-5% annually to 2%. Among the political measures to attain this energy policy was the act on municipal energy planning (SFS 1977:439).

1977-1984 Nuclear power and energy conservation

The political standpoint after the election in 1976 was that no new nuclear reactors should be started (not even those under construction), and those already in operation be phased out by 1985 (Moberg, 1987). In 1980, an advisory referendum on nuclear power was held. The political decision after the referendum was that all reactors in use were to be kept, and those under construction were to be started. Sweden would end up with 12 reactors in all – a decision that would double the installed capacity of nuclear power in a few years. All nuclear power would then be phased out by 2010

A ten year plan for energy conservation in buildings was launched in 1978 with a goal to reduce energy use by 25-30%. This energy conservation programme continued into the early 1980s. To strengthen against oil dependence, municipalities were now also obliged to produce an oil reduction plan (Moberg, 1987).

District heating was expanded from 15 to 40 TWh between 1975 and 1985; this rapid expansion was made possible with the aid of different kinds of subsidies (Swedish National Energy Administration, 2001b). In 1980, 90% of district heating was based on oil, but the use of energy carriers shifted towards cheap coal. Some municipalities invested in waste incineration.

1985-1996 Dependence on nuclear energy

The main outline in the energy policy from 1975 was maintained in the 1985 energy policy, and the last two nuclear reactors were started in 1985 (Vedung, 2001). After the Chernobyl accident in 1986, new investigations on nuclear phase-out alternatives and safety aspects were launched, but it was reported that no new safety aspects were evident (Moberg, 1987). However, a government bill in 1987 presented new goals for the nuclear phase out: two reactors should be shut down by 1995. However, the phase-out agreement was abandoned again in 1991 (Vedung, 2001). In the new policy, the importance of "securing the supply of electricity and other energy" and maintaining "competitive prices" to promote economic growth were highlighted. The fixed date for the phase-out of nuclear energy was abandoned. The Swedish electricity market was deregulated in 1996.

During this period, use of oil decreased steadily. In district heating systems, oil was replaced by coal and biomass (Swedish National Energy Administration, 2001b). Natural gas was also introduced in 1985 in the south and southwest of Sweden. Gas use increased steadily until 1992, when use stabilised (ibid).

1997- Building a sustainable energy system

In June 1997, the Swedish government delivered yet another energy policy (Government bill 1996/97:84). The objective in this energy policy was to create a sustainable energy system by creating conditions for efficient energy use and cost-efficient energy supply. The policy was based on three main goals: "secure energy supply", "competitive energy prices", and "low negative impact on health and the environment". Furthermore, the bill states that this energy policy is a part of a goal to make Sweden a forerunner when it comes to ecological sustainability (Government bill 1996/97:84). To monitor the energy policy goals established in the 1997 energy policy, the Swedish Energy Administration (SEA) designed twenty indicators (Swedish National Energy Administration, 2002b; Swedish National Energy Administration, 2002c). In short, "secure energy supply" is measured by indicators about renewable and locally-supplied energy as well as efficient electricity use. Combined heat and power (CHP) generation is regarded as efficient. (Implicit is that district heating is the first choice for space heating in densely-populated areas in Sweden.) Energy prices should be kept down, preferably by efficient energy use. The goals for the environment are both related to emissions and resources, but focus is on emissions of CO_2, SO_2, and NO_x. The resource issue is followed up by indicators about locally-produced renewable energy sources.

A financial programme was launched after the 1997 energy policy. Support was given for connecting buildings to district heating systems, and new electricity production from renewable energy sources was subsidised. Priority was also given to research programs that would address keeping the cost of renewable energy low in order to make it competitive with nuclear and fossil energy. The financial programme following the 1997 energy policy included possibilities to develop local district heating systems and wind power. Municipalities could participate in a Local Investment Programme (LIP), which provided potential funding for increased use of RE (SFS 1998:23). Many municipalities have used the opportunity to apply for LIP funding to extend district heating.

3.2 Energy in Sweden today

As the outline of Swedish energy policy indicates, there have been large variations when it comes to the nuclear energy issue. In reality, nuclear power has persisted and represents roughly half the Swedish electricity supply; the other half comes from hydropower. Electricity is still relatively cheap, which has lead to Swedish industry using more energy than comparable industries in other countries (Dag, 2000). Low energy prices have contributed to low incentives for energy conservation, even though this has been on the political agenda for many years. Opportunities for improving the efficiency of Swedish energy systems have been emphasized for example in Dag (2000) and a governmental report (SOU 2001:2).

General trends for Swedish energy use between 1995 and 2000 is described by the Swedish National Energy Administration (2001b). Industrial energy use increased 16%, while energy use in the public service sector decreased by 8%. Total electricity use increased four per cent between 1995 and 2000. The largest increases were found in the transport (32%) and industry (7%) sectors. For households, total electricity use was constant, but for electricity-heated houses, use decreased 19% (Statistics Sweden, 2003). After the deregulation of the electricity market in 1996, electricity prices went down (Swedish National Energy Administration, 2001b).

Swedish energy policy has been more successful when it comes to efficiency in space heating; district heat is the dominating heating source in densely populated areas. In fact, forty per cent of the heat supply comes from district heating (Swedish National Energy Administration, 2001b). However, small scale combustion and especially electricity for heating are still common (Swedish National Energy Administration, 2005).

3.3 Swedish municipalities

In this thesis, the term “municipality” is used for the Swedish word “kommun”, which includes local government, local authority, and local territory within municipal borders. The local government (political body) and the local authority (administrative body) have the overall responsibility for delivering public services within the municipal territory.

3.3.1 Municipal responsibilities and the energy sector

The local authority is responsible for preparing plans, maintenance of municipal properties, and service deliverance, whereas the local government adopts policies and plans and bears official responsibility. Sweden has a long tradition of self-governance (Gustavsson, 1999), and municipal competence is regulated by the Municipal Act (SFS 1977:179, ; SFS 1991:900). The Municipal Act regulates municipal responsibilities, for example social and technical services such as water supply and waste and sewage treatment (Swedish Association of Local Authorities, 2003). A traditionally important part of the Municipal Act was a self-cost principle, which meant that the municipality could not use technical services to generate profit to support for example social services. Energy supply has traditionally been a municipal responsibility, even though it has not been an official part of municipal competence (Linquist, 1993).

With the deregulation of the Swedish electricity market came some exceptions in the Municipal Act (Gustavsson, 1999): municipal energy companies became free to pursue customers outside their municipality, and free to set prices at market level. The deregulation also led to many municipalities either selling or privatising their local energy companies (Swedish National Energy Administration, 2002a). For some municipalities, the energy company is now very profitable; for others, the deregulation was an opportunity to sell the energy company and quickly improve the financial situation (Palm, 2004).

Local authorities possess many opportunities to influence their local energy system: as planning authority, energy user, and public transportation provider. A significant part of the total energy demand in a municipality comes from the municipality's own organisation (Statistics Sweden, 2003). In addition, the municipality often provides energy-related information and advice to its citizens.

It is important to note that conditions differ widely between Swedish municipalities. Geographical locations, stock of local resources, political government et cetera all affect the prerequisites for the local energy system – and hence municipal energy planning.

3.3.2 Municipal energy planning

The act on municipal energy planning was established in 1977. It has been revised and completed with additional legislation several times. For example, to emphasise the reduction of oil dependency, a further requirement for a complementary municipal oil reduction plan was presented to municipalities in 1981 (Statens Energiverk, 1986). This complementary legislation addressed the conversion of local energy systems from oil-based systems to alternative energy sources and more efficient energy technologies. After the 1985 energy policy, the separate oil reduction plan was removed (Statens Energiverk, 1986). The municipal energy planning act was revised and the role of energy users as an important part of the energy system was acknowledged. Municipalities were encouraged to plan for supply, distribution, and use of energy (Swedish National Audit Office, 1991). Another goal following the 1985 policy was to integrate energy into the municipalities' overall planning process. In 1991, a requirement for environmental impact assessment (EIA) for the energy plan was added to the act on municipal energy planning. This requirement was replaced in 1997 with a weaker statement that required only a general environmental assessment of the energy plan.

The requirements in the act were vague, and therefore led to uncertainty about the obligations the municipalities had concerning municipal energy planning or how the planning should be performed (Riksrevisionsverket, 1991). When the act was adopted, the interpretation was that the municipalities were encouraged, rather than required, to develop energy plans (Swedish National Audit Office, 1991). Additionally, no national agency was appointed to approve or control the municipal energy plans (Statens Energiverk, 1986). During the 1990s, first the Swedish Agency for Economic and Regional Growth (NUTEK), and thereafter the National Energy Administration made several initiatives to encourage energy planning and clarify what energy planning could encompass. In addition, a series of handbooks on the subject were published (MILEN-serien) (Swedish National Energy Administration, 1998; Swedish National Energy Administration, 2001c; Swedish National Energy Administration, 2001a). However, in a national study in 2002, it was concluded that a minority (40%) of the Swedish municipalities had an energy plan that was less than five years old and 25% did not have an energy plan at all (Swedish National Energy Administration, 2002d).

4 Research process and scientific methods

In this chapter, the research process is described, along with the research studies, papers and how they relate to the three research questions. A description of how the studies were conducted is also provided.

4.1 Research process

This thesis is based on three sequential studies that resulted in three papers (Papers I-III) and two appended work papers (Appendices I and II). The first study contributes to answering RQA and RQC, while the second and third studies contribute to all three research questions. Relations between studies and papers and their contributions to RQA, RQB and RQC are presented in Figure 4.

The three studies are:

- First study – Scope of energy in a Swedish region (Papers I and II)
- Second study – Plan and reality in 7 Swedish municipalities: scope of energy plans and development in municipalities with energy plans adopted between 1995 and 1998 (Appendices I and II).
- Third study – Case study: Kungälv (Paper III)

The first study was performed to gather empirical basis for answering the three research questions RQA (scope), RQB (plan and reality), and RQC (correspondence to Swedish energy policy), but as the energy plans were collected and analysed it became obvious that the plans varied widely in age. As some energy plans were twenty years old, it seemed unlikely that they would have any influence on today's energy system. However, the first study provided interesting information about how energy planning has developed over time (giving more depth to RQA).

Empirical basis for the second study was chosen more carefully to be able to answer RQB (the second study also contributes to RQC, but RQB was the focus when this choice was made). Municipalities were chosen from different parts of the country and the energy plans were of similar age: old enough for changes to occur, but not out-of-date as many of the plans in the first study. Development in the studied municipalities was studied with aid of national statistical data (Statistics Sweden, 2003) and information from the local authorities. However, finding information about everything that was planned for in the energy plans was very difficult, and it became evident that it would not be realistic to follow up development thoroughly for all seven municipalities. Therefore, a decision was made to conduct a case study on the municipality that had the most information available, which became the third study.

