

THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Organising matters for the environment
Environmental studies of housing management and
buildings

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ORGANISING MATTERS FOR THE ENVIRONMENT: Environmental studies of housing management and buildings

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ABSTRACT

Buildings give rise to several environmental problems over the whole life cycle. To reduce these, technical measures with focus on energy are commonly used. However, environmental problems are more than energy and cannot be solved with technical measures alone.

This thesis seeks to *understand* the relationship between organisation and the environment. The question is *how* environmental effects of organising can be studied and *how* organisation and management influence environmental performance. These issues are explored in the field of housing management and life cycle assessment (LCA). Understanding is sought through comparative studies of housing management companies and their buildings, in which qualitative organisational data were collected from interviews, observations and internal documents and quantitative data were collected from internal documents (Papers II and III). A 'hybrid' methodology based on the concept of environmental assessment of organising (EAO) has been developed here (Paper I). Research literature on environmental management and indicators are also explored and compared with housing management practice (Paper IV). Furthermore, a life cycle methodology was used for the comparison of passive and conventional building chains including actors and their choices along the chain (Paper V).

This thesis has shown that it is possible to study the environmental effects of organising by including humans in the life cycle assessment (LCA) methodology. The way organisation and management influence environmental performance is through the combination of many actions. The concept of 'action nets' and the 'theory of practice' are found to be especially useful here.

It is concluded that organising matters for the environment. A form of organising that pays close attention to the building and its physical flows seems to be important for a better environmental performance. Environmental indicators need to be specific for work processes and physical environmental flows. Passive house buildings are not always better than conventional buildings and that resident's choice of eco-labelled electricity matters most.

Keywords: environmental assessment, life cycle assessment (LCA), field studies, housing management, organisation theory, action nets, buildings, passive house technology, environmental management, environmental management systems (EMS)

LIST OF INCLUDED PUBLICATIONS

This thesis is based on four journal publications and one manuscript:

PAPER I

Baumann, Henrikke and Brunklaus, Birgit (2008). Using LCA in organisational studies – Finding operational environmental opportunities. *IntJLCA* (submitted).

PAPER II

Brunklaus, Birgit (2008). Does organising matter? Tracing connections to environmental impacts in different housing estates. *Journal of Progress in Industrial Ecology* (under review).

PAPER III

Brunklaus, Birgit (2008). *Organising emerges locally: the unsought environmental consequences in different housing estates*. Environmental Systems Analysis, Chalmers University of Technology, Gothenburg, Sweden. (manuscript)

PAPER IV

Brunklaus, Birgit and Malmqvist, Tove and Baumann, Henrikke (2008). Managing stakeholders or the environment? The challenge of relating indicators in practice. *Corporate Social Responsibility and Environmental Management* (accepted, DOI:10.1002/csr).

PAPER V

Brunklaus, Birgit and Thormark, Catarina and Baumann, Henrikke (2008). Beyond the energy accounting: Introducing environmental and actor perspectives in comparisons of passive and conventional buildings. *Journal of Building Research and Information* (submitted).

I am the solely author of two empirical papers, paper II and III, which comprises all steps from research design, data collection, analysis of results and writing the paper.

I am the main author and was responsible for the writing of two papers, *paper IV and V*. For paper IV I did the literature review and the analysis and came up with meaningful indicators, while I received some valuable input from my co-authors, empirical material from Tove Malmqvist and

discussing the results with Henrikke Baumann. For paper IV I did most of the writing, most of the calculations of environmental impacts and the actor analysis, while my co-author Catarina Thormark contributed most of the data collection, part of the calculations and part of the writing. During the process most of the steps were discussed with Henrikke Baumann.

Paper I was performed in collaboration. My contribution lies in the empirical test and further development of a new LCA methodology for organisational studies, while the main author Henrikke Baumann has developed the theoretical concept of the new LCA methodology. This paper resulted out of an ongoing discussion of theoretical concept and empirical work and was therefore written in collaboration. My contribution lies mostly in the procedure and the concluding discussion, while Henrikke Baumann's contribution lies mostly in the concept and the areas of application.

OTHER PUBLICATIONS BY THE AUTHOR

Brunklaus, Birgit and Baumann, Henrikke (2001). Environmental assessment of housing management with LCA and time series, *1st Conference on Life Cycle Management*. Copenhagen, Denmark.

Brunklaus, Birgit (2002). *Bostadsförvaltning, miljöarbete och livscykelerspektivet – en litteratur - och branschöversikt*. ESA-report 2002:5 Chalmers University of Technology. Gothenburg, Sweden.

Brunklaus, Birgit and Thuvander Liane (2002). *Do Swedish property management companies have the necessary conditions for environmental management? An interview study on environmental data availability*. Greening of Industry Network Conference, 23-26 June 2002, Gothenburg, Sweden.

Brunklaus, Birgit and Baumann, Henrikke (2002). *Vad innebär ett ökat träbyggande i Sverige för miljön? Granskning av jämförande LCA-studier av stombyggnadsmaterial i hus*. Environmental Systems Analysis, Chalmers University of Technology. Gothenburg, Sweden.

- Baumann, Henrikke and Brunklaus, Birgit, and Gluch, Pernilla and Kadefors, Anna and Stenberg, Ann-Charlotte and Thuvander, Liane (2003). *Miljöbarometern för byggsektorn 2002*. Environmental Systems Analysis & Centrum för management i byggsektorn, ESA-report 2003:2, Chalmers University of Technology. Gothenburg, Sweden.
- Brunklaus, Birgit and Baumann, Henrikke (2004). *Environmental improvement potential for housing management: LCA's possibilities for organisational studies*. SETAC Conference, 18-22 April 2004, Prague, Czech Republic.
- Brunklaus, Birgit (2005). *Organizational background to environmental impacts: Field study on housing managed in Gothenburg*. Thesis of the degree of Licentiate, Environmental Systems Analysis, ESA Report 2005:1, Chalmers University of Technology: Gothenburg, Sweden.
- Gluch, Pernilla; Brunklaus, Birgit; Johansson, Karin; Lundberg, Örjan; Stenberg, Ann-Charlotte; and Thuvander, Liane (2007). *Miljöbarometern för bygg- och fastighetssektorn 2006 – en kartläggning av sektorns miljöarbete*. CMB. Chalmers University of Technology, Sweden
- Brunklaus, Birgit (2007). *Understanding organizational influence on environmental performance: Studies of housing management in Sweden*. 3rd Conference on Life Cycle Management, 27 – 29 August 2007, Zürich, Switzerland.
- Brunklaus, Birgit and Lundberg, Örjan (2007). *Energideklarationer – en bra väg mot energieffektiviserinar*. Bygg & Teknik 2.
- Brunklaus, Birgit; Thormark Catarina; and Baumann, Henrikke (2008). *Passivbus och konventionella bus – en miljöjämförelse*. Bygg & Teknik 5.

PREFACE AND ACKNOWLEDGEMENTS

During my final years of research I have read a lot of social science literature. Thanks to the ORM research programme – Organisering för Miljön - I have got to know more about sociology and organisation theory, and I found an interesting quotation about technology:

*The social nature of technology
might be hidden from its user (Hatch 2006).*

Undertaking research in a social science field has possibilities and drawbacks. It is a pleasure to read social science research, especially the recent style of narrative approach by Czarniawska (2004). However, writing social science myself I found some drawbacks, especially about the languages and interpretations. During my research I was looking for connections between social science and the natural science, I found a classic story about another scientist ‘Faust’ looking for connections:

*Ich will wissen was die Welt
im inneren zusammenhält. (Faust II, Göthe)*

I would like to thank both my supervisors: Henrikke Baumann for interpreting organisation theory and environment management, and for giving me the words I always seem to lack. And, thanks for the ‘pinart’ and the vitamins. Karin Andersson for being open for managerial issues, and providing positive feedbacks.

I should like to thank FORMAS and the Adalbertska fond for financing the project and listening to suggestions. Thanks to the organisations Familjebostäder AB, HSB Svärdslijan, Wallenstam and Dalavik for the cooperation and special thanks to the caretakers, technical managers and

the chairwoman for sharing their stories about handling buildings. Without your help I would not be able to write this thesis.

I am also grateful for my co-authors in my last two papers: Tove Malmqvist for sharing experiences from ambitious environmental management in housing management companies. Catarina Thormark for having so much energy for collecting data; for your interest in environmental issues, and for your hospitality.

Finally, I should like to thank my family: Mama und Papa, Danke für all die Hilfe in meiner stressigen Phase. Andreas, Danke für Dein offenes Ohr für die kleinen und grossen Dinge im Leben. Thank you Ove and Nils, for your distractions while sitting in front of the computer. There is another life out there. I am really looking forward for relaxing in your new built sauna Ove.

Göteborg, November 2008

BIRGIT BRUNKLAUS

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1. INTRODUCTION

“We hope that science and technology will come to the rescue. However, as we are finding out, these in themselves give us knowledge and power, but not wisdom.