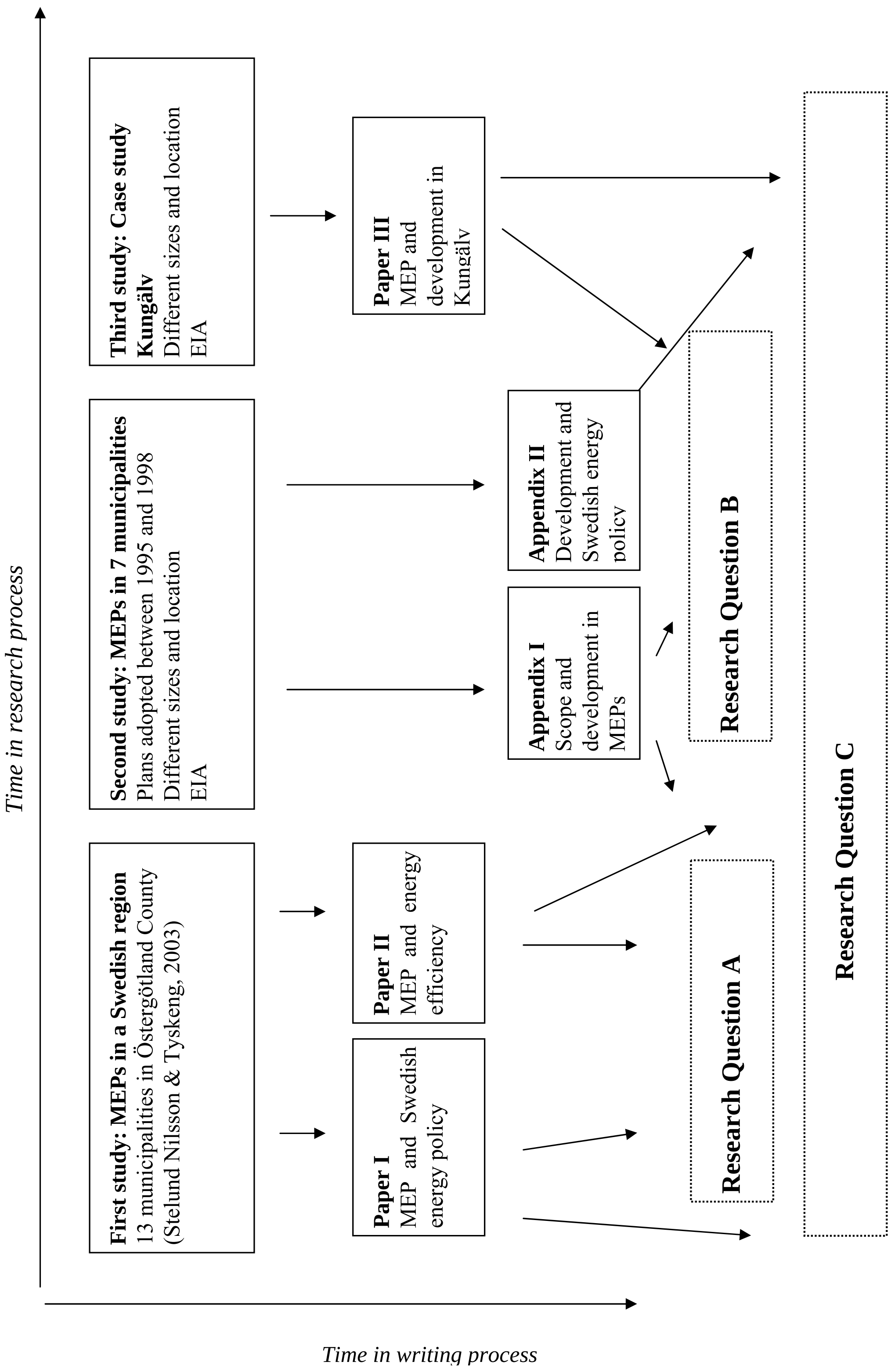

Figure 4. Visualisation of research process.

When starting the work with the cover essay for this thesis, the author realised that there was an unused link between the first and the third study in the unanalysed data from the second study. It became apparent that if the data collected in Study II were to be analysed, it would contribute to RQA, RQB and RQC. The results from study II are presented in Appendices I and II.

4.2 Research approach

The analyses of energy planning in this thesis are loosely based on systems analysis. As a starting point, the processes related to energy planning are regarded as black boxes as seen in Figure 5. Here, the three points of observation of the municipal energy system are before the energy plan was adopted, the energy plan itself (the document), and the energy system some years after adoption of the energy plans. The energy planning and implementation processes are regarded as black boxes.

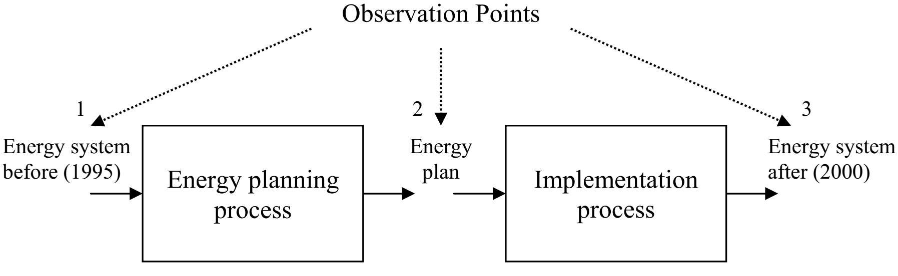

Figure 5. The research approach presented as a black box model. Points of observation are the energy system 1995 (1), the energy plan (2), and the energy system 2000 (3). The energy planning and implementation processes are regarded as black boxes.

RQA is answered from Observation Point 2, while RQB is answered by comparing Observation Points 3 and 1. RQC is answered by combining information from all three observation points and relating the information to national energy policy.

4.3 Methods in the first study – Scope of energy plans in a Swedish region

This study was performed in 2001 and resulted in a report (Stenlund Nilsson and Tyskeng, 2003) and three papers of which two are appended to this thesis (Papers I and II). The aim of the first study was to analyse the scope of energy plans, and later to compare plan and reality.

4.3.1 Selection of study object

Östergötland County in southern Sweden, with its thirteen municipalities of different types and sizes, was chosen as the study object. The region possesses high tech as well as more traditional manufacturing industry and service business. It also has coastal and extensive inland areas and agricultural areas, and also (by Swedish standards) large cities. For these reasons, it was considered to represent the diversity of Swedish municipalities fairly well.

4.3.2 Forming the empirical basis

The most recently adopted energy plan was collected from each of the municipalities. Following this, their contents were categorised and analysed with the aid of a set of questions. The questions were based on both the assumptions described in the theoretical framework, and on a number of handbooks issued by the Swedish National Energy Administration, for example *A Sustainable Local Energy Strategy* (Swedish National Energy Administration, 2001a) and *International Local Energy Planning* (Swedish National Energy Administration, 2001c). Further description of creation of the questionnaire can be found in the report *The Scope of Municipal Energy Plans in a Swedish Region. A review of energy and environmental issues in the energy plans* (Stenlund Nilsson and Tyskeng, 2003).

Most of the contents in the energy plans were categorised and analysed, since the questionnaire was very detailed. However, since the contents of plans differed widely, there were many questions that did not meet corresponding information in any energy plan. Even though it was interesting to find that very few energy plans discussed certain issues, it made the results more difficult to generalise.

4.3.3 Analysis method

For each question, every plan received a grade based on whether it contained no, some or much information about the issue. All questions in each analysis category were summarised and presented in tables. These tables revealed trends for the issues covered by energy pans, and to what extent. The tables were analysed in relation to age of the energy plan and (contemporary) national energy policy.

4.4 Methods in the second study – Energy plans adopted between 1995 and 1998

The aim with the second study was to find a set of energy plans to compare with real development.

4.4.1 Selection of study object

In the second study, energy plans adopted between 1995 and 1998 from five additional municipalities were collected and added to those plans from the first study that were also adopted between 1995 and 1998. The aim was to get plans old enough to provide an opportunity for changes to occur, but not so old that they would be completely out of date, and to obtain diversity regarding geography (coast or land, north or south). There was also an additional criterion: that there should have been an environmental impact assessment for an energy facility performed during that period. This criterion was chosen to facilitate cooperation with another research project, a study on "tiering" (links between) planning levels such as planning of energy plant projects, municipal energy planning, and regional planning for the waste and energy sectors (Tyskeng, 2006). In this case, sharing cases and material has certainly contributed to the research process described in this thesis, since it has provided deeper knowledge about the study objects other than those found in the author's own research.

The author is aware that choices of what to study, and how, affect the outcome, and therefore might affect the results. When choosing municipalities that did actually have an energy plan, and had also planned for a larger energy facility, municipalities that worked with energy-related issues were also chosen. This means that these municipalities are "good examples" rather than average Swedish municipalities.

4.4.2 Analysis method

As described in Appendix I, the second study was conducted in four steps:

1. Sampling
2. Identifying all the goals (or visions) stated in the municipalities' energy plans
    a. Grouping goals stated in the energy plans
    b. Analysing the goals' systems approach
    c. Analyse who is responsible for fulfilment of goals
3. Following up development for each group of goals
4. Combining results from steps 2 and 3 in each group

Of these four steps, 3 and 4 form bases for analyses of plan versus development. These analyses are divided into two parts: development in relation to goals stated in energy plans, and development in relation to national energy policy.

Were goals and visions fulfilled?

Analysing whether development corresponds to plan is in this case a compromise between accuracy and generality. Using statistical data from Statistics Sweden (2003) means that the material is similar for all municipalities and therefore possible to generalise, but possibilities to follow up specific goals is limited. Statistical data for municipal energy balances is of high quality and contains detailed information on fuels and energy use per sector. Therefore, it gives a rather accurate picture of changes in energy supply and use. Linking development according to statistics to goals stated in energy plans may lack accuracy, but here the general trends for district heating and shifts of energy carriers are considered as reliable.

Combining what was learned about contents of energy plan with what energy statistics told about the development is complicated. The choice was made to summarise a large group of goals in general terms, and thereafter look for evidence of development in statistical data. These results are heavily aggregated, but also show some interesting patterns and links between focus in energy plans and real development.

Relating plan and development to national energy policy

Development in terms of the national energy indicators was calculated for each municipality and for the years 1995 and 2000 (statistics for year 2000 were the most recent statistical data available when this study was conducted). In addition, these calculations were based on national statistics, but in this case indicator values were calculated. Indicators from the Swedish National Energy Administration were used in both the second and the third studies. The choice was made to use these indicators, since they are the official national monitoring instruments for the current energy policy.

Life cycle data was used to estimate changes in indicator values for emissions of CO_2, SO_2, and NO_x. Life cycle data for energy carriers was obtained from the Swedish Environmental Research Institute (IVL) (Uppenberg, Almemark et al., 2001a; Uppenberg, Almemark et al., 2001b).

As is also mentioned in Appendix I, to the decision was made to regard only biofuelled CHP and wind power as renewable electricity choices. This is because these are the only realistic choices for a local authority to increase self-sufficiency in electricity supply.

4.4.3 Forming the empirical basis

The approach of this research to compare plan and reality was to list all goals and visions for a future energy system, and then follow up what had happened. To structure the results all goals were put into groups based on a number of topics. These topics were also based on the assumptions described in the theoretical framework chapter and the handbooks issued by the Swedish National Energy Administration, but modified to fit what was learned in the first study to be addressed by the energy plans). An extra group for “other” goals was also established. In this group, goals were placed regarding for example information campaigns and reports. Each group was then divided into subgroups according to the systems approach and with actor or actors who “naturally” owned the issue (for a more specific description, see Appendix I).

When analysing goals from a systems point of view, the author needed to decide on which systems level the goal fitted. These decisions were sometimes fairly subjective. The systems levels were the detailed, technical and LTS types, as described in the theoretical framework chapter. For most issues, the choice on how to classify the goals was fairly easy, but in some cases where goals were vaguely stated, a decision had to be made how to interpret the statement. In general, the choice was made to interpret goals on a wider systems level rather than vice-versa. For example, general statements about reducing energy use have been interpreted as being on the LTS level.

The same was the case for "responsible actor": in some cases it is not clear who "owns" the issue. When it was not certain, the goal was placed in the "both" group. However, since all municipalities differ, there can be cases when for example the LA does act as a responsible actor even though the issue is not part of the LA's competence (professional responsibilities).

Development was primarily studied with the aid of national energy statistics. Changes in energy use or supply were calculated for some commonly occurring goals. However, many goals in the energy plans were site-specific and were not possible to follow-up using statistical data only. Therefore, one of the municipalities was studied more thoroughly in a case study.

4.5 Methods in the third study – Case study: Kungälv

Since there are many things relevant to the development in a municipal energy system that are not possible to see explicitly in statistical data, the decision was made to perform a case study on one of the municipalities. The aim was to be able to follow up every goal stated in Kungälv's energy plan.

4.5.1 Selection of study object

Kungälv is a suburb in the Gothenburg region in south-western Sweden. Kungälv has been active in energy issues, for example participating in a national eco-energy municipality project, and has also been approved national funding (so called LIP funding as described in Chapter 3) for a number of projects with the direct intention to improve the environmental performance of their energy system. Extensive documentation and the high priority of energy concerns in the municipality made Kungälv a suitable municipality to study. Kungälv can be viewed as a "good example" when it comes to working with municipal energy issues.

4.5.2 Forming the empirical basis

Results in the case study are to a large extent based on material from the LA, interviews with the municipal ecologist, and a visit to the municipality. But the results are also validated and completed with statistical data as in second study.

Also in the third study, the energy plan's effectiveness in terms of fulfilling planned goals and in terms of fulfilling national policy goals are analysed. Development in relation to national energy policy was also studied using the national indicators. Indicator values were calculated for both end-use and lifecycle emissions.

Determining whether goals had been fulfilled was a rather straight-forward analysis using statistical data from Statistics Sweden (2003), a large number of documents issued by the municipality, and interviews with the municipal ecologist. Development in terms of the national energy indicators was calculated in a way similar to that in the second study. In this case, however, additional indicators issued by the Swedish association of local authorities were used (Swedish Association of Local Authorities, 2000). For Kungälv, goals and development were related to the national energy policy goals (see Paper III).

5 Results

Results from the three studies are presented in this chapter. Results are presented in three parts, according to the three research questions. At the end of each section, the questions are answered.

5.1 Results related to RQA – Scopes of energy plans

As described in the methods chapter, empirical material to answer Research Question A is based on two studies. The first study, presented in Papers I and II, provides information about the content of the studied energy plans, how scope has changed over time, and how scope relate to national energy policy. The second study, presented in Appendix I, provides information about goals and visions in energy plans.

5.1.1 Results from Papers I and II – Scope of energy plans in a Swedish region

The ages of energy plans between the ten municipalities varied widely; in one case there had never been any energy plan. A summary of the contents of the energy plans is presented in Table 3.

Systems perspectives

As papers I and II indicate, systems approach in energy plans has widened over the years. In the 1980s, there was much focus on fuel supply and for energy efficiency in buildings and appliances. By the late 1990s, however, overall energy use and environmental concerns had become more important. The shift is not only from details in the energy system, but also from supply to users.

Table 3. Summary of the contents of energy plans in the first study. Plans are sorted after year of adoption. --- indicates that the issue was not presented in energy plans from the time. (Thorough descriptions of the studied energy plans are presented in the report *The scope of municipal energy plans in a Swedish region. A review of energy and environmental issues in the plans* (Stenlund Nilsson and Tyskeng, 2003).

Contents in energy plans	**1977-1985**	**1985-1996**	**1997-**
Author	LA work group	Consultant	Civil servants
Focus	Supply issues	Supply issues: natural gas grid	Renewable energy sources
Relate to comprehensive planning	Yes	Yes	Yes, as a measure to reduce energy use
Reference to other technical systems	---	Indicates importance of transports	Indicates importance of transports
Technical descriptions	Facts and figures	More analytical	Concise and analytical
Goals for	Oil reduction Energy efficiency	District heating Reduced emissions	Reduced emissions Reduced industrial energy use Renewable energy
Energy efficiency – technical measures	Heat pumps, lower indoor temperature, improved insulation	---	Optimisation of the energy system. Efficient appliances
Energy efficiency – measures for behavioural issues	Measuring energy use Energy advising	Measuring energy use Energy advising	Measuring energy use Energy advising
Environmental aspects	Possibilities to utilise local energy resources Reducing local emissions	Reducing env. impacts at local and regional level Impacts associated to energy plants	Environmental issues for the entire energy system Local level focus, other levels with references to LA21
Expected development	Increased energy use	Increased energy use	---
Alternatives for the future		Different fuels and kinds of energy plants	Alternative developments are presented
Measures and action plan	Detailed descriptions, no over all strategy	Detailed descriptions	Action plan and strategies for implementation
Description of auditing	No	No	Indicators to monitor energy efficiency
Other	---	---	Employment issues National environmental goals

5.1.2 Results from appendix I – Goals in energy plans adopted between 1995 and 1998

As mentioned above, also the second study contributes to answering RQA as it provides information about goals and visions in energy plans. Goals in the studied energy plans were placed in different groups according to focus. Below is a short summary on goals within different topics. All numbers in parenthesis refer to the number of plans (out of seven) in which this goal (or a very similar one) occurs.

Goals regarding plant-related issues

This group of goals was dominated by district heating issues (6). More goals on a more detailed level often concerned maintenance of public buildings. One third of the plant-related goals were mainly connected to the municipality's business; examples included district heating and systems to investigate possibilities to produce biogas from sewers and sludge (4).

Goals regarding transport issues

The most common goals for transports were improvements of the public transport system (4), decreased use of fossil fuels (3), and the development of rail transports (3). Two of the plans each stated goals for providing environmental requirements when purchasing transport services, supporting the transition to alternative vehicle fuels, increasing travelling with public transports, optimising transports, and the localisation of plants and infrastructure to reduce environmental impacts.

Goals regarding energy efficiency

The most commonly occurring goals for energy efficiency were reduced electricity use in municipal buildings (6) and the consideration of energy efficiency during spatial planning (6). Other common goals were: decreased use of heat in public premises (5); follow-up of municipal energy use (4); use of waste heat from industry (3); decreased use of heating in private residences, optimisation and improved control of HVAC systems and lighting (3); and use of energy-efficient devices (3).

Goals regarding energy carriers

All plans included some kind of statement about reducing fossil fuel use and increasing the use of renewable fuels. The most commonly occurring goals were: reduced oil use (general statements) (3); decreased use of electricity and oil for heating purposes (3); introduction of solar heat outside district heating areas (3); and increased utilisation and use of biomass (3). Biomass should preferably come from neighbouring areas (3). Four plans commented on energy supply from a regional perspective, and four from a regional as well, but most goals concerned energy carriers in district heating plants, other heating purposes, and vehicle fuels.

Goals regarding emissions and resources

End-of-pipe solutions were common in environmental goals; in these cases, emissions were the focus and measures to reduce them often entailed more efficient exhaust gas cleaning technologies. However, transport planning to reduce emissions from the transport sector and concerns about resources were mentioned as well. The most common goals were reduced CO_2-emissions (6), reduced NO_x-emissions (5), reduced sulphur emissions (5), ash recycling (3), sorting and recycling of waste (3), small scale combustion in environmentally licensed boilers for small scale biomass combustion and general statements about caring for the environment (3). Among measures to fulfil goals, half (eight goals in total, as there can be more than one measure presented in a plan) were linked to change in behaviour and half to improved technology. Two plans presented goals for LA actions.

Goals on other issues

Among the goals that did not fit under the other categories were: education and information to different groups (6); energy advice in general (4); information and advice on energy efficiency (3); information about energy and environmental issues at schools (2); and organization of a new group or appointing a person to work with energy issues (2). Other examples presented in one plan were goals for environmental reports and yearly reports on small-scale combustion.

Other goals stated occasionally were: improving knowledge about health effects from small scale combustion; the local authority setting good examples; the local government adopting environmental reports every year; yearly summaries on the status of small scale combustion boilers; and the auditing of the goals in the energy plan.

Systems approach

The systems level for the goals in the energy plans varied somewhat according to issue as shown in Figure 6. Regarding plant-related issues, the dominating systems approach was not the plant itself (detailed approach), but rather technical systems and infrastructure in connection to plants. However, there were many possibilities for system optimisation and cooperation when it came to the local energy supply, and this possibility as seldom developed in the plans. For goals about transports, the situation was the opposite; in this case, infrastructure was the least developed part, but there were many goals concerning vehicles and fuels. Policies for the LA were common, but there were also many goals with behavioural approaches and goals for integrated planning to reduce transports. The most commonly occurring goals for the studied energy plans were goals for reducing energy use. This group of goals was dominated by goals for system optimisation and reducing energy use with behavioural change. Goals for energy carriers mostly concerned energy sources used for heating buildings and adapting plants for biomass-based fuels. There were few statements referring to an overall transition from fossil fuel-based energy to renewable energy sources (as the Swedish energy policy states). Goals about environmental aspects were the most similar between energy plans: they all contained goals about reduced emissions.

Systems levels vary with each group of goals, but the general trend was that technical aspects of the energy systems were central. Humans and human behaviour were not the focus. However, there were some goals regarding the dispersion of information about energy issues to the public. These kinds of statements indicate awareness about the importance of behavioural aspects for energy use.

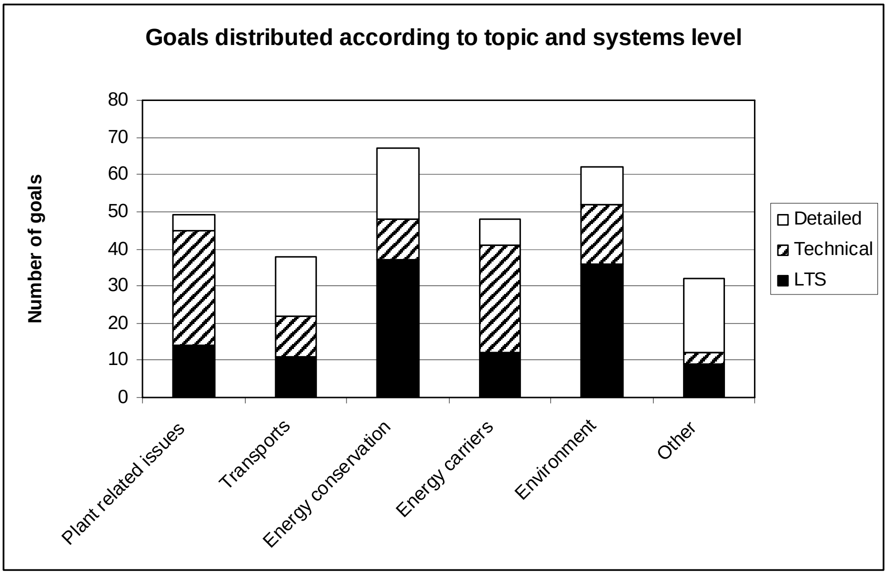

Figure 6. Distribution of goals in energy plans according to topics. “Number of goals” refers to the total number of stated goals in the group or sub-group (if the same goal occurs in several plans, every occurrence is counted).

5.1.3 Answering RQA – What is the scope of Swedish municipal energy planning?

Goals in energy plans

The kinds of goals stated in energy plans varied with age as well as issue. In the first study (Papers I and II), it was possible to see a change from specific goals on details to a wider systems approach. In older plans, the focus was oil reduction and energy efficiency in buildings; in plans from the middle period, district heating expansion was important; and in newer plans, renewable energy was important. In the newer plans industrial energy use was also highlighted, which further proves how views on the energy system and its actors have widened.

Energy plans in the second study (Appendix I) presented most goals for energy conservation, environment, and plant-related issues. Among energy efficiency goals, those for reduced electricity use and that energy efficiency should be considered during spatial planning were the two most commonly occurring. When it came to goals for environmental issues, most plans presented the same kind of goals: reduced emissions from energy conversion. For plant-related issues, most goals concerned infrastructural matters such as district heating grid expansion. The most detailed goals (from a systems perspective) were those for the transport sector, which were dominated by goals for vehicles and fuels. Humans and human behaviour were not the focus, but were more or less explicitly expressed in goals regarding the importance of providing information about energy issues to the public.

Technical descriptions

Technical descriptions in the energy plans in the first study varied with age. The older plans contained more technical descriptions than the newer, especially when it came to describing the energy system with facts and figures. Most extensive technical descriptions were presented in plans adopted between 1985 and 1994. Municipal energy systems were referred to as "systems" in the newer plans. Most plans included descriptions on the occurrence of small-scale solid fuel combustion, district heating grids, and the use of different energy carriers (fuels). Few plans described visions for the future fuel mix. Opportunities for electricity production were described in almost all plans.

Environmental assessment

Environmental assessments were more frequent and extensive in newer plans in the first study (Papers I and II). Newer plans referred to national environmental goals. Environmental goals for the energy sector were described in the newer plans. Direct effects (like acidification) were described in two plans, indirect local environmental effects were described in one plan, but there were no descriptions concerning indirect environmental effects at the regional or national level. Future local environmental impacts (mostly emissions) were described in most of the plans.

Goals for environment were the second largest group of goals in the second study (Appendix I). Almost all goals concerned emissions from energy conversion. Energy resources were mentioned in some plans, but were not the focus. Environmental issues in the case study mostly regarded emissions such as NO_x, SO_2, CO_2, and VOC.

Measures to follow up the plan

Follow-up measures are mentioned in two (one middle-aged – adopted between 1985 and 1996 – and one new – adopted 1997 or later) plans in the first study. One plan stated an explicit goal to follow up the plan in the second study. There were other goals concerning measuring emissions and environmental reporting; these, however, were not expressed as measures to follow up the energy plan. As in most plans in the second study, there was no explicit goal for follow up presented in the energy plan in the third study either. However, an annual environmental report issued by the LA describes environmental performance for the municipality.

How does the MEP relate to municipal comprehensive planning?

How energy planning relates to other municipal planning is described in older (adopted before 1985) and middle-aged plans in the first study (Paper I). In the second study (Appendix I), six of seven plans state some kind of goal for energy efficiency to be regarded during planning for buildings. In addition, in the case study (Paper III) there was a goal for taking energy issues into account when planning for new residential areas. This goal, however, was not fulfilled.