It is we the humans who have to learn to choose which direction in science and which applications of technology will help us out of our present ecological problems.” Eco-Renovation by Ecology Building Society, 1993

Buildings give rise to several environmental problems throughout their whole life cycle. Among other things, the building sector utilises 40% of the national amount of energy and material (BYKR 2001; OECD 2003). Environmental systems studies on buildings are usually about technical systems. They have shown that for conventional buildings 85% of the life cycle energy is used during the occupation phase (Adalberth 2001), and have led to the introduction of a rather complicated technology, the passive house technology. Other simpler technical solutions exist for buildings (Azar and Lindgren 1998, CEC 2005). However, repeated surveys have shown that technical solutions are not implemented to a great extent (Energisparcentrum 1988, Boverket 2003, Bygga/Bo 2003, CEC 2005). What is the problem? Even though managerial efforts such as environmental management systems have been introduced since the 1990s, they do not necessary lead to improved environmental performance (Ammenberg 2003, Zobel 2005). Some researchers point to the need for better understanding of the human and organisational dimension of the problem (Guy and Shove 2000, Heiskanen and Jalas 2003, Baumann 2004). Environmental problems arise out of our actions and these are managed through our organisations. It is the humans that have to learn. What can we learn from taking in humans into

environmental systems studies as well? We do not necessarily need more technical solutions, we need to organise the ones we have in an environmentally smarter way. Maybe that will give us wisdom.

1.2 Aim and procedure

This thesis aims to understand the relationship between housing management and the environment. It is about *how* the environmental effects of organising can be studied. The question is *how* organisation and management influence environmental performance, in other words, *how* does the daily work and actions in companies lead to environmental impact? The thesis aims to *explore* these issues in the field of housing management and life-cycle assessment (LCA).

Further on, the implications for related research fields are studied: building research and the environment; social science in the field of LCA; environmental management and the environment. Specific questions are:

1. What does LCA studies of building chains mean for buildings and their management?
2. What does including an actor perspective imply for LCA?
3. What do the field study findings mean for general environmental management, particularly in relation to environmental management systems (EMS) and environmental indicators?

These issues are explored within the study of housing management practices and their properties in Gothenburg/Sweden. This has led to two empirical papers, paper II and III, and to the methodological development of using LCA in organisational studies. The research has been carried out in an interdisciplinary way, combining organisational research methods based on a grounded approach (Glaser and Strauss

1967, Silverman 1995), and environmental research methods based on a life-cycle approach (Baumann and Tillman 2004). Existing concepts (Baumann 2004, Hatch 2002/2006, and Czarniawska 2005) guide my methodological work, which led to one method paper, Paper I. Further on, implications for related research fields are dealt with in two additional studies, one literature study on Environmental Management Systems EMS and the use of environmental indicators, Paper IV, and the other an LCA study on building chains including an actor perspective, Paper V.

1.3 Papers and Outline

The doctoral research is based on five papers the following two areas: organisation and the environmental (figure 1.1).

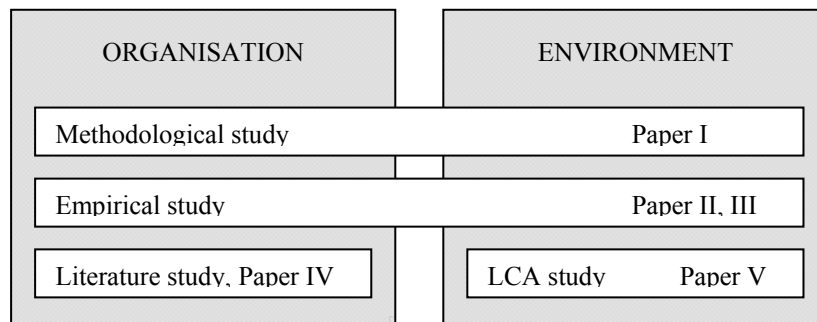


Figure 1.1: The thesis is based five papers within two areas: organisation and the environment.

Paper I outlines a modified LCA methodology to assess the organisational causes of environmental impacts, a ‘hybrid methodology’ based on qualitative and quantitative methods for the Environmental Assessment of Organising (EAO). The LCA procedure is presented in the light of organisational studies that shift the focus from the technical to the social source of environmental problems. The new methodology can be applied for the production and service industry.

Paper II and III present empirical applications and a test of the EAO concept in the field of housing management. They present a detailed study of a comparison of four studies of housing management practices and trace the organisational-energy/water connections. They complement the more general methodological description of EAO and are the empirical basis for Paper I. These studies have led to an organisational understanding of environmental performance in buildings rather than the dominant technical-economic one. While *Paper II* has shown connections within housing management companies, *Paper III* has additionally shown connections to tenants and suppliers.

Paper IV takes the learnings from the housing management studies and puts them into a context of environmental management systems and environmental control using indicators. It presents an overview of current literature on environmental indicators and discusses useful indicators for the organisation, based on organisational theory and organisational cause-effect chains in the field, and useful indicators for the environment, based on a life-cycle approach. This paper also presents examples of useful indicators in the field of property management.

Paper V presents a comparative LCA study of passive and conventional buildings and how actors' green choices within the chains influence the overall environmental impact of buildings. Furthermore, it presents an introduction of an actor analysis to the LCA of buildings.

Organisation and environment have been related to each other in various ways in the different papers. In the present work, organisation and environment, are put into a wider research perspective (philosophy of science), in order to explain some of the current problems found in

research and practice, and in order to stress the uniqueness of relating these two. I shall only briefly comment that in some of the chapters.

Chapter 1 is the introductory part of this doctoral thesis, where I give a background on current ideas to solve environmental problems, technical ideas in the building sectors and managerial ideas in environmental management, and presents an aim for an alternative idea: organising for the environment. *Chapter 2* gives an overview of related research fields: environmental management and the environment, environmental systems research (LCA), and buildings and the environment. *Chapter 3* presents the idea of organising for the environment; the concept and research programme, the hybrid methodology and the specific organisations and buildings studied. *Chapter 4* presents the results of the empirical work. The environmental consequences of organising are described and discussed for housing management, production, and for building product chains. Specific methodological contributions to Life-Cycle Assessment are presented and discussed in *Chapter 5*. Contributions to environmental management systems, specifically for indicators are described in *Chapter 6*. In *Chapter 7* the implications of the findings are made for related research fields (environmental management and the environment, environmental systems research (LCA), and buildings and the environment), and recommendations are made for their respective communities. I end the thesis with my research reflections; my suggestions for future work/research and present some final remarks in *Chapter 8*.

2. RELATED RESEARCH FIELDS

In order to understand the relationship between housing management and the environment, three research fields are introduced. There is the research on building and the environment, which serves as introduction to Paper II and III. The research on social dimensions in LCA research serves as introduction to Paper V, and the research regarding environmental management and the environment, which serves as introduction to Paper IV.

2.1 Research on building and the environment



In the field of building and the environment, technical studies with focus on energy and the life cycle are predominant in Sweden. Social aspects are seldom included in environmental studies, in spite of the existence of tenants and other actors and their behaviour.

Environmental studies on buildings and housing management

There is large volume of environmental studies, but these are still technical and often concern themselves with issues related to new construction rather than those of existing buildings: material studies (e.g. Erlandsson et al 1997, Björklund 1999, Jönsson 1998), building studies (e.g. Adalberth et al 2001, Thormark 2002), urban studies (e.g. Forsberg 2003), and national building stock studies (e.g. Kohler et al 1997, Thuvander 2002). Typical for this field is also the development of LCA-based tools for buildings, for example, BREEAM in Great Britain or 'Eco-Effect' in Sweden (Glaumann 2002). The ambition of the developers of the 'Eco-Effect' tool is that it should take root in all different kinds of building-related practice, including building

construction and housing management. Currently large amounts of environmental data are collected in order to feed the need (Malmqvist 2007). However, collaboration around tool development with other LCA researchers in other industrial fields is uncommon.

Even though there is a larger amount of existing buildings, only some environmental studies focus on existing buildings and housing management. Among these there are the studies that focus on environmental management systems in the Stockholm area by Malmqvist (2004), descriptive studies that focus on technical management in the Gothenburg area by Brunklaus (2005). Then there are studies of a housing management company in Helsingborg with various focuses: one with the focus on the company and technical management (Johansson and Wijkmark 1999); another with the focus on participatory processes (Johansson and Sundström 2000) and one with the focus on buildings and tenant life-styles (Lundberg and Wijkmark 2002).

Technical studies on buildings and energy use

Many different environmental technologies exist in the building area (e.g. passive house technology and other renewable energy technologies like solar and wind energy



(European Commission 2002), but studies of their environmental benefits are usually based on energy and not on environmental studies. Life-cycle energy studies of passive house technology are frequently studied (Sartori et al 2007, Thormark 2002/2007, Joelsson 2008), while there are few environmental life-cycle studies (Kohler et al 2004, Citherlet and Defaux 2005). However, it is the environmental studies that indicate that some of the environmental problems are lacking in the energy is studies, for

example acidification or radioactive waste. Another problem is that researchers assume that environmental technologies are environmental better in their own right and forget how all the different actors' behaviour/handling can influence environmental results. Both these shortcomings have been dealt with in Paper V.

Technical studies on buildings and social aspects



There is research on social aspects that hinder the introduction of environmental technologies: lack of interest and action

(Nilssen 2003; Nässén 2007), failing operation and maintenance as well as tenant behaviour (Energisparcentrum 1988 Hiller 2003; Bygga/Bo 2003), and low maintenance standards (Boverket 2003). However, they also seem to assume that environmental technologies are environmentally better in their own right and again forget how all the different actors' behaviour/handling can influence environmental results. Social aspects that favour the introduction are often not investigated any further (Energisparcentrum 1988) or hard to detect due to lack of data over time (Hiller 2003). Technical research is expected to take root in social practice with optimal technical and cost-benefit solutions (CEC 2005, Weber 2002, Känzig 2006). However, this has not led to the introduction of environmental technologies to a great extend. Technical experiences regarding the introduction of environmental technologies exist, such as solar heating (Dalenbäck 2006). They need to be completed with social research that tells the stories about people/companies introducing environmental technologies are needed.

Social studies on buildings

Asking for optimal solutions and cost-benefit analysis are signs of a rational view of humans and their organisation, according to the sociologists Guy and Shove (2000). More interesting are the studies on buildings that focus on social aspects and the theory of practice, which complement my work. Parallel to the technical studies there are sociologists searching to understand levels of energy and water usage. There are a number of social studies on energy use and a few on water uses. All of these studies point out the importance of understanding the user perspectives (Lagergren 2004, Guy and Shove 2000, Shove 2003, Guy 2004, Wilk 2007). Similar to my approach, the theory of practice is based on action patterns including both material and symbolic aspects (Shove 2003, Medd and Shove 2005). However, only one suggestion for the study on individual professional user practices has been found in the field of housing management (Guy 2004).

In contrast, there are a number of social studies that try to understand tenants and consumers. These studies concern the choice of eco-labelled electricity (Konsumenverket 2007, DN 2007, Ek and Söderholm 2006), consumption trends (Browne and Frame 1999, Ellegård 2008), tenants behaviour and the social construction of environmental problems regarding energy and waste (Lindén 1997; Klintman 2000). Among the few organisational studies there are also studies that focus on the social construction of environmental issues (Stenberg 2006, Gluch 2005) and studies that try to solve environmental problems with participatory processes (Elfors 2006, Nilsson 2003, Svane



1999, Johansson and Sundström 2000). However, these do not include quantitative environmental impacts.

My organisational studies on housing management, described in Papers II and III, go beyond individual professional user practices and include an organisational dimension. They extend beyond existing organisational studies by including quantitative energy and water data.

2.2 Social dimensions in LCA research

In a LCA study, the environmental impacts of products and services are calculated. Thereby the whole industrial production associated with a product or a service is described from cradle (raw material extraction) to grave (disposal). Social aspects are seldom included in LCA, except when dealing with the environmental impacts, e.g. evaluation, and weighting of results. LCA belongs to a 'family' of Environmental Systems Analysis ESA tools, where the social system (the people involved), the technical system (the industrial system) and the natural system (resources used and emissions released) are modelled (Baumann and Tillman 2004). From the start the technical system remains central in LCA. The people (social system) in a life cycle those related to the technical system e.g. consumer or manager. They are not explicitly dealt with in the modelling.

Social LCAs

The development of LCA as a tool has dominated the research theme, at least since the late 1980s and early 1990s. LCA started as a quantitative tool. Today, LCA comes in both quantitative shapes (stand-alone LCA for single products, accounting LCA for communication, change-oriented LCA for decision-making), and more recently in qualitative shapes (life-cycle thinking LCT for supply chain and life-style choices, life-cycle management LCM for organising and management practice) (Baumann

and Tillman 2004). Lately, some attempts to include social issues have been made (Udo de Haes et al 2004). In addition to the natural environment and natural resources, human health and human well-being are also integrated in the 'area of protection' in the impact assessment methodology of LCA (Weidema 2006). An LCA including social issues in the impact assessment phase is called Social Life Cycle Assessment, SLCA.

A recent review by Jorgensen and colleagues (2008) revealed some methodological problems of SLCA in nearly all steps of the methodology. They found difficulties in choosing social impact categories and how to measure these. They found difficulties in choosing between the organisational and the individual level, and choosing between site-specific investigation and generic statistical sources. Besides these difficulties Kloepfer (2008) makes a further attempt to include social, economic and environmental issues into the framework of LCA and create a Life Cycle Sustainability Assessment (LCSA = LCA + LCC + SLCA). Udo de Haes (2008) criticises the scientific basis of Kloepfer's attempt at SLCA and doubts that SLCA will be useful for finding social solutions. His main criticism is the problem of translating social indicators into LCA terms (qualitative data) and the problem of defining suitable social indicators. My perspective on social LCAs is that they only deal with social issues as (end-point) impacts of technology and not with social/organisational arrangements that handle the technology and their environmental consequences.

Applications of LCA



Over the last decade LCA studies have become more and more established in industrial practice.

Previously, hierarchies of environmental waste management strategies (e.g. reuse better than recycling) were the means of guiding environmental decision-making. LCA also received much attention as a tool for decision-making for product development in the beginning. With LCA, it became possible to calculate whether reuse was better than recycling. By now, LCA has spread into many different applications e.g. product design, process design, purchasing, public policies, and it has also become a tool for communication e.g. Eco-label and EPD (Baumann and Tillman 2004). However, LCA's main role in industry seems to support learning (Baumann 1998). Over the years researchers and practitioners have learned about the locations of environmental risks in product chains and have used this knowledge e.g. in the development of technical improvement possibilities, and to select environmental indicators. Only some of the LCA researchers have studied the use of LCA in industrial practice. A decade ago Heiskanen (1997) demonstrated the social construction of LCA and its use, such as LCA as a scientific method and LCA as management tool. Other studies in the same vein, for instance, are institutionalisation of LCA (Baumann 1998), translations of LCA (Heiskanen 2000), Life cycle Management (Poikkimäki 2006), Life cycle thinking (Rex 2008). These studies are useful in understanding how applications of LCA take place in practice, but do not explain application to new areas.

Only one LCA study is found including an actor perspective in the study of product chains i.e.



the study of the post-farm milk chain (Berlin, Sonesson and Tillman 2008). After all, LCA is developed for environmental evaluation of products and services. While eco-labels for some services, such as stores, hotels or cleaning, already exist on the market (Miljöstyrningsrådet 2006), studies of services seem to be rare in the LCA literature. Among the few references found in the International Journal of LCA mostly product services are studied (Graedel et al 2002, Rozycki et al 2003). Only one LCA study is found dealing with services i.e. Junilla's study of banking and facility management (Junilla 2006). Another study deals with eco-efficiency and with services and organisational dimensions, such as professional planning, designing and operation (Heiskanen and Jalas 2003). So far there few attempts known to expand the LCA into organisational studies. One is PSS, product service systems, from the field of eco-design (Matzen and McAloone 2008). The other is the concept of environmental assessment of organising EAO by Baumann (2004), and the study of housing management (Brunklau 2005).

My position regarding the social dimension in LCA research

My perspective on the social dimensions in LCA research is that SLCA's are limited to social issues as (end-point) impacts of technology. LCA is established in industrial practice and researchers have studied the use of LCA in industrial practice, but LCA is not applied in organisational studies. LCA studies of products, there are many of, while LCA studies of services are rare.

My work expands the social attention in LCA in three ways. First, it includes an organisational dimension into LCAs (see Paper I). Secondly, it includes an actor perspective to the study of product chains (see paper V), and a thirdly it applies LCA on less studied areas, the area of service as a product (see Paper II and III).

2.3 Environmental management and the environment

Environmental management is referred to as how environmental issues are handled and acted upon in industry. Environmental management involves several disciplines, such as natural science, engineering, policy studies, economics, and management and organisation theory (Welford 1997, Füssel 2005).

Dominant and emerging positions



Füssel (2005) distinguishes between dominant and emerging ‘tracks’ in the environmental management literature and their scientific perspectives: managerial techniques and strategic evangelism, corporate and internal practice. The most dominant track in the environmental management literature consists of ‘managerial techniques’ for controlling and monitoring e.g. the Environmental Management System EMS. Another main track is ‘strategic evangelism’ - it deals with the changing of norms and values. Propositions are typically idealistic and not empirically based e.g. the urge towards sustainability. Both ‘tracks’ are based on a modernistic perspective, where management is used a tool. A third emerging track deals with descriptions to explain how environmental issues enter the organisation, called ‘mechanism of organisational greening’. This track is based on a hermeneutic perspective, where studies are empirically based. Some descriptions focus on the business translations and corporate

practice. Other descriptions focus on local translations and organisational practice. I would position my research as descriptions of organisational practice. Füssel (2005) points out two challenges for environmental management as a discipline: how to deal with different conceptions of the natural environment, and how to deal with different perspectives and methodologies in management and organisational studies. I have also chosen a life-cycle perspective for the natural environment. I have chosen a hermeneutic/interpretative perspective and an empirically grounded approach in organisational studies.