5.2 Results related to RQB – Energy plans and energy system's development

The second study (Appendix I) provides information about development in seven municipalities in general terms. The third study, the case study on Kungälv (Paper III), provides detailed information about whether goals and visions stated in the energy plan were fulfilled or not.

5.2.1 Results from the second study – Development in municipalities with energy plans adopted between 1995 and 1998.

Development in seven municipalities with MEPs adopted between 1995 and 1998 was analysed in order to answer RQB. All statements that could be interpreted as goals for the municipal energy system that were stated in the energy plans were collected. All goals were then placed in groups according to issue, so that the most commonly occurring goals would emerge. General trends for each issue-group were then calculated with the aid of statistical data. All results from the second study are presented in Appendix I.

Plant-related issues

When it comes to new energy generation facilities, the most commonly stated goals were for expanded district heating systems within population centres, and for small-scale biomass-based heating outside densely populated areas. Some energy plans included goals for wind power and development of existing hydropower. Four included goals for biogas plants, and one for an ethanol plant, to produce alternative vehicle fuels.

District heating had increased in five of the seven municipalities between 1995 and 2000, and hence also the total part of space heating that came from district heating systems. New wind power plants had been built in two of the four municipalities that stated goals for wind power. The two municipalities with goals for expanding hydropower both showed an increase of hydropower-based electricity generation. There was no evidence for production of biogas or ethanol production during 2000.

Transports

An overall goal for energy use in the transport sector was reduced fuel consumption and use of more renewable fuels. However, energy use for transports increased in five of the seven municipalities. A measure to reach the goals mentioned in four plans was to improve public transport. Electricity use for transports had increased in six of the seven municipalities, since electricity was mainly used for rail transports; this was an indication that rail transports had increased.

Energy conservation

All energy plans contained goals for energy conservation. The most commonly stated were reduced energy for heating public buildings, especially electricity based, and the goal that energy-efficient technology should be taken into account during spatial planning and building construction. Energy use per capita increased slightly in six of the seven municipalities. Table 4 shows changes per sector.

Table 4. Change in energy use per sector in the seven municipalities. Results are related to the average among Swedish municipalities.

Sector	**Reduced energy use/capita**	**National average (per capita)**
Transports	3 of 7	+5%
Industry, building construction	3 of 7	+15%
Public sector	6 of 7	-9%
Agriculture, forestry, fishing	2 of 7	-4%
Energy used by households	6 of 7	-8%
Other services	5 of 7	+2%

Energy carriers

No specific goal dominates this group of goals, but the general meaning is reduced fossil fuel use and increased use of renewable energy sources. Some MEPs stated goals for locally produced renewable energy carriers. There was a reduction in fossil fuel use in six of the seven municipalities, and the total share of renewable energy increased in five. This change can partly be explained by the increased share of biomass-based district heating.

Emissions and resources

Goals for minimization of environmental impact from the energy system were stated in several energy plans. Six plans contained goals for reduced CO_2 emissions, and five for SO_2 and NOx respectively. Resources are mentioned in vague statements for locally produced biomass. Five municipalities reduced CO_2 emissions (3-20%), while NO_x- and SO_2 emissions decreased in four of the seven municipalities, respectively.

Other goals

Most energy plans contained goals about information campaigns for different groups of citizens. These goals were not followed up within Study II.

Summary of goals and development for the municipalities with plans adopted between 1995 and 1998

Development varied between the groups, as seen in Tables 4 and 5. It appears that different projects, mostly district heating expansion, were successfully completed by the local authorities and the municipal administration. But even though, for example, public transports improved and more inhabitants use public transports, the total energy use for transports has increased. The same was the case for energy conservation: even though energy use in households and in the public sector has decreased, there was a net increase in energy use per capita in all the studied municipalities but one. The increase has been for industry and transports, sectors with private actors.

The most positive trend was the group of goals about energy carriers. There has been a general transition in the use of energy carriers in all municipalities. One reason was the expansion of district heating systems.

Table 5. Summary for each group of goals: systems approaches, dominating responsible actors and development. For more detailed data, see Appendix I.

Group	**Dominating systems approach**	**Dominating actor**	**Development**
Plant related issues	Technical (50%)	LA (62 %)	Positive to some extent
Transports	Detailed (38%) and LTS (35%)	LA (81%)	Mostly negative, increase in use.
Energy conservation	Detailed (53%)	LA (50%)	Negative total trend, positive in some sectors
Energy carriers	Technical (61%)	LA (45%) Private (32%)	Positive
Environment	Detailed (50%)	Both (44%)	Positive
Other	Detailed (40%) LTS (45%)	LA (100%)	N/A

5.2.2 Results from the third case study: Kungälv

The case study on Kungälv (Paper III) provides detailed information about whether goals and visions stated in the energy plan were fulfilled or not. As for all MEPs in the second study, all statements that could be interpreted as goals for the municipal energy system were collected and placed in groups. In this case study, however, each goal was followed up.

Plant-related issues

Kungälv's energy plan presented many goals for expanded district heating: expansion of the existing main grid to new neighbourhoods, sun collectors in the main grid, upgrading the existing plant to combined heat and power (CHP), and new bio-fuelled plants for local district heating systems. There were also goals for wind power establishment and environmentally adapted small-scale biomass combustion.

Many investments in energy facilities have been made since the adoption of the energy plan. Large parts of the city centre have been connected to a district heating grid, and local district heating grids have been constructed. Many of the investments were partly financed with LIP funding, and this funding has most likely sped up the district heating expansion process. Some projects, such as one of the planned biomass-fuelled energy plants, has been postponed because no LIP-funding was received for the project (Kungälvs kommun, 2002c).

Eight land areas were reserved for wind power plants in the new municipal comprehensive plan. However, no new plants have been built or received admittance for building (Kungälvs kommun, 2003b).

The number of small-scale solid fuel boilers has decreased by 30% between 2000 and 2002, and a large number of homeowners has received funding from the local authorities to replace their old solid fuel boilers with solar heat, wood pellet burners or to install reservoirs for heat accumulation (Kungälvs kommun, 2002a; Kungälvs kommun, 2003b).

Transports

Increasing transports was highlighted as a problem in Kungälv's energy plan. The overall goal was not to allow an increase larger than 10%. There were also goals about increased use of public transport and goals for the local authority's own transports.

Transports within Kungälv city centre have decreased almost 25% since 1995, but transports on major roads have increased rapidly, in one case almost doubling (Kungälvs kommun, 2003b). Travelling with public transports has increased, especially with regional buses (Kungälvs kommun, 2003b; Kungälvs kommun, 2003c).

Energy conservation

Kungälv's energy plan presented an overall goal for decreased energy use. Within this goal lies guidelines for energy efficiency in public buildings and for public services, as well as checklists for energy efficiency during public building construction and renovation. There were also specific goals for reduced electricity use (10% in general – industry not included, and 20% for electricity use for heating purposes).

Energy use had increased slightly between 1995 and 2000. Industry showed the largest increase (+80 %), while use within the public sector decreased significantly (-25 %). According to the municipal ecologist and the district heating manager for the local energy company in Kungälv (Nilsson and Nilsson, 2003), there had been expansion of industrial activities during this time. Energy use per capita had increased slightly between 1995 and 2000. If the considerable increase in industrial energy use is disregarded, energy use in Kungälv decreased 6 % since 1995.

Energy carriers

Kungälv’s energy plan contained goals for transition from oil and electricity to biomass for heating privately owned estates, increased renewable energy use in the public sector, and that gasoline and petrol for transports should not increase. There were also goals for breeding energy crops and investigating possibilities for fermentation of sewage to produce biogas.

Electricity use in Kungälv has increased 2% per capita since 1995, and the LA regarded the 10% reduction goal as hard to reach (Kungälvs kommun, 2003b). Electricity for heating had not decreased (Statistics Sweden, 2003). The use of oil had decreased almost 37% between 1995 and 2001, and the local authority estimated that the goal to reduce the use of oil for heating purposes by 50% would be reached if the expansion of district heating and energy advising to the citizens continued (Kungälvs kommun, 2003b). Bio-fuels dominated the fuel mix for district heating (90%) (Kungälvs kommun, 2003b). Petrol and diesel oil retail have both increased, but the LA estimated that the goal for no increase in retail within the municipality would be reached for petrol but not for diesel oil.

There is no production of energy crops within the municipal territory today. An analysis has been made for potential biogas generation, but it showed that there were no economical possibilities with today’s energy prices (Kungälvs kommun, 2003a).

Resources and emissions

Kungälv’s energy plan was issued while there was a requirement for an environmental impact assessment for the energy plan, and it included a number of quantified goals for reduced emissions of carbon, nitrogen, sulphur, and volatile organic compounds (VOC). There was one goal that refers to saving resources: ash recycling from the bio-fuelled energy plant.

Most environmental goals were estimated to be reached (Kungälvs kommun, 2003b), thanks to improved emission treatment technology, cars with catalytic converters, and district heating expansion. The ash recycling project was completed despite the fact that no funding was received for this purpose (Kungälvs kommun, 2002b).

Other goals

There are several goals for energy issues that should be taken into consideration during spatial planning; energy analyses should be performed when new residential areas are planned. There are also goals for starting up environmental reporting activities and informing citizens about energy-related issues within the framework of the local Agenda 21 activities.

Energy issues were not yet taken into consideration during detailed spatial planning (Nilsson, 2003), but two new publications are now released for environmental reporting and information to the citizens.

5.2.3 Answering RQB – What happened after energy plans were adopted?

Were goals stated in the energy plan fulfilled?

To sum up the results from the second study (Appendix I), there were positive developments for technical goals where the LA was the responsible actor. For goals where both private actors and the LA were responsible actors, development was mostly positive for goals at the detailed systems level, and mostly negative for goals at the large technical systems (LTS) level. Unfortunately, available statistical data does not allow extensive possibilities to follow up development in municipalities in terms of example projects. Therefore, the method used in the second study was not applicable to follow up many goals where private actors owned the issue.

However, the case study (Paper III) provided more information about fulfilment of a variety of goals. For plant-related goals, half of the goals have been successfully fulfilled. Here, LA was responsible for most goals. Most goals regarding transport issues were also fulfilled; for this group of goals both LA and Private actors were responsible. When it comes to goals for energy efficiency, goals owned by the LA were most often fulfilled, and those with private actors responsible not. For energy carriers, half of the goals were fulfilled. Of the ones not fulfilled, most were owned by private actors. Half of the environmentally-related goals were fulfilled.

What happened to energy-related emissions?

Carbon emissions were reduced in five of the seven municipalities in the second study (Appendix I). Reductions were from 3% to 20%. Both nitrogen and sulphur emissions were reduced in four municipalities, respectively. No calculations for emissions of PAH or particles were performed, but a fair guess is that these emissions have increased slightly, due to increased transports and increased biomass combustion.

In the case study (Paper III), all calculated emissions (NO_x, CO_2 and SO_2) decreased. According to the LA’s own measurements, air quality within Kungälv city has improved during the years after the energy plan was adopted.

5.3 Results related to RQC – Scope and development related to Swedish energy policy

Scopes related to Swedish energy policy

Papers I-III all describe how scopes of energy plans have varied over time, and in Paper I this variation is related to the development of Swedish energy policy. The first study (Papers I and II) shows that municipal energy systems have evolved with the Swedish national energy policy during the past three decades. Oil dependence has decreased, the use of electricity for heating purposes has increased during the 1980s, and the share of renewable energy has increased steadily. Goals for the municipal energy systems state that the objectives have been increased use of renewable energy sources and energy efficiency, issues that have been important elements of Swedish energy policy since the 1970s. However, goals in the set of energy plans in the first study are vaguely stated and leave room for new energy policies. Additionally, policy measures such as subsidies are often not described extensively in the plans.

The newer MEPs in the second study (Appendix I) do to some extent reflect current energy policy: secure energy supply, competitive prices, and environment. However, as the heights of the bars in Figure 1 indicate, MEPs include most goals for energy conservation. Transports are not a very important part of Swedish energy policy, which is also reflected in the energy plans.

Development related to Swedish energy policy

Changes in the studied municipalities have been analysed using national indicators (see Appendix II). These results are related to the overall national energy policy goals in Table 6.