Also Dobers et al (2001) point out management as technique/tool and as a dominant 'cluster' in their review of the environmental strategy research (Hart 1995, Porter and van der Linde 1995, Burrell and Morgan 1979, Welford 1995). This dominant cluster is based on theory and leave less space for hermeneutic research and empirical descriptions. They conclude that empirical studies are rare. Therefore Dobers and colleagues point out several risks. There is a risk that environmental management attempts based on of theories and tools (top-down studies) may not lead to real environmental improvements, without the empirical studies on mechanisms behind an environmental situation (bottom-up studies). Without empirical studies there is a risk that the environmental management field becomes unbalanced and single-tracked without empirical research.



My position in the field of environmental management

My work is balancing the field in several ways. One way is to perform empirical studies on practices in companies. Another is to apply the learnings from the empirical studies for the environmental management tools, such as environmental management systems and environmental control using indicators. Thereby I contribute with a life-cycle perspective and organisational theory into the field of environmental management tools.

3. UNDERSTANDING THE RELATIONSHIP BETWEEN ORGANISATION AND ENVIRONMENT

In order to study how housing management affects the environment a number of terms and concepts need to be explained. Even a 'hybrid method' is needed that combines a quantitative study of the physical environmental aspects with a qualitative study of the organisational arrangements. What is to be found in literature about the relationship between organisation and environment?

3.1 Terms in the area of organisation and environment

There are two main areas in this thesis, 'organisation' and 'environment'. The terms related to these two areas can be easily misunderstood as they come from different scientific areas, such as organisation theory and natural science/engineering. For example, the terms 'organisation' and 'organising' seem to have the same meaning, which is a misunderstanding.

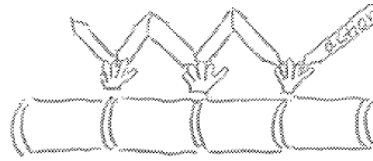


The term 'organisation' in this thesis refers to a formal arrangement, in other words a 'company'. The term 'organising' is a dynamic process and can involve several 'organisations'.

Another example is the term 'environment', which has different meaning in the organisational and the life cycle literature. In this thesis, 'environment' is understood as the 'natural environment' as in natural science and the life-cycle literature (Baumann and Tillman 2004). 'Environment' is also used in organisation theory where what surrounds an organisation is called the environment (Hatch 2002). This means that an organisational environment usually consist of other organisations. In

this thesis 'environment' is not understood as 'company environment', which are other organisations.

Organisations are understood as 'social construction' – action nets (Czarniawska 2005).



Also the term 'management' needs to be explained, as it is used in two areas, housing management and environmental management. 'Management' is defined as 'the process of dealing with or controlling things or people' (Oxford University Press 1998). It originates from the term 'manage' defined as 'maintain, control or influence' based on Latin *manus* 'hand', and is also referred to as 'handling' and 'manipulation' (Roget's International Thesaurus 1992). In this thesis the term 'management' in the area of housing management is referred to 'handling' buildings and its installations, but it is also referred to as 'handling' the humans related to buildings, such as employees, tenants and suppliers. The term 'management' in the area of environmental management means the 'handling' of environmental issues, that means the handling of the 'natural environment' (e.g. climate change) the 'physical environment' (e.g. buildings) and the 'organisational environment' (e.g. stakeholders). For a detailed overview of the terminology in the area of environmental management see Dobers (1998).

3.2 Previous research on organisation and environment

There is a small body of literature that concerns itself with understanding different aspects of the relationship between organisation and the environment. In the works by Ammenberg (2003) and Zobel (2005) the use of Environmental Management Systems EMS is evaluated with regard

to its effect on environmental impacts. Their work shows that the relationship is not straightforward: an EMS does not guarantee reduced environmental impact. The reason for this lies in the requirements. Only some environmental aspects need to be improved, but these are not always the most important ones for the environment.



Detailed descriptions of organisational links to the environment are rare. Among the few examples one finds Adolfsson's study of Stockholm water and city administration (2003) and Malmqvist and Glaumann's environmental assessment of various housing management services in Stockholm (2006). Adolfsson studied organisational actions directly involving attached to the physical environment in a study of water quality measurements in Stockholm's water and city administration (2003). Her work focuses on the organisational description. Malmqvist and Glaumann (2006) performed environmental performance assessments on several housing management services. Their work focuses on the environmental description. The works by the sociologists Guy and Shove (2000) suggest sociological studies on buildings as an alternative to the unusually technical ones e.g. studies of practitioners' daily work explaining the consumption practice of organisations. Their work focuses both on the organisational and the environmental link.

This body of knowledge has been used as orientation and inspiration for the methodological development of the 'hybrid method' presented here. The empirical work positions itself in a way as a combination of Adolfsson (2003), Malmqvist and Glaumann (2006), Guy and Shove (2000).

3.3 EAO, the general concept and specific for housing management

In order to learn about the ways in which housing management influences the environmental performance of managed properties, a hybrid research approach named Environmentally Assessment of Organising (Baumann 2004) was employed. In this thesis the concept was tested in field studies of housing management and formed the basis for further methodology developments. The more detailed methodology for using LCA in organisational studies is presented in Paper I. The specific methodologies and the first two EAO studies on housing management are presented in Papers II and III. The specific methodology applied to organising in product chains for a comparative environmental and actor analysis for building chains is presented in Paper V. In the following the basic description of the EAO approach is cited from Baumann (2004) and the specific considerations for housing management are described.

"EAO is the combined study of the organising features and the environmental aspects of a technical system. By comparing different cases and by keeping the technology (relatively) similar in these comparisons, relationships between organising features and environmental aspects can be discerned."

The technical system in housing management is the building and its technical systems. The buildings have to be the same type, age, and size and climate area. County Governor style apartment blocks from the 1930s on the same street with about 100 apartments each have been chosen in the first comparison (Paper II), and parts of building blocks with about 15 apartments have been chosen in the second comparison (Paper III). These studies cover four property owners and thereby four housing management styles.

"Environmental parameters could be based on LCA or on site-specific environmental indicators. Environmental systems studies (LCA, MFA, etc) from the past decade are a source of essential information and knowledge of the choice of environmental parameters in EAO studies."

The environmental parameters in my studies are based on a life-cycle approach, which led to consumption data of energy, material and water. ‘Upstream’ and ‘downstream’ LCA data could in principle easily be added to the consumption data. However, the four property owners have the same water supplier and heating supplier. Being identical, those parts of the life-cycles could be excluded in the comparison of property companies. Including the supply chains could be interesting to see to what extent the property owner indirectly affects the environment. Consumption data is only a reflection of companies’ direct environmental effects. ‘Upstream’ and ‘downstream’ LCA data are reflections of companies’ indirect environmental effects. Only the combination of direct and indirect data gives the overall environmental effect.

“Organisational parameters (difficult methodological issue), on the other hand, may include anything from size and organisational structure to governance, organisational culture and economic performance. Organisational data is the rich material resulting from following and documenting activities involved in the handling of the technologies and material flows.”

Organisational parameters tested in housing management have been the organisational structure and the organisational culture of handling buildings (operation and renovation practice). In the end, I was following and documenting the activities in the handling of the technologies and the material flows.

“An additional and most important parameter for explaining organisational influence on the environment is time. Environmental performance measured over time can display trend breaks, which can be traced back to changes in the organising processes.”

The importance of data over time has led me to choose only water and energy data for heating, since both are recorded over a long time in housing management organisations, about 10 years in form of physical data (kWh and L) and up to 30 years in form of economic data. The detailed study of trend breaks can be found in Papers II, III and briefly in Chapter 4.1, 4.2.

"Detailed fieldwork involves the parallel recording of environmental, technical and organisational characteristics and can open black boxes of relationships and causalities"

The parallel recording of energy and water use over time, on the one hand, technical status and changes to the building, its installations and operational and renovation characteristics, on the other hand, have been studied for housing management, mostly in the form of observations and interviews.

"EAO puts into practical application theories developed within sociology of technology and organisational theory, particularly those concerning (socio-technical) hybrid networks by Latour and action nets by Czarniawska."

The social dimension and the technical dimension of housing management come to play in the act of operation and renovation, socio-technical hybrids, so as to say. The act of operation and renovation are stories of conflicts and relationships that are characteristic for each organisation. The handling of buildings, the daily work and actions of people managing buildings, is described as combination of actions, 'action nets', so to say. These combinations of actions have environmental consequences.

"EAO draws on the same type of functional comparison that is also used in the LCA approach. A place to look for case studies is in sectors where there are several companies competing on the same market, operating ...on different scale...under different types or ownership."

The companies in my studies are competing on the residential market in Majorna/Gothenburg and operating with different ownerships (municipal, cooperative, private). The functional comparison is carried out regarding the companies managed area, the building block; and since the size of buildings blocks varies, the data is normalised per m².

"Measuring the environmental performance of various organising features...requires a careful choice of studies. Otherwise findings will be confused by the presence of too many variables influencing environmental performance."

In order to be able to identify the environmental effects of organising features, other features have to be kept similar. In the case of housing management, the building technology (type and year of building), climatic circumstances and type of tenants are kept similar for the compared properties. Similar apartment blocks on the same street have been chosen, managed by differently owned organisations.

"With such an understanding (of the organising processes), implementation of environmental strategies in industrial organisations and policy making stand a better chance to be not only environmental effective but also organisational efficient."

In this thesis, recommendations are made specifically for the housing management organisations (Papers II, III), the building chains (Paper V) as well as for environmental management strategies (Paper IV). Suggestions are also made in general for the field of building research, LCA research and environmental management research, see Chapter 7.

3.4 ORM, the research programme and new terminologies

My research with environmental and organisational studies of housing management has partly been conducted within a research programme called *Organisation for the Environment* (ORM, *Organisering för Miljön* in Swedish). This programme was set up in December 2006, which is why my work has only partially been conducted within its framework. It draws together interdisciplinary researchers and their studies on 'organising processes and their relationship to the environment': Adolfsson (2003), Brunklaus (2005), Lundberg (2008). Studies explore the same basic notions described through the EAO concept: the relationship between organisation and the environment through the comparative study of technical system or natural phenomena, but with different organisation (Baumann 2008).

Within the programme the researchers have focused on different parts. While Baumann (2004, 2008) has worked on general concepts and terms, my contribution to the research programme has laid in the empirical study concerning organisation and the environment. The parallel and detailed recording of organisational, technical and environmental parameters, as well as the tracing of organisational influence on the environment (energy and water) has only been studied by myself in the programme, and is presented in this thesis. A related work is the comparison of retailing properties by Lundberg (2008), but this has been less detailed in the environmental dimension. Another work within the programme is the studies by Adolfsson (2003, 2007). Adolfsson has followed water quality measurements and describes how water becomes part of Stockholm's city administration (2003). She has also followed a reformation of water authorities in Sweden when letting the waters decide on areas and boundaries for management and control (2007).

Discussions within the programme have led to the development of new terms and the development of existing terms in order to communicate and discuss organisational-environmental relationships. Among these are the terms *socio-material interaction*, and *interaction points*. These terms are used in an example described in the next chapter. The term socio-material is inspired by Wilk (2007) and Guy and Shove (2000) and reflects the human and the physical relationships. Interaction points are the points where the human and the physical dimension meet and interact. For a more detailed overview of terminology see Baumann (2008).

3.5 Example of organising the water flow in housing management

To illustrate some of the new ORM terminology a concrete example using a water pipe is presented, inspired by Baumann (2008). Socio-

material interaction points represent the points in the technical system, where *socio-material interaction* takes place. Several socio-material interaction points are found along a single water pipe (Figure 3.1). The socio-material interactions are *actions* by different actors. For water management these actions can be for example (1) regulating and (2) measuring temperature for warm water by the district heating company, (3) regulating and (4) measuring the water flow by the housing management organisation and (5) the consuming of water (washing) by the consumer. The material relationship between socio-material interaction points (along the water pipe) can be compared with the organisational relationship between the same points (action pattern). For water management, a simple material relationship is paired with a complicated organisational relationship (Baumann 2008).

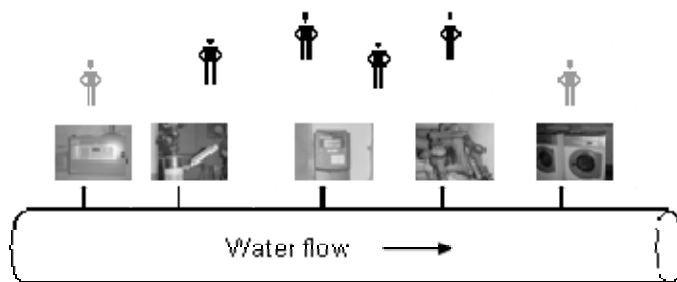


Figure 3.1: Water management including water pipe, water flow, actions and actors (inspired by Baumann 2008). Photographs were taken at the municipal housing organisation Fambo by Brunklaus.

For energy management, the socio-material analysis is more complicated, since it includes many more actions and interaction points. District heating companies can regulate and measure the temperature of district heating flow. Housing management operation can regulate and measure

temperature, pumps and hot water flows. They also can regulate air flows with ventilation and heat recovery with a heat exchanger. Tenants can open windows or turn on heating. Housing management renovation can insulate windows, walls and roof.

3.6 Buildings and organisations involved in housing management studies

In order to understand the relationship between housing management and the environment, two comparative studies including four housing management organisations and some of their properties are studied. The studied buildings and housing management organisations are presented here.

In the first study ‘County Governor’ style residential blocks in Majorna/Gothenburg, dating from the 1920s and 30s, with a size of approximately 100 apartments were studied, (Paper II). The organisations in this study are a HSB housing cooperative and a municipal housing company, ‘Fambo’. The housing cooperative was founded in 1927 and is a member of HSB, a large nationwide organisation. In Gothenburg alone there are about 35 000 apartments managed by HSB housing cooperatives. In these the tenants own their apartments, while buildings and installations are managed by the cooperative. Cooperatives can get managerial support and knowledge centrally from HSB, but each local cooperative is independent and has a large amount of freedom. ‘Fambo’ was founded in 1950, and specialised to some extent in managing ‘County Governor’ style buildings in the 1970s. ‘Fambo’ owns and manages about 18000 rental apartments and their buildings and installations in Gothenburg. ‘Fambo’ is organised in districts of about 4000 apartments, each with a specialised work organisation. Environmental work has been conducted for more than 30 years.

The housing properties in the second study (Paper III) are again ‘County Governor’ style housing blocks in Majorna/Gothenburg, dating from the 1920s and 30s with a similar size, this time 15 apartments instead of 100 as in the first comparison. The reason for the smaller units is that the companies studied own smaller units of properties in the area. The organisations in this second study are two private housing management companies, Dalavik and Wallenstam. The private organisation, Dalavik, is originally a small shipping company that invested in 4 properties in Gothenburg in the early 1990s. Dalavik’s managerial knowledge is based on experience from the shipping business, but the chairman has an overview and mandate over her 4 properties and her employees. Wallenstam was founded 1944 as a construction company and in 1984 property management was introduced. The company owns and manages about 10720 apartments in Sweden and 2770 in Gothenburg. County Governor style buildings are one of many building types managed by Wallenstam. The properties studied here are managed since the early 1990s. Environmental work was introduced in 2000.

3.7 Buildings and actors involved in studies over the life-cycle

In order to understand the relationship between organisation and the environment of over the life-cycle of buildings, a number of existing residential buildings in Sweden are environmentally compared over their life-cycle, three passive-house buildings and four conventional buildings. Instead of organisations, this time actors are used to present the organisation over the life-cycle of buildings. The buildings are categorised according to type of energy used and presented with the amount of operational energy use. Environmental effects are calculated with help of a LCA methodology. Since the buildings are different in size, the

functional unit for operational energy use is presented in form of kWh/m², which refers to the buildings and not that of their users. Two typical passive-house buildings equipped with electric cartridges, in Lindås with an energy use of 68 kWh/m² and in Värnamo with an energy use of 67 kWh/m². One passively heated house with district heating, in Karlstad with an energy use of 83 kWh/m². Four conventional buildings, in Malmö with an energy use of 100 kWh/m², in Helsingborg with an energy use of 121 kWh/m², in Växjö with an energy use of 150 kWh/m² and in Stockholm with an energy use of 121 kWh/m².

Among the many actors involved the life-cycle of buildings, there are three main actors, which importance were analysed in the study: the material producers, the construction company and the residents. Among the many choices these actors can make, energy-related choices are those regarding material production, transport emissions and electricity production. Analysing the environmental consequences of actors' energy-related choices is relevant because energy for heating can have different sources: electricity or district heating. This is relevant for environmental comparisons of the building types. The LCA results are presented in form of an 'actor analysis' where environmental impacts are traced to each respective actor, instead of tracing them to technical processes as in a 'dominant analysis', frequently used in LCA studies.

4. THE ENVIRONMENTAL CONSEQUENCES OF ORGANISING IN HOUSING MANAGEMENT AND OTHER EXAMPLES

Many think that environmental differences depend on technology. In this chapter I shall instead try to show *how* the process of organising influences the environment. I use mainly my own studies, but even some examples from literature, in order to illustrate how organising can influence the environment.