District heating has increased, and most district heating systems were based on renewable energy sources. In some cases, district heating was based on waste incineration, which is to some extent renewable. Combined heat and power has increased in only one municipality, even though district heating has increased in the majority. Efficiency for heating buildings has improved. There has been some increase in local electricity generation. The general trend for energy efficiency was negative, but there have been improvements in for example public sectors and energy used by households.

Table 6. Development in the seven municipalities related to the three main Swedish energy policy goals.

Over-all goal	Indicator	
Secure energy supply	1	The share of energy from renewable energy sources has increased, and most comes from bio-mass. Waste incineration has also increased, which is also in a way a local energy resource.
	3	Combined heat and power have increased in only one municipality. Less domestic production means less control.
	8	There has been an increase in wind and hydro power in some municipalities.
Competitive prices	1	The share of energy from renewable energy sources has increased, which implies that the share of domestically-produced energy has increased.
	3	CHP has not increased.
Environment	1	Even though total energy use has increased slightly, total emissions seem to have decreased due to the increased use of renewable energy sources.
	2	The use of fossil fuels has decreased.
	5	Carbon emissions have decreased in most municipalities. As shown in Paper III, results vary somewhat according to the calculation method.
	6	Sulphur emissions were reduced in 4 of 7 municipalities.
	7	Nitrogen emission were reduced in 4 of 7 municipalities.

The national energy policy goals included statements such as “low impact on the environment” and that fossils fuels should be kept at a “low level”. Total emissions from the studied municipal energy system have decreased, even though the total energy use has increased. This improvement is thanks to increased use of renewable energy sources, and decreased use of fossil fuels[2].

[2] As mentioned in Appendix II, the method used here does not regard technological improvements in for example exhaust gas cleaning. This means that improvements may be larger than the figures indicate.

5.3.1 Answering RQC – How does energy planning correspond to national energy policy?

How is energy policy reflected in the scope of energy plans?

Older energy plans and the energy policy 1977-1984

Older energy plans describe energy systems highly dependent on fossil fuels and with an expected growth in energy demand. Energy efficiency in buildings and oil reduction were dominant parts of the older energy plans in the first study. This corresponds to the national policy for oil reduction and the energy efficiency in buildings programme. As requested by the government in the early 1980s, one of the energy plans included an oil reduction plan. New nuclear power was not directly mentioned in the plans, however advantages of electrical heating were mentioned.

Middle-aged energy plans and the energy policy 1985-1996

The alternating national energy policies are illustrated as diffuse goals in energy plans from this period. Abundance of electricity can also be recognised in the energy plans: many plans described how the municipality should prepare for space heating based on electricity. National goals for more comprehensive planning with energy issues discussed in relation to spatial planning can also be observed. Most plans from this period related to spatial planning issues. Examples in the plans were the importance of taking district heating and climate conditions into account when planning for new residential areas.

Newer energy plans and the energy policy after 1997

National goals for more renewable energy sources in the energy system as well as the financial support program, LIP, with subsidies for a sustainable energy system, can be traced in the energy plans. For example, goals and visions describe potential wind power projects and possibilities for combined heat and power plants based on biomass fuels.

How does the development correspond to national energy policy goals?

As presented in Appendices I and II, use of local energy resources has increased in the studied municipalities. The share of energy from renewable energy sources has increased, as well as waste incineration. This would mean a positive development for the energy policy goals “secure energy supply” and “competitive prices”. However, combined heat and power have increased in only one municipality, and energy use per capita has increased in six of seven municipalities. This would not mean a positive development for the energy policy goals.

When it comes to the energy policy goal for "environment", development has been positive. Even though total energy use has increased slightly, emissions have decreased. Fossil fuel use has also decreased.

6 Concluding discussion

This chapter discusses the overall research question "is energy planning effective?". This is followed by a discussion of shortcomings in energy plans, and how energy planning might be improved to encompass a wider scope and better facilitate a participatory approach. Finally, a future research project is introduced, where an attempt to improve energy planning will be tested.

This thesis has assessed whether energy planning is effective on two levels, implementation of energy plans in terms of fulfilment of goals and visions stated in the plans, and whether energy planning contributes to fulfilling national energy policy goals.

Based on fulfilment of goals and visions in energy plans in the studied municipalities, energy planning is fairly effective. Energy planning has been most effective for technical solutions and issues that are owned by the local authorities, and less for goals at the large technical systems level involving private actors. Even though effectiveness of energy planning varies, the development in the studied municipalities contributes, more or less, to fulfilling the national energy policy goals.

Palm (2004) and Olerup (2000) conclude in their studies on Swedish municipalities that municipalities have limited influence over the local energy system, including the municipality-owned energy company. The results presented in this thesis, especially the case study in Kungälv, indicate that the municipality can use energy planning to influence the local energy system. However, some weaknesses in the scope of energy plans were identified.

As mentioned in the results chapter, the studied municipal energy plans were rather technical in their approach, and environmental analyses were very basic or even missing. Furthermore, the focus in the energy plans was found to be energy supply and energy efficiency measures for the service sector. Even though the service sector represents a significant part of energy use within municipalities, the largest energy users were industry, transports and households. All together, this indicates narrow scopes in energy plans and raises two questions. First, do goals presented in energy plans lead to real change in the energy systems, or do they merely present what the civil servants at the LA already know will happen? Second, would energy planning be more effective if the plan had wider scope and proposed more relevant goals and deeper analyses? The importance of wide system boundaries and thorough environmental analyses during planning, including energy planning, is highlighted in the EU directive (2001/42/EC) on the assessment of the effects of certain plans and programmes on the environment (European parliament and the council, 2001). The directive presents a planning process framework where, among other things, scoping is an important component.

Another weakness found in the studied municipal energy plans are loose connections to other municipal planning activities, for example spatial planning and building permission. The importance of close connections between energy planning and other planning is for example described by Jaccard, Failing et al. (1997), Sadownik and

Jaccard (2001), and Guy and Marwin (1996). Jaccard, Failing et al. state that choices made during urban design will affect future energy demand, Sadownik and Jaccard mean that implementation of energy management strategies will rely on how well these are integrated in urban planning, and Guy and Marwin (1996) present urban design as a powerful tool to implement local energy strategies.

As previously mentioned, energy planning was less effective in the studied municipalities when goals or visions were owned by private actors. This finding suggests that there is a need to invite private actors as well as municipal civil servants into the planning process. The importance of consulting with the public during the assessment of plans and programmes is also an important part of the EU directive, where it is stressed that the public should be informed and enabled to express its opinion about the plan (European parliament and the council, 2001)

One example where public participation has become an important part of infrastructure planning is the Netherlands. As described by Woltjer (2002), Dutch planners of infrastructure projects have increasingly followed a participatory planning mode. Participatory planning is considered to be effective in terms of acceptance and its ability to generate public support. It is the view here that participatory planning could be suitable for energy planning purposes, since acceptance and action from private actors is important in implementing the plans.

Thus, a question is raised: would energy planning improved if a wider systems approach and deeper environmental analyses were applied, and if energy planning was performed in connection with comprehensive planning, and with a participatory planning approach? This will be studied in a research project based on the process framework from the EU directive (2001/42/EC), which will be used throughout an energy planning process. The tested energy planning process includes several workshops with representatives from the local authorities, the public, and industry, and will employ the scenario technique and environmental assessment, including both lifecycle analysis and qualitative assessment (Mårtensson, Björklund et al., 2005). Furthermore, this energy planning project is the predecessor to forthcoming comprehensive planning in the municipality. Energy strategies from the energy plan are intended to form the basis of the municipal comprehensive plan.

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Appedix I

TABLE OF CONTENTS

About this appendix

This appendix is a presentation of empirical data from the second study conducted by the author in the research project Strategic Environmental Assessment of Local Energy Systems. Data presented here form the basis for analyses related to research questions RQA and RQB in the thesis. Deeper analysis and discussion of the results are not presented in this appendix, but in the cover essay.

The second study was made because empirical data from the first study on municipal energy plans in Östergötland County was not sufficient for RQB, concerning correspondence between energy plans and real development of energy systems. Most of the energy plans in the first study were produced before 1995; therefore, other, more recent plans and policies were seen as influencing the development in the municipalities more than old energy plans. The second study was designed to provide information about energy plans and development in reality after adoption of energy plans, and the findings are presented in this appendix. The second study also developed into a case study (Paper III), since there are many components of the development of energy systems that were not possible to follow up with the methods used for this study. This is further discussed in both Paper III and the "Research process and scientific methods" section of the cover essay.

This appendix provides more empirical data and further analysis of scopes of energy plans, and a general picture about the development in the studied municipalities after energy plans were adopted. Some of the data presented here were published in a report to the Swedish Energy Agency in March 2004[1]. However, this appendix presents more empirical data than the report, but above all, the results presented here are analysed more thoroughly.

The aims for this study are twofold and directly connected to both RQA and RQB in the cover essay:

RQA - Analyse goals stated in energy plans with a systems analysis approach.

RQB - Analyse statistical data to find out what has happened after energy plans were adopted.

The contribution to the thesis is more generality when it comes to scopes of energy plans and what has happened after energy plans were adopted. Hence, the latter will also contribute to the discussion about effectiveness of energy plans.

[1] Stenlund Nilsson, Tyskeng et al., Strategisk miljöbedömning av lokala energisystem, projektnr: P12615-1, slutrapport 2004-03-31 från ett projekt i Energimyndighetens program Utsläpp och luftkvalitet.

Methods

The methods used in this study can be summarised in four major steps:

1. Choosing municipalities
2. Identifying the different goals (or visions) stated in the municipalities' energy plans
    a. Grouping goals stated in the energy plans
    b. Analysing the goals' systems approach
    c. Analysing who is responsible for fulfilment of goals
3. Following up development for each group of goals
4. Combining results from Steps b-c in each group

The first step is the only one that does not directly generate results. When results are presented in the Results chapter, the groups under Step 2 are used as headings under which the result from the analytical Steps 3 and 4 also are included.

Step 1 - Choosing municipalities

As the principal aim for this study was to compare planning and reality, it was necessary that the energy plans had been in use for several years, thus providing a period for changes to occur but ensuring that the plans were nor completely out of date. Two municipalities from the first study fit this profile: Norrköping and Mjölby, which adopted their energy plans in 1995 and 1998 respectively. An additional five municipalities with energy plans adopted between 1995 and 1998 were also to be chosen from different parts of the country. Many Swedish municipalities had energy plans adopted between 1995 and 1998. Therefore, an additional requirement was added for having had an energy project that required an environmental impact assessment (EIA) in the municipality between 1995 and 1998. (For more discussion about this choice, see the cover essay). In summary, the energy plans in this second study meet the following requirements:

- Energy plan adopted between 1995 and 1998
- Environmental impact assessment for an energy project made between 1995 and 1998
- Represents different parts of the country

Table 1 presents the municipalities that were chosen for this study.

Table 1. Municipalities studied, with statistical data from Statistics Sweden (2004).

Municipality	**Geographic location**	**Number of citizens**	**Energy use (GWh)**	**Industry**
Bollnäs	Middle, inland	27 900	870	Pulp/paper
Falun	Middle, inland	54 400	1 990	Manufacturing
Härjedalen	North, inland	12 100	670	Manufacturing
Kungälv	South west, coast	36 300	890	Manufacturing, Food industry
Mjölby	South, inland	26 000	820	Manufacturing
Norrköping	South east, coast	123 800	9 230	Pulp/paper
Sundsvall	Middle north, coast	94 530	8 240	Pulp/paper

Step 2 - Assembling and grouping goals stated in the energy plans

All goals stated in the energy plans were cited and collected in a database.

Step 2a – Dividing goals into groups

Goals were placed in different groups based on typical issues covered by Swedish energy plans (Stenlund Nilsson and Tyskeng, 2003):

- Plant related issues. Examples include goals for heating and electricity generating facilities and plants for biogas.
- Transports. Examples include goals for vehicles, alternative fuels, and public transports.
- Energy conservation. Examples include goals for reducing energy use and energy efficient equipment.
- Energy carriers. Examples include goals for fuels.
- Environmental impact. Includes goals for reduced emissions, flue gas and ash treatment, and utilisation of renewable energy resources.
- Other goals that do not fit into any of the other groups. Examples include goals for implementation, information and advice.

Each one of these groups is represented as a heading in the results chapter. The most commonly occurring goals in each group, and goals directly connected to national energy policy goals[2], are presented for each group.