4.1 Examples from municipal and cooperative housing management

The environmental consequences of organising in the municipal organisation Fambo and the HSB housing cooperative, presented in *Paper II*, are described in the form of consumption data (energy and water) for technically similar properties. The findings show that consumption levels are both lower and less variant in the housing cooperative in comparison with the three studied municipally-owned properties.

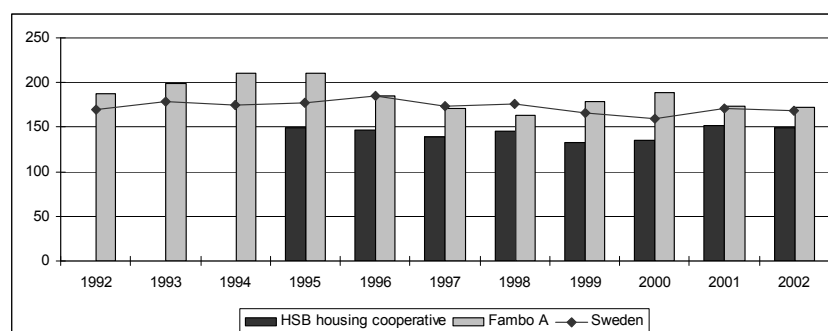


Figure 4.1: Energy use for heating and hot water [kWh/m²*year] in housing cooperative HSB, municipal Fambo A and Sweden during the years 1992 and 2002

The HSB housing cooperative shows on average a 30% lower energy use and up to 50% lower water use (see figures 4.1 and 4.2). Moreover, the

cooperative's levels are below the Swedish average, while the three municipally-owned properties' levels exceed the Swedish average. So it is clear that environmental performance is different. The question is; can it be explained by organisational differences, rather than technical ones, or differences in households, location and local climate?

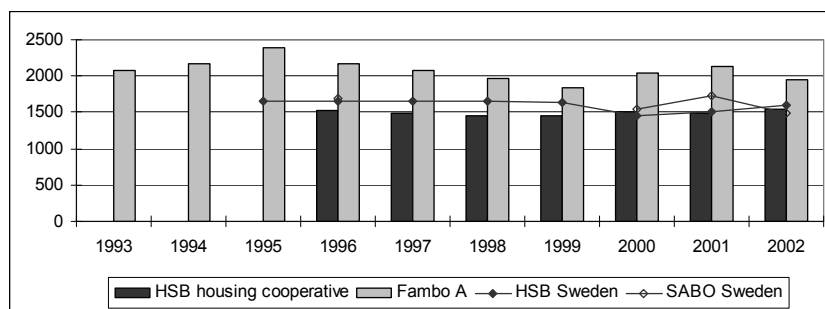


Figure 4.2: Water use [L/m²*year] in HSB housing cooperative and municipal Fambo A, HSB Sweden and SABO Sweden during the years 1993 and 2002

Differences in technology, households, location and local climate are kept to a minimum. The properties studied are of the same type, age, and size. County Governor apartment blocks from the 30s on the same street in Majorna/Gothenburg with about 100 apartments each have been chosen here. Trickier to account for is the differences in household behaviour. Even if I assume similar types of households (1/3 single households, 2/3 families) with a similar attitude (for Majorna that is a more environmental one), there might always be differences. However, household behaviour cannot solely explain such large differences as 30% for energy use and up to 50 % for water use and especially not their differences in variation from year to year. Instead, the variation in environmental performance is interesting as a first place to look for organisational differences. The minimum level, representing a better environmental performance, indicates what is possible in similar properties, whereas the maximum level, representing a poorer environmental performance, indicates what

the organisation allows before action is taken to reduce levels. The HSB housing cooperative shows less variant levels, which means better control of consumption levels. To better understand organisational differences related to the properties, both operation and renovation practices were studied and characterised. Both organisations have managed their properties more than 30 years. A detailed description of the handling of buildings and its installations (in other words ‘socio-material interactions’, see Chapter 3) is found in *Paper II*, while only a brief description is made here.

When it comes to operation practice in the cooperative housing management, there is the caretaker that has been working there for many years. He likes to explain the uniqueness and complexity of the energy and water installations. To him, the building is not just a building – it is a ‘beloved child’ that he cares about. He likes to continuously check and regulate both the heating systems and ventilation, and he likes to coordinate their regulation. When it comes to renovation practice, the people working with this (also live in the building) really want to find technical solutions that are adapted to the needs of the building. For example, cultural heritage demands became a tricky problem in the 1980s regarding the extra insulation of windows and walls, but this was solved by adding a third glass pane to existing windows and adding roof insulation instead of wall insulation. Also water management is performed in a similar way, and measures concerning the water system are preformed continuously.

Operation practice in the municipal housing management company has changed from continuous to emergency driven, where time constraints are important. This change in operation practice happened in the early 1990s, slightly before the consumption data series presented. It happened due to a rationalisation process at the same time, and due to a client-focus

management (inspired by hotel management) introduced shortly after. Local caretakers have been replaced by technicians working in larger areas. At the same time, extra service personnel for gardening and tenant contact were introduced. The machinist's work follows a cyclic scheme that tells him when to check and restore failures. Emergency measures are prioritised according to what is known as the 'top 10 list' of housing blocks with the worst energy performance. Also water management follows an emergency based logic. When it comes to renovation practice, the people working with this follow a 30-year cycle. Also here cultural heritage demands became a tricky problem regarding the extra insulation of windows, but here the conflict stopped the introduction of 3-glaze windows and the 2-glaze windows remained. The coming renovation aims at modernising the standard of water systems and kitchen/bathroom/washing machine appliances. Doing something about the windows this time is not in line with the present client-focus, which favours nice kitchen and bathrooms before energy efficiency.

How can these descriptions explain environmental differences? Many think that these descriptions are about technical changes. Yes, there is a technical side, but not only. What type of technical changes, where and when they are performed, are for example organisational questions. As a result, the combination of technical changes is unique for each property and management style. It is the combination of technical changes at many different points, which can explain environmental differences and organisational differences. On the one hand, single actions such as the change from 2-glazed to 3-glazed windows, lead to a reduced consumption level. On the other hand, single actions become characteristic for each management style. The overall consumption levels, presented in figure 4.1 and 4.2, can only be explained by the combination of single actions, an 'action net'.

Characteristic for the action net in the cooperative housing management is honouring the buildings' constraints, while time constraints and tenant demands come into play for the municipal housing management. Therefore the relatively low and stable energy and water consumption can be traced to what I call the 'caring' management style of this particular HSB cooperative, while the relatively high and variant consumption levels can be traced to what I call the 'emergency driven' and 'client-oriented' management style in Fambo. These descriptions are the first examples on how organising (action nets) influence the environment (energy and water consumption).

4.2 Examples from private housing management

Studies of properties belonging to two private companies, Wallenstam (W) and Dalavik (D) are follow-up studies and more examples of housing management. They show environmental differences and similarities. The differences lie in consumption levels for energy, which are lower for Wallenstam compared to Dalavik. The similarities lie in variations of energy use and the uneven water use in organisations (see figures 4.3 and 4.4).

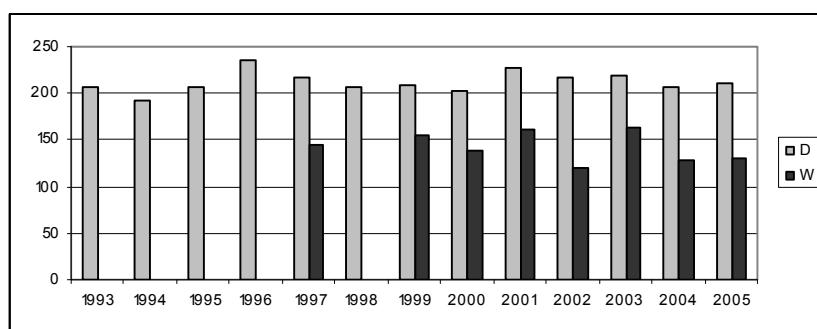


Figure 4.3: Energy use for heating and hot water [kWh/m²*year] in the small organisation 'D' and in the larger organisation 'W' during the years 1993 and 2005.

Wallenstam shows on average a 30% lower energy use compared with Dalavik, and values lie below the Swedish average. Dalavik's values exceed the Swedish average for both energy and water. So it is clear again that the environmental performance is different. The question is again; can it be explained by organisational differences, rather than technical ones or differences in households, location and local climate?