Step 2b – analyzing the goals' systems approach

Each group of goals has been analysed and divided into sub-groups based on a systems perspective and responsible actors. "Systems perspective" is divided into three sub-groups: "detailed", "technical systems", and "Large Technical System" (LTS). Below are a few examples of the chosen systems levels:

[2] The national energy policy goals are presented both in the cover essay and Paper III.

Detailed

Heating in houses, devices, vehicles, administrative tools

Technical

Technical solutions: plants, infrastructure, and energy use

Large technical system, LTS

Sociotechnical aspects, system integration, planning, information campaigns, national issues

Step 2c – Analysing who is responsible for fulfilment of goals

The method used to categorise goals according to ”responsible actors” was similar to that used in the ”systems approach”. All goals in a group were placed in sub-groups depending on if the local authority (LA) or private actors ‘own’ the issue, and hence would be the most important actor when it comes to fulfilling goals. In some cases this was explicitly stated in the energy plans, but in most cases a judgement was made by the author regarding which goals would be placed in which groups. There is also a third sub-group for goals, where both the LA and private actors are more or less responsible[3].

Step 3 – Following up development for each group of goals

Statistical energy balances for each municipality were analysed to find out what changes in the energy systems between 1995 and 2000 (Statistics Sweden, 2003). Results were calculated and assembled for each group. Some of this calculated data was not directly related to a specific goal stated in energy plans, but was relevant to the group of goals as a whole. When calculating values for emissions from different energy sources, life cycle data based on Uppenberg, Almemark et al. (2001a; 2001b) was used. These calculations are more thoroughly described in Appendix II.

Step 4 – Combining results from Steps 2 b, 2c and 3

In this step, information about the systems approach, responsible actors and the development of each group of goals was combined. The aim was to analyse correspondence between systems level, responsible actors, and development. The results are shown in figures similar to Table 1, a matrix of nine entries, one for each combination.

[3] The natural “owner” of the issue can also depend on tradition and culture in the municipalities, and therefore varies. Those issues that were not clearly a LA responsibility or depended on private initiatives were placed in the “both” group.

Table 1. Matrix for analysis of correspondence between the systems approach, responsible actors, and the development of each group of goals.

Large technical systems approach Local authority responsible	Large technical systems approach Both local authority and private actors responsible	Large technical systems approach Private actors responsible
Technical systems approach Local authority responsible	Technical systems approach Both local authority and private actors responsible	Technical systems approach Private actors responsible
Detailed approach Local authority responsible	Detailed approach Both local authority and private actors responsible	Detailed approach Private actors responsible

The number of goals in the group that fit into each entry was noted. Indication for development for the entries was stated as far as information was available in the statistical data. Statistical data which was deemed insufficient for a fair judgement of whether the development had been positive or negative was denoted with N/A, for "method not applicable".

Empirical findings – scope and development

In this section each group of goals from energy plans are presented, scopes and responsible actors are analyzed, and the development in the municipalities is presented in relation to the goals.

Many kinds of goals occur in energy plans. They vary in detail, ambition, and responsibilities. A general trend is that there are many detailed goals for the local authority and municipal administration, and goals with wider systems approaches are more visionary. Table 2 summarises how goals are distributed and describe their systems level and responsible actors.

Table 2. This table denotes goals in seven energy plans divided into groups depending on subject. “Occurring goals” means total number of different goals stated in the group, while “average” is the average number of goals per plan and category. “Systems approach” is divided into three levels, where “detailed” means very narrow system boundaries, and “LTS” means Large Technical System”, which is a wide systems approach. In addition, “LA” means that it is mainly the local authorities’ responsibility to fulfil the goals, and “private” means that fulfilment lies with private actors.

Group	Occurring goals	Average no. of goals in each plan	Type of systems approach			Responsible actors		
			Detailed	Technical	LTS	LA	Both	Private
Plant related	26	7	9	13	4	16	3	7
Transports	26	5.4	10	7	9	21	3	2
Energy conservation	32	9.6	17	7	8	16	8	8
Energy carriers	31	6.1	8	19	4	14	8	9
Environment	29	8.9	17	10	7	11	15	8
Other	20	4	8	3	9	20	0	0

Plant-related issues

Goals

When it comes to new energy generation plants, the most commonly stated goals are for expansion of district heating within the population centres, and for small scale biomass-based combustion for heating outside of densely populated areas. There are also goals for new wind power and hydropower development. The most commonly occurring goals are listed in Table 3.

Table 3. Most commonly stated plant related goals and the number of plans they occur in (out of seven).

Description	Stated in number of plans
Expanded district heating systems	6
Plants for bio gas	4
New wind power	4
Environmentally adapted small scale biomass based combustion for heating	3
Expanded hydropower	2

Systems approach

Goals for expanded district heating and new district heating plants dominate the technical parts of the energy plans. Most goals (60%) are at this systems level. Detailed goals are mainly of maintenance character for public buildings, for example improvements in HVAC systems, solar heat and environmentally adapted small scale biomass-based combustion for heating private estates.

Responsible actors

One half of the goals address both municipal and more private aspects of energy plants. One third of the goals are mainly the LA's responsibility:

- District heating systems
- To investigate possibilities to produce biogas from sewage sludge

Goals that address private aspects are for example wind power and small-scale solid fuel combustion.

Development

District heating has increased in four of the seven municipalities between 1995 and 2000, and hence also the total part of space heating that comes from district heating systems as seen in Table 4.

Table 4. Energy from district heat in relation to total energy supply

Municipality	District heat percentage of energy supply	
	1995	2000
Bollnäs	13	16
Falun	7	9
Härjedalen	4	4
Kungälv	0	9
Mjölby	14	15
Norrköping	13	10
Sundsvall	8	6

There were goals for new wind power in four of the plans. Two of these municipalities have wind power today, and one municipality that did not have goals for wind power also has wind power plants today. The two municipalities with goals for expanding hydropower showed different developments: one a large increase (23%) and one a small (3%) reduction. As for the wind power case, one of the studied municipalities showed a 24% increase in hydropower even though there was no plan for expansion.

Four plans stated goals for biogas plants, and one for an ethanol plant, to produce alternative vehicle fuels. No biogas or ethanol production can be traced in the statistical data for year 2000.

Combined analysis

Table 5 presents a combined analysis for plant related goals and development in the municipalities. Positive developments are for example that energy use in the public service sector has decreased and that district heating has increased.

Table 5. This table shows plant-related goals presented in groups by systems approach type and responsible actors. The "detailed" entry label denotes very narrow system boundaries, while "LTS" stands for "Large Technical System" - a wide systems approach. "LA" means that it is mainly the local authorities' responsibility to fulfil the goals, and "private" means that fulfilment lies with private actors. The ☺ symbol means positive and ☹ negative development according to statistical data. N/A means that available statistical data is insufficient to make a statement about the development, and hence the method is not applicable for that issue.

LTS/LA Number of goals: 2 Example: Planning Development: N/A	**LTS/Both** Number of goals: 1 Example: cooperation with industry Development: N/A	**LTS/Private** Number of goals: 1 Example: local production plant for biofuels Development: N/A
Technical/LA Number of goals:8 Example: District heating Development: ☺	**Technical/Both** Number of goals:1 Example: biogas plant Development: ☹	**Technical/Private** Number of goals: 4 Example: biofuel plants Development: N/A
Detailed/LA Number of goals:6 Example: HVAC systems Development: ☺	**Detailed/Both** Number of goals: 1 Example: water-based heating in buildings Development: ☺	**Detailed/Private** Number of goals: 2 Example: More efficient small- scale combustion Development: N/A

Transports

Goals

The overall impression of goals for the transport sector is diversity. There was only one issue covered in four plans: improving public transports. Two issues were covered in three plans: decreasing fossil use and developing rail transports. Among other goals for the transport sector were goals for “green” vehicles within the local authority’s organisation, improving possibilities to travel by bicycle, and improving the availability of alternative fuels. The most common goals are summarised in Table 6.

Table 6. Most commonly stated goals and the number of plans they occur in.

Description	Stated in
Improvements in public transports	4
Reduced use of fossil fuels for transports	3
Development of rail transports	3
Environmental requirements when purchasing transports	2
Support alternative vehicle fuels	2
Increased utilization of public transports	2
Optimise tranports/make transports more efficient	2
Locate facilities and infrastructure to decrease environmental impacts from transports	2

Systems approach

There are two kinds of goals that dominate this category: vehicles and the transport system. Goals at the technical level regard infrastructural projects. Statements at the systems level appear to be more wishes than goals, and there are very few goals concerning implementation at a larger systems level.

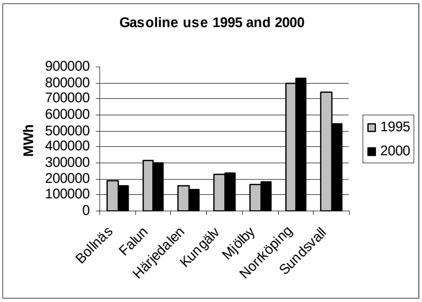
Responsible actors

Most goals are LA’s responsibilities: improvements in public transports, vehicles used by the municipal administration and civil services, or planning to facilitate transports.

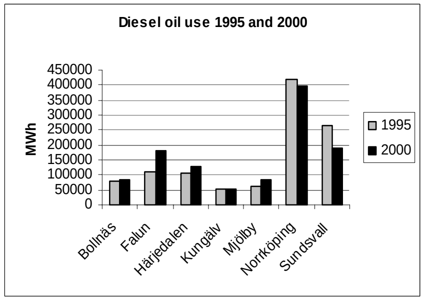
Development

Energy use for transports has increased in five of the seven municipalities, and decreased in Bollnäs and Sundsvall, as seen in Figures 2a-d and Figure 3a. Use of gasoline has decreased in four of the seven municipalities, while diesel oil has increased in four. Trends differ between fuel types - only two show the same trend for both. Mjölby shows a slight increase in both cases, and Sundsvall a significant reduction. Electricity use for transports has increased in all municipalities but one.

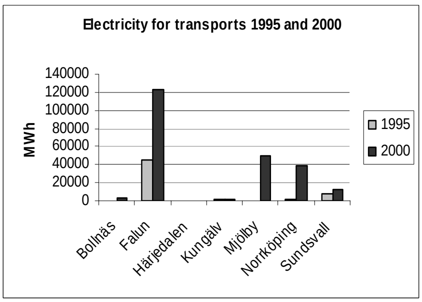
It should be noted that the only energy plan with an explicit goal for reducing electricity use for transports is the one that shows the largest increase[4].



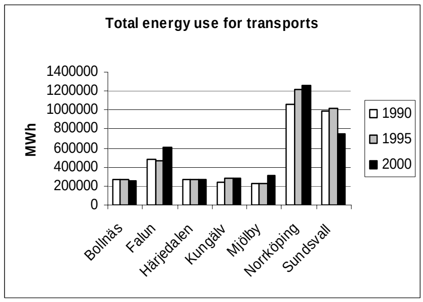
a. Gasoline used for transports in the studied municipalities.



b. Diesel used for transports in the studied municipalities.



c. Electricity used for transports in the studied municipalities.



d. Total energy used for transports in the studied municipalities for 1990, 1995, and 2000.

Figures 2 a-d. Statistical data for energy used for transports.

[4] An explanation for this is that the Swedish rail system was deregulated in 1995, and new actors could start traffic on for example commute destinations. There have been shifts in the ownership of many destinations, and therefore also a shift in where electricity purchase is noted in statistics. This can help explain why some municipalities show such a large increase in electricity use. (Regeringen (1994). Regeringens proposition 1993/94:166. Avreglering av järnvägstrafiken och riktlinjer m.m. för SJ:s verksamhet under åren 1994--1996.
, SJ. (2005). "Historiska fakta." Retrieved 2005-11-10, 2005, from http://www.sj.se/sj/jsp/polopoly.jsp?d=538&a=2192&l=sv.

Combined analysis

Table 7 presents a combined analysis for transport related goals and development. The general trend for the transport sector is increased energy use. This also includes public transports. There is no evidence in the statistical data that there were any alternative vehicle fuels for retail in 2000.

Table 7. This table shows transport-related goals presented in groups by systems approach type and responsible actors. The “detailed” label means very narrow system boundaries, while “LTS” stands for “Large Technical System” - a wide systems approach. “LA” means that it is mainly the local authorities’ responsibility to fulfil the goals, and “private” means that fulfilment lies with private actors. The ☺ symbol means positive and ☹ negative development according to statistical data. N/A means that available statistical data is insufficient to make a statement about the development, and hence the method is not applicable for that issue.