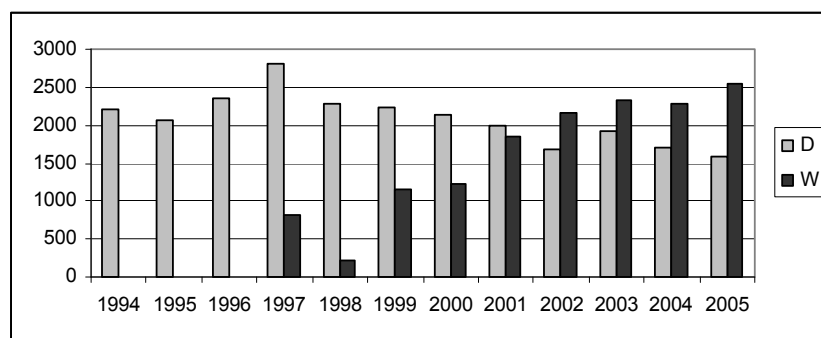


Figure 4.4: Water use [L/m²*year] in the small organisation 'D' and larger organisation 'W' during the years 1994 and 2005.

Differences in technology, households, location and local climate are kept to a minimum. The properties studied are of the same type, age, and size. County Governor apartment blocks from the 1930s in Majorna/Gothenburg, but this time with about 15 (instead of 100) apartments each have been chosen here. However, local organisation and patterns were enough to explain environmental performance. These are completed with studies of practice of other actors involved in the local handling the energy and water flows: previous owner, supplier and tenants. Local practices of previous owner were studied through records from planning permissions. Local practices of supplier's were studied through local housing personnel's interviews about suppliers work. Local practices of tenants were studied through observations (i.e. frequency of

open or windows and doors). However, each of these practices cannot solely explain such large differences as 30% for energy use and neither their difference in their variation from year to year.

To understand how these different consumption levels arise, socio-material interactions have been identified and the action nets that handle the building and its technical systems have been studied and characterised. Both organisations have managed their properties since the beginning of the 1990s. A detailed description is found in *Paper III*, while here only a brief description is made.

There is hardly any operation practice in the small private housing management company. The operation of the energy and the water system is handled externally by suppliers. A technician from the energy supplier is continually measuring the energy flow. Another technician from the energy supplier is checking the heating system, although more seldom. Similarly, the water supplier is handling the water system. Renovation practice is handled internally. The chairwoman is planning renovations with help of a 'simple' Excel file. Since this company has only recently changing business focus from shipping to housing management, she is not an expert on housing management. The property is in great need of renovation, but only a little is carried out. Measures are taken 'according to needs', as the chairwoman says. For example, water installations are of recent standard. Measures are taken 'step by step' and according to 'economic constraints', as the chairwoman explains. For example, only some of the bathrooms were renovated and only some of the windows were changed from double to triple-glazed windows, probably due to tenant demands for sound protection. Additionally, tenants tend to keep their windows and doors open more.

Regarding Wallenstam, operation and renovation are taken care of by a group of young professionals. The manager in charge of the technical system has 15 years experience. He knows every part of his technical systems, since he is currently working on adapting them to the properties. Previously this has not been prioritised by the company. Normally operation is performed after a cyclic scheme towards what is called the 'Wallenstam standard', which aspires to 150 kWh/m². Measures are prioritised according to what is known as the 'top 10 list' of housing blocks with the worst energy performance. Renovation work also follows a cyclic scheme aimed towards what is called the 'Wallenstam standard', which includes choice of products. Renovation measures are not standardised. They are adapted to buildings needs. 'Every building has different prerequisites' explains the technical maintenance manger. However, the insulation of inner walls due to fire protection in the 1970s is unknown by the organisation, since this was carried out by the former owner of the company. Additionally, tenants tend to keep their windows and doors closed more. Regarding the operation and renovation of the water system, the company has a water saving programme, but it has not reached this property yet. Since the water supplier seldom undertakes measures, there is little going on that can change water consumption levels.

How can these descriptions explain environmental differences? Again, it is the combination of technical changes at many different points, which can explain environmental differences and organisational differences. On the one hand, single actions such as the change from double to triple-glazed windows, lead to a reduced consumption level. On the other hand, single actions become characteristic for each management style. The overall consumption levels, presented in figure 4.1 and 4.2, can only be explained by the combination of single actions, an action net.

Characteristic for the larger private organisation, Wallenstam, are the actions adapted to the buildings, while economic constraints and tenant demands come into play for the smaller organisation, Dalavik. Therefore, the relatively low energy and uneven water consumption can be explained by what I call the ‘professional’ management style adapted to the buildings’ constraints, while the relatively high energy and uneven water consumption levels can be explained by what I call the ‘self-made’ management style following economic constraints and tenant demands regarding Dalavik. These descriptions are more examples on how organising (action nets) influence the environment (energy and water consumption).

4.3 Literature examples about production

More examples on how organising influences the environment can be found in environmental studies on production: production of bread (Senett 1998), production of yogurt (Berlin 2005) and the production of cement (Gäbel 2001). Instead of describing whole action nets here only some organisational elements specific for the production processes in question can be discerned, such as work-time schedules, product sequencing and raw material changes. Environmental consequences in production processes have been described in several ways, for example, in amount of waste produced, amount of cleaning products or amount of emissions released.

For the production of bread the environmental consequences can be described as more or less bread wasted. Work-time schedules adapted to the worker led to reprogramming the computer and starting all over before going home instead of finishing the bread (Senett 1998). Therefore, an ‘automatic’ production style adapted to the workers’

working time has led to more waste than a 'manual' production style (old fashioned 'manual' baking).

For the production of yogurt, the consequences are described as more or less waste of yogurt and the cleaning of equipment, as well as levels of CO₂, SO₂ and NO_x emissions. Marketing initiatives to raise consumer demand for yogurt product has led to a large variety of products and more product sequencing within operation (Berlin 2005). This has led to more waste of yogurt and more cleaning of equipment and eventually to higher levels of CO₂, SO₂ and NO_x emissions. Therefore a 'product variety' management style adapted to client demands and marketing constraints has lead to more environmental consequences.

For the production of cement, the environmental consequences are described as levels of CO₂, SO₂ and NO_x emissions. Calculations on different operational alternatives, such as changing the raw material mixture, changing the cement mixtures and changing the use of alternative fuels can lead to ¼ reductions (Gäbel 2001). Therefore a 'raw material' management style adapted to emissions released may decrease environmental burdens.

These descriptions are neither detailed examples of socio-material interactions nor descriptions of action nets. However, they give more indications about how organising influences the environment, that are of interest for further study.

4.4 Examples from building chains

Previous sections have described socio-material interactions in companies in order to describe how organising is influencing the environment; here socio-material interactions over the whole product chain are described.

The building chain of passive house building is compared to that of conventional building; see Paper V. Energy use and environmental consequences are described with the help of a life-cycle assessment. Organising is described as green actions by different actors along the building chain. Green actions are energy-related actions regarding material, electricity and transport. The actors are the material producer, building constructor and residents. The findings are described for energy use and life-cycle impacts in two scenarios: one ‘conventional choice’ scenario and one ‘green choice’ scenario.

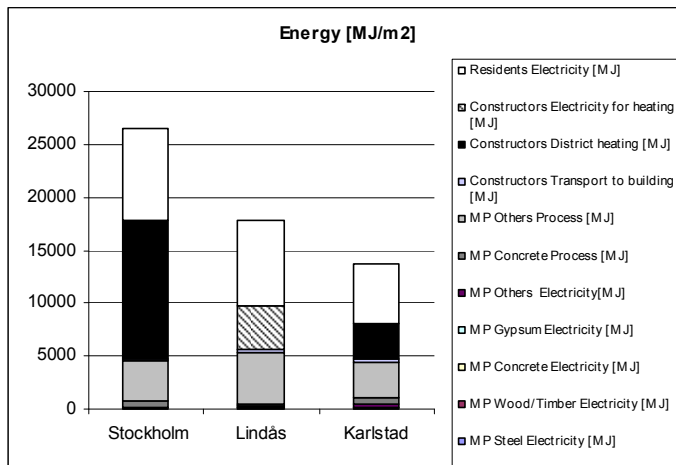


Figure 4.5. Actor analysis for energy use. Buildings presented are Stockholm (conventional building), Lindås (traditional passive house), and Karlstad (passive house with district heating).

The results for energy use (Figure 4.5) and ‘conventional scenario’ (Figure 4.6) show different things for each actor:

- Construction companies are reducing energy use by choosing heating energy source by 30%, while the total global warming emissions might not be reduced at all (e.g. Stockholm compared to Lindås). Additionally, environmental impacts from heating energy point to either district heating companies or residents. For global warming emissions that means similar values, 20% for heating companies or residents (in the example of the Stockholm house).
- Residents are the most important source of buildings total environmental burden, independent of the type of building. For global warming emissions that can be 60% for the Stockholm house and 80% for the Lindås house.
- Together, material producers can be as important as a source of environmental pollution as the construction companies’ choice of energy source, such as district heating. For global warming emissions that means about 20% for both (in the example of the Stockholm house).