LTS/LA Number of goals: 5 Example: Information about transport issues Development: N/A	**LTS/Both** Number of goals: 2 Example: Not increased transports Development: ☹	**LTS/Private** Number of goals: 2 Example: Increased use of public transports Development: ☺
Technical/LA Number of goals:7 Example: Develop public transports possibilities Development: ☺	**Technical/Both** Number of goals: 0 Example: - Development: -	**Technical/Private** Number of goals: 0 Example: - Development: -
Detailed/LA Number of goals: 9 Example: Alternative fuels in vehicles Development: ☹	**Detailed/Both** Number of goals: 1 Example: Fuel station for alternative fuels Development: ☹	**Detailed/Private** Number of goals: 0 Example: - Development: -

Energy conservation

Goals

All energy plans contain goals for energy conservation. The two most commonly occurring are decreased electricity use and energy for heating public buildings, and taking energy-efficient technology into account during spatial planning and construction of new buildings. The most commonly occurring goals are listed in Table 8.

Table 8. The most common goals for energy conservation.

Description	**Stated in**
Reduced electricity use in municipal buildings	6
Energy conservation in mind during spatial planning and building construction	6
Reduced energy for heating public buildings	5
Audit of energy used by the municipal organisation and for public services	4
Waste heat utilisation	3
Reduced heat use in private residences	3
Installation of timers and maintenance optimisation	3
Use and purchase of energy-efficient equipment	3

Systems approach

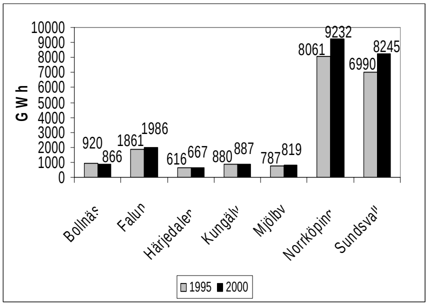
Most goals in this category focus on energy use and users, but a few also focus on efficient energy supply. To include energy conservation in spatial planning suggests a wide systems approach. However, most goals are detailed and focused on buildings and energy-efficient technology.

Responsible actors

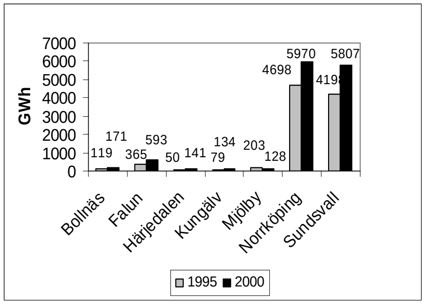
Most goals are LA responsibilities: energy efficiency in public buildings and planning issues. Among measures with other actors involved are utilisation of waste heat (from industries) and reduced heating demand in private residences. (It is possible that the term “private residences” is used in some energy plans as a synonym for flats owned by a municipal company, and not all private residences in the municipal territory.)

Development

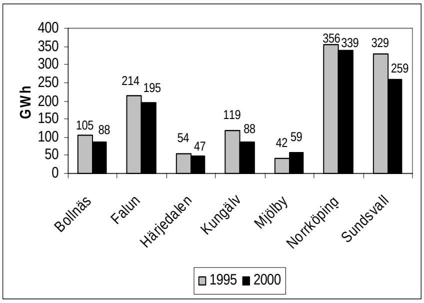
Total energy use has increased in six of the seven municipalities, which is also the case for the industrial sector. Energy use has decreased in the public sector in six of seven municipalities, and for the agricultural sector there was a decrease in four of seven. As was mentioned above, there was increased energy use in the transport sector in five municipalities. Figures 3a-f show changes in energy use per sector.



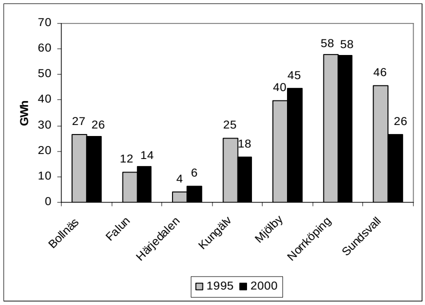
a. Total energy use, 1995 and 2000.



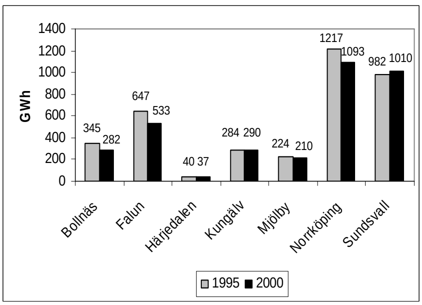
b. Energy used in industry and building construction, 1995 and 2000.



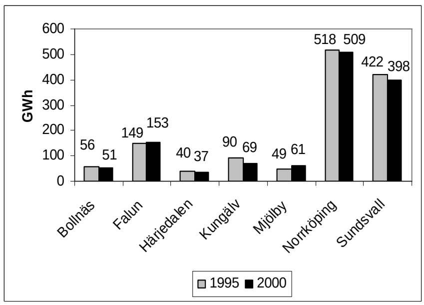
c. Energy use in the public sectors, 1995 and 2000.



d. Energy use in agriculture, forestry, and fishing, 1995 and 2000.



e. Energy used by households, 1995 and 2000



f. Energy used for other services, 1995 and 2000.

Figures 3a-f. Energy use in 1995 and 2000: total energy use and use in different sectors.

Combined analysis

Table 9 presents a combined analysis for goals regarding energy conservation and the development. The general overall trend is that energy use has increased per capita, but energy use has decreased for space heating and in the public service sector.

Table 9. This table shows goals for energy conservation presented in groups by systems approach and responsible actors. The "detailed" label means very narrow system boundaries, while the "LTS" refers to "Large Technical System" - a wide systems approach. "LA" means that it is mainly the local authorities' responsibility to fulfil the goals, and "private" means that fulfilment lies with private actors. The ☺ symbol means positive and ☹ negative development according to statistical data. N/A means that available statistical data is insufficient to make a statement about the development, and hence the method is not applicable for that issue.

LTS/LA Number of goals: 4 Example: information about energy savings Development: N/A	**LTS/Both** Number of goals: 4 Example: energy conservation in general Development: ☹	**LTS/Private** Number of goals: 0 Example: - Development: -
Technical/LA Number of goals: 2 Example: reduced electricity use in the public sector Development: ☺	**Technical/Both** Number of goals: 2 Example: use of waste heat Development: N/A	**Technical/Private** Number of goals: 3 Example: energy efficiency in industry Development: N/A
Detailed/LA Number of goals: 10 Example: optimisation of HVAC systems Development: ☺	**Detailed/Both** Number of goals: 2 Example: reduced energy for heating buildings Development: ☺	**Detailed/Private** Number of goals:5 Example: decreased electricity use in households Development: ☹

Energy carriers

Goals

There is no specific goal that dominate this category, but the general context is reduced use of fossil and an increased use of renewable energy sources. Some of the plans state goals for locally-produced renewable energy carriers, as seem in Table 10.

Table 10. The most common goals for energy carriers.

Description	Stated in
Reduced oil use	3
Reduced electricity for heating (conversion to other energy sources)	3
Increase supply and use of renewable energy sources	3
Preferably local resources of biomass	3
Solar heat outside district heating areas	3

Systems approach

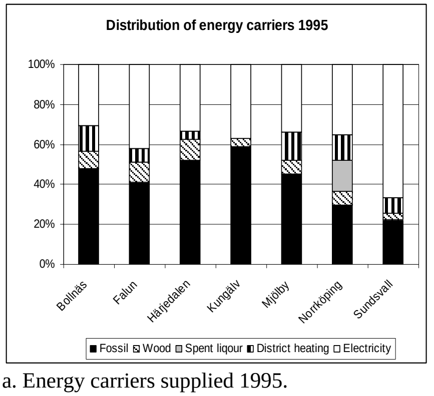
The focus in this category is on fuels and boilers, not an overall transition to renewable energy resources. This also applies to some goals that were mentioned in the transport category: focus on alternative fuels and alternative technologies. However, some regional aspects are covered when it comes to utilisation of biomass resources.

Responsible actors

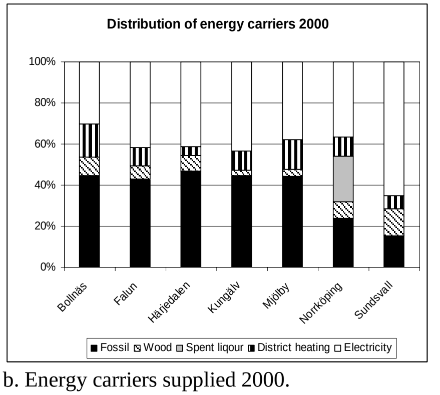
Most goals in this category regard private actors, and the role of the local authority is only vaguely stated. There are many statements, however, that imply that the local authorities should act to promote the transition towards more renewable fuels even though they do not explain how.

Development

The total share of fossil fuels has decreased in six of the seven municipalities, and the total share of renewable energy has increased in five, as seen in Figures 4a and b. This change is partly due to the increased share of biomass-based district heating.



a. Energy carriers supplied 1995.



b. Energy carriers supplied 2000.

Figure 4. Energy carriers, 1995 and 2000.

Combined analysis

Table 11 presents goals regarding energy carriers and development. Positive developments are represented by a general trend towards more biomass and less fossil fuels for heating purposes.

Table 11. This table shows goals for energy carriers presented in groups by systems approach and responsible actors. The “detailed” label means very narrow system boundaries, and “LTS” means “Large Technical System” - a wide systems approach. “LA” means that it is mainly the local authorities’ responsibility to fulfil the goals, while “private” means that fulfilment lies with private actors. The ☺ symbol means positive and ☹ negative development according to statistical data. N/A means that available statistical data is insufficient make a statement about the development, and hence the method is not applicable for that issue.

LTS/LA Number of goals: 1 Example: Protect protected rivers Development: ☺	**LTS/Both** Number of goals: 3 Example: *varies widely* Development: N/A	**LTS/Private** Number of goals: 0 Example: - Development: -
Technical/LA Number of goals: 8 Example: District heat based on biomass Development: ☺	**Technical/Both** Number of goals: 3 Example: General oil reduction Development: ☺	**Technical/Private** Number of goals: 8 Example: Local utilisation of biomass Development: N/A
Detailed/LA Number of goals: 5 Example: LA uses tools to facilitate transition to RE Development: N/A	**Detailed/Both** Number of goals: 2 Example: Less oil and more RE for heating buildings Development: ☺	**Detailed/Private** Number of goals: 1 Example: Heat accumulation in private houses (when small scale combustion) Development: N/A

Environmental impact

Goals

Minimization of environmental impact from the energy system is stated in several energy plans. Six plans contain goals for reduced CO_2 emissions, and five for SO_2 and NO_x, respectively. Resources are mentioned in vague statements for locally-produced biomass, and that respect should be paid to man and the environment (Table 12).

Systems approach

Most goals have rather narrow systems approaches regarding local emissions and technical changes of local character. There are some goals, however, that focus on global and regional effects.

Table 12. Most commonly stated goals regarding environmental issues.

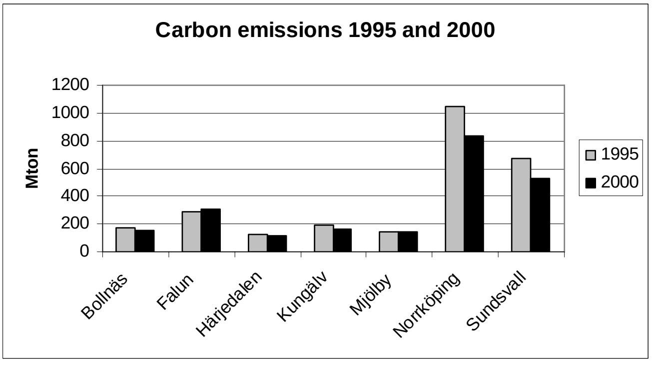
Description	**Stated in**
Reduced emissions of CO_2	6
Reduced emissions of NO_X	5
Reduced emissions of SO_2	5
Respect for man and environment	3
Flue ash recycling	3
Waste sorting and recycling	3
Small scale combustion in environmentally adapted boilers	3

Responsible actors

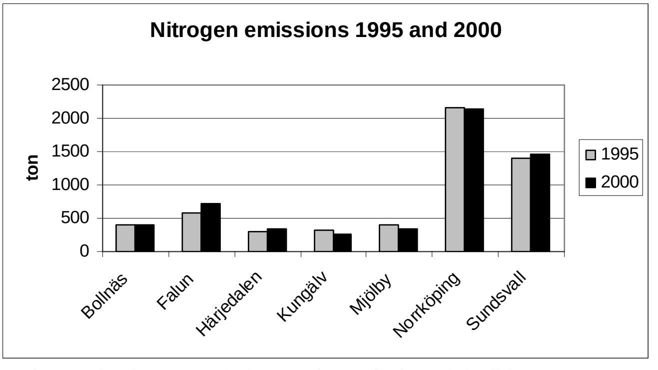
As for energy carriers, most goals involve private actors and the role of the local authority is vaguely stated: reduced emissions would involve a large number of actors. There are many statements about planning for, and restricting, utilisation of energy resources.

Development

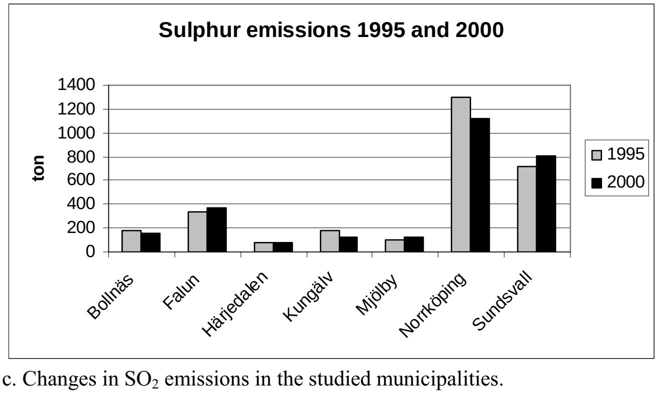
Five municipalities reduced CO_2 emissions (3-20%). NOx and SO_2 emissions have decreased in four of the seven municipalities respectively, as seen in Figures 5a-c.



a. Changes in CO_2 emissions in the studied municipalities



b. Changes in nitrogen emissions in the studied municipalities.



c. Changes in SO_2 emissions in the studied municipalities.

Figure 5. Calculated carbon, sulphur, and nitrogen emissions in the municipalities for 1995 and 2000.

Combined analysis

Table 13 presents a combined analysis for goals regarding emissions and resources, and the development. Positive trends are for reduced emissions.

Table 13. This table presents environmental issues grouped by systems approach type and responsible actors. "Detailed" label means very narrow system boundaries, and "LTS" means "Large Technical System" - a wide systems approach. "LA" means that it is mainly the local authorities' responsibility to fulfil the goals, while "private" means that fulfilment lies with private actors. The ☺ symbol means positive and ☹ negative development according to statistical data. N/A means that available statistical data is insufficient make a statement about the development, and hence the method is not applicable for that issue.

LTS/LA Number of goals: 4 Example: Planning for local use of biomass resources Development: N/A	**LTS/Both** Number of goals: 3 Example: Minimise environmental impact from the energy system Development: N/A	**LTS/Private** Number of goals: 0 Example: - Development: -
Technical/LA Number of goals: 3 Example: Use local biomass resources Development: N/A	**Technical/Both** Number of goals: 2 Example: Reduce use of fossil fuels Development: ☺	**Technical/Private** Number of goals: 5 Example: Improve small scale combustion Development: N/A
Detailed/LA Number of goals: 4 Example: Monitor emissions Development: N/A	**Detailed/Both** Number of goals: 10 Example: Reduce emissions Development: ☺	**Detailed/Private** Number of goals: 3 Example: Environmentally approved small-scale combustion Development: N/A

Other goals

Goals

Most energy plans contain goals about information campaigns to different kinds of citizen groups. The most frequently occurring goals are listed in Table 14.

Table 14. A selection of goals that did not fit in the other categories.

Description	Stated in
Education and information to different groups	6
Energy advice	4
Information and advice about energy efficiency	3
Information about energy and environmental issues in schools	2
Appoint a person or group responsible to organize energy-related issues	2

Other goals are that the LA should set good examples in energy-related issues and for auditing fulfillment of the goals stated in the energy plan. Many of the goals in this group deal with implementation of the plan, for example goals for communicating goals externally and internally and establishing or developing the role of energy advice.

Systems approach

I have chosen not to comment on the systems approach for this group of goals, since whether the action will have a wide systems approach or not depends on its implementation.

Responsible actors

Goals in this group are all more or less directly connected to the LAs and their activities.

Development

Goals in this category are hard (or impossible) to follow up with the aid of statistical data only. They require a deeper analysis of actual development in each municipality. One such case study is presented in Paper III.

Summary

Scoping and systems approach

For the “plant-related issues” group, the dominating systems approach is not the plant itself (detailed approach), but rather technical systems and infrastructure in connection to plants. However, there are many possibilities for system optimisation and cooperation when it comes to local energy supply, and this possibility is seldom developed in plans.

In the “transports” group the situation is the opposite – infrastructure is the least developed part; there are many goals on vehicles, fuels and internal policies for the local authority, but there are also many goals with behavioural approaches and goals for integrated planning to reduce transports.

Most common in all energy plans are goals for saving energy, i.e. energy conservation. This group is dominated by goals for technical solutions and devices. Goals for energy carriers are almost as common as those for energy conservation. Goals are mostly about energy in buildings and for adapting plants for biomass-based fuels. There are few statements about an overall transition from fossil fuel-based energy to renewable energy sources (as the Swedish energy policy states). Goals about environmental aspects are the most alike between energy plans: they all contain goals about reduced emissions.

The last, “other”, group of goals are mostly of two kinds: how the local authority shall act in different situations, for example when purchasing technical equipment, and about information and education on energy- related issues.

The systems level varies with each group of goals, but the general trend is that technical aspects of the energy systems are central. Humans and human behaviour are not the focus. Connection to other planning is not often stated.

Development and responsible actors

As shown in Table 14, development varies between the groups. As far as it was possible to analyse the development in the studied municipalities with aid of statistical data, this study shows projects owned by the LAs or municipal administration have been more successful than projects owned by private actors. But even though for example public transports have shown development, the total energy use for transports has increased. The same is the case for energy conservation: even though energy use in households and in the public sector has decreased, there was a net increase in energy use per capita in all studied municipalities but one. The increase has been for industry and transports, and sectors that include private actors.

The most positive trend is the group of goals about energy carriers. There has been a general transition in the use of energy carriers in all municipalities. One reason is expansion of district heating systems. Table 15 summarises the results from this study. Please read the cover essay for further analysis.

Table 15. This table summarizes all sub-groups of goals and respective development. For each entry, there is a general example of goals that fit in each systems level and actor responsibility. "Detailed" means narrow system boundaries, while LTS (Large Technical System) denotes a wide systems approach. "LA" means that it is mainly the local authorities' responsibility to fulfil the goals, and "private" means that fulfilment lies mainly with private actors. For development, there is a symbol for each group of goals. The ☺ symbol means positive and ☹ negative development. N/A means that available statistical data is insufficient to make a statement about the development, and hence the method is not applicable for that issue. A dash means that there where no goals in the sub-group, and therefore the development was not followed up.

LTS/LA Number of goals:16 Example: Planning Development: N/A N/A N/A ☺ N/A	LTS/Both Number of goals:13 Example: General improvements Development: N/A ☹ ☹ - N/A	LTS/Private Number of goals: 3 Example: Increased use of public transports Development: N/A ☺ - - -
Technical/LA Number of goals: 28 Example: District heating Development: ☺ ☺ ☺ ☺ N/A	Technical/Both Number of goals: 8 Example: Plant for biogas Development: ☹ - N/A ☺ ☺	Technical/Private Number of goals: 20 Example: Utilisation and upgrade of biofuels Development: N/A - N/A N/A N/A
Detailed/LA Number of goals: 34 Example: Devices used by LA Development: ☺ ☹ ☺ N/A N/A	Detailed/Both Number of goals: 16 Example: Reduce fossil and more efficient buildings Development: ☺ ☹ ☺ ☺ ☺	Detailed/Private Number of goals: 11 Example: Small-scale combustion Development: N/A - ☹ N/A N/A

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Appedix II

About this appendix

This appendix contributes to answering RQC of the thesis, and is a further attempt to describe development of the local energy systems for the municipalities in the second study.

Methods

The empirical base for this appendix is data from Statistics Sweden (Statistics Sweden, 2003) that was analysed using indicators designed by the Swedish Energy Administration (Swedish National Energy Administration, 2002; Swedish National Energy Administration, 2002). These indicators were designed to monitor whether the Swedish energy system develops according to the three energy policy goals. The Swedish National Energy Administration has designed a large number of indicators, but those relevant to local energy systems are:

1. Part of total energy supply that is renewable
2. Part of total energy supply that is fossil
3. Part of district heat that is produced in a combined heat and power (CHP) plant
4. Energy use for heating purposes
5. CO2 emissions (per sector)
6. SO2 emissions (per sector)
7. NO2 emissions (per sector)
8. Self-sufficiency in energy supply

Indicator values are calculated for each municipality and for the years 1995 and 2000, and changes in indicator values between these years are analysed. Indicator values for emissions of CO2, SO2, and NO2 from the energy system were calculated from life cycle data published by the Swedish Environmental Research Institute (IVL) (Uppenberg, Almemark et al., 2001; Uppenberg, Almemark et al., 2001). None of these calculations are time or site-specific, which means that changes in combustion and exhaust cleaning technologies are disregarded. This means that improvements in environmental performance from for example district heating may be underestimated.

When it comes to the first indicator, I chose to regard wind power and electricity generated in biofuelled CHP plants as the only renewable electricity option. This choice was made because even though the Swedish electricity system consists of one-half hydropower, hydropower will probably not be expanded in the nearest future. In addition, if there is an upgrade of existing hydropower plants, that will not be an issue for the municipality to decide. Therefore, it was concluded that the only realistic possibility for municipalities to increase their share of renewable electricity is wind power and biofuelled CHP.

Appendix II – Study of energy systems development in terms of national indicators

Results

Indicators 1 and 2

Most plans include goals about increased use of renewable energy and reduced fossil fuel use. Most municipalities have increased the share of renewable energy and decreased fossil in their mix of energy carriers.

Indicator 3

Most municipalities have invested in district heating systems, but not in combined heat and power plants. (This can be explained by low electricity prices during this period).

Indicator 4

Energy use for heating purposes has decreased. (Statistics for heating buildings is only available for private estates). The reduction can be explained by for example increased district heating (more efficient), heat pumps and improved insulation.

Indicators 5, 6, and 7

The trends for emissions are slightly positive: reductions have been achieved in more than half of the municipalities, but the changes were not overwhelming. One reason could be that electricity use has increased and life cycle emissions for electricity are fairly high.

Indicator 8

Self sufficiency would be enhanced if more electricity was generated locally and less used. The trend is the opposite in almost all the studied municipalities.

The results are summarised in Table 1. There, changes are referred to as improvements instead of increases or decreases, since improvements according to the indicators could mean an increase in one case as well as a decrease of an indicator value in another.

Table 1. Improvements of the studied local energy systems according to national indicators. The number in the right column is out of seven.

Indicator	Improvement in
Part of total energy supply that is renewable	5
Part of total energy supply that is fossil	6
Part of district heat that is produced in a combined heat and power (CHP) plant	1 (of 3, no CHP in 4)
Energy use for heating purposes[1]	6
CO2 emissions	5
SO2 emissions	4
NO2 emissions	4
Self-sufficiency in energy supply[2]	4

Changes compared to national average

Energy use per capita and sector is an indicator used by the Swedish association of local authorities (2000) that is useful when it comes to comparing municipalities. In this study, this indicator was chosen to compare the development in these municipalities to the Swedish average. Changes in the municipalities related to the national average are presented in Table 2.

Table 2. Change in energy use per sector in the seven municipalities. The middle column presents the number of municipalities out of the seven studied that reduced per capita use. Results are related to the Swedish average.

Sector	Number of municipalities that reduced energy use per capita	National average per capita change
Transports	3	+5%
Industry, building construction	3	+15%
Public sector	6	-9%
Agriculture, forestry, fishing	2	-4%
Energy used by households	6	-8%
Other services	5	+2%

[1] For private homes only.
[2] For electricity only.

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