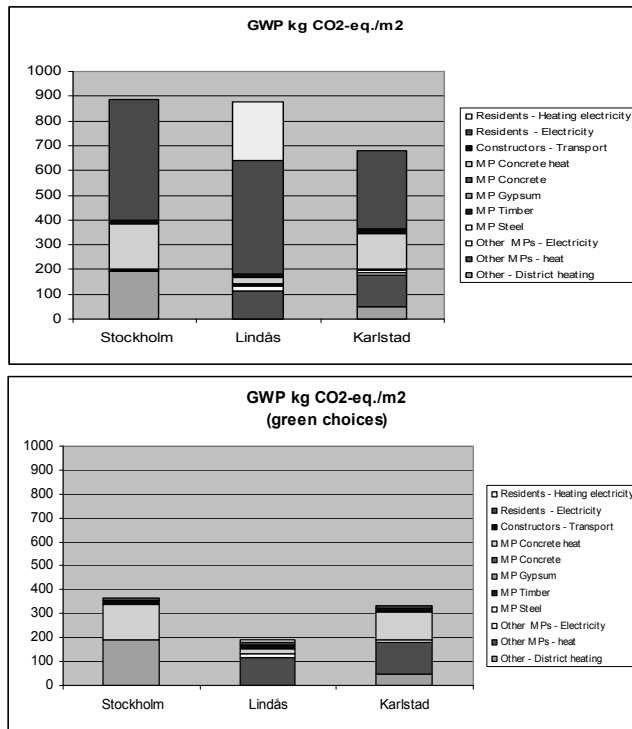


Figure 4.6. Actor analysis of the conventional scenario and green choices scenario along the building chain. Buildings presented are Stockholm (conventional building), Lindås (traditional passive house), and Karlstad (passive house with district heating). Environmental impacts presented are global warming. Others (acidification photo-oxidant formation, land use and radioactive waste) are presented in paper V.

The results for the ‘green choice scenario’ in figure 4.6 show other things for each actor:

- Residents have the most environmental influence by choosing eco-labelled electricity.
- Construction companies have the least influence. They can only recommend residents to choose eco-labelled electricity.
- Material producers are become environmentally important when residents start making green choices.

Studies show that one cannot say that a building technology is environmentally better than another, because the same building technology sometimes is better and sometimes worse depending on how the different actors act. Only the combination of actions along the chain reflects the buildings' environmental burden. The studies show that it is not sufficient to rely on passive house technology and energy analyses as is often the case within 'green building' research. The studies also show that the construction companies are not the central and most important actor; the residents are.

4.5 Conclusions

Some might still think that the environmental differences in these studies depend on technology. However, the technology has been kept similar in these studies. Yes, there is a technical side, but this is "embedded" in organisational action nets. What type of technical actions, and where these are performed, are organisational issues. The way organising in companies is influencing the environment is through the *combination of single green actions*, their management style. This can be studied with help of a socio-material analysis. The way organising along the whole product chain is influencing the environment is through *collective green actions*, their management style. This can be studied with help of an actor analysis.

A number of "green" management styles have been discerned: (1) combination of actions adapted to the buildings, instead of economic constraints and tenant demands, (2) combination of actions honouring the buildings' constraints, instead of time constraints and tenant demands, (3) actions adapted to the bread, instead of the workers' time schedule, (4) actions adapted to yogurt production technology, instead of consumer demands and marketing constraints, (5) actions adapted to

cement production technology regarding raw material and emissions, (6) collective action regarding energy resources. To conclude, the combination of actions and collective actions seem to be important. Moreover, the adaptation of actions to the product and to the production technology also seems to be important.

To sum up, both the socio-material analysis and the actor analysis have shown how organising is influencing the environmental in different ways. Both analyses include a social side and a material side. The social side in actor analysis includes many organisations, while the socio-material analysis includes many individuals. The material side in actor analysis includes technical processes throughout the life-cycle, while single technical actions in the socio-material analysis.

5. METHODOLOGICAL CONTRIBUTIONS TO LCA

The Life-Cycle Assessment (LCA) methodology has been used for more than a decade for environmental assessment in a number of areas in order to find environmentally better technical solutions (Baumann and Tillman 2004). Ordinary LCA methodology studies technical systems. However, in everyday life these technical systems do not exist on their own. It is the humans in various organisational arrangements that are handling these technological systems. We perhaps also need organisational arrangements that favour the environment. So far, this has not been dealt with in the LCA methodology, except within the EAO concept (Baumann 2004), see Chapter 2.2. Therefore an attention to organisational processes has been used to modify the LCA methodology. This has been done within the EAO concept, see Chapter 3.

5.1 Using LCA in housing management studies

The modified LCA methodology, described in Paper I, has been successfully tested in the comparison of two housing management organisations in Sweden, Paper II, and in the comparison of two additional housing management organisations, Paper III. Ordinary LCA methodology has been used in some ways in housing management studies before. My studies differ in that the whole life cycle is not modelled, yet I call them life cycle studies of housing management. So, where others see consumption statistics, in my studies I see the modified LCA methodology. Here I shall explain the modified LCA methodology. I shall compare how this modified LCA methodology differs from more ordinary LCA methodology.

Goal and scope definition, inventory analysis and data analysis are found here in the same way as in ordinary LCA studies. Within the goal and scope definition, the technical flow model has been used to identify environmentally relevant mass and energy flows (energy, material and water consumption) and to identify environmentally relevant technical systems influencing the flows (energy system, buildings insulation, and water system). The concept of the functional unit has been used to find comparable managed areas; here housing management is carried out per housing block including several technical systems. A comparative study strategy has been used as is the case with most LCA studies. The division of foreground and background systems to find a data collection strategy and to exclude the environmental consequences of consumption data have been used. Site-specific data has been used to describe site-specific organisational characteristics.

Within the inventory analysis, the technical flow model has been used to describe organisational workflows. The material/energy flows and technical systems are described as usual, adding “only” a study of organisational work processes and their connections, ‘interactions points’. Regarding material and energy flows (environmental data), only consumption data over a period of time is included in my studies, although site-specific LCA data on supply can be added. Thus data availability over time has limited the choice of organisation and object of study as well as data collection strategy. The technical systems are described together with the actions and the timing of actions in order to capture action pattern. Interviews and observations have been useful to observe action pattern. The organisational work processes are incompletely presented, since only the technical management is included in my studies, not marketing nor finance. However, this has been

sufficient to provide an understanding of how organising and management influence environmental impact.

Concerning the interpretations of results, organisational patterns of similar residential blocks (type of building, climate and tenants) are related and compared to environmental patterns over time. For the environmental analysis, single actions have been related to the theoretical reduction potential of consumption data. Specific combinations of actions in each organisation have been related to real consumption data. Similarly for the organisational analysis, the single actions are its starting point. The single actions are related to organisational characteristics. Instead of structural aspects, these are organisational 'metaphors' that include principles for how organising is performed.

5.2 Using LCA in product chain studies

Previous studies on housing management, Papers II and III, and a study on actors in the milk chain (Berlin et al 2008) has led to introducing an actor perspective to the LCA methodology, see Paper V.

Introducing an actor perspective to LCA means that the technical system is presented together with its actors and their actions, and the results are analysed from the perspective of various actors. In the product chain, every actor has a variety of choices to improve the overall environmental burden of a product.

The challenge is to choose actors and options to study. The main actors are those with possibilities to reduce the environmental burden of a product, in other words actors with direct influence e.g. material producer, construction companies and residents in building chains. Some actors influence indirectly through putting demands on other actors in the product chain e.g. construction companies can put demands on material

producers. These influences become visible only with an actor perspective, not in a technical comparison. The modelled options for these main actors can be either energy related choices, such as choice of energy supplier (and thereby energy generation), or material related choices, such as reuse or recycling. In our LCA study of building chains (Paper V), energy related choices have been used.

Adding an actor perspective to a LCA study demonstrates the social nature of technical systems. In order to illustrate actors' influence over the life-cycle, their alternatives can be modelled. In our study, we analysed 2 scenarios: one 'conventional choice scenario' and one 'green choices' scenario. The results can be described for each actor and presented as part of the total environmental impact, an actor analysis so to say.

The actor analysis in the conventional scenario shows to what extent the different actors contribute to the environmental pollution of the whole product chain, which can seem like the usual dominance analysis or decision-maker analysis. However, the actor analysis goes beyond both the dominance analysis and decision-maker analysis in LCA, since even indirect influence, such as choice of suppliers, can be analysed. In the green scenario, it shows to what extent the different actors influence the environmental burden of the whole product chain. However, environmental pollution and environmental influence is not the same thing. For example, residents in building chains contribute to similar environmental pollution than the material producer and district heating together, while residents have the most environmental influence. Actors can contribute to environmental pollution, while their options are small compared to others in the chain. For example, construction companies in building chains can influence energy use by choosing passive house technology, while they might not influence global warming potential with

their action. Additionally, comparing and analysing actors in different chains can show a responsibility shift among actors in the product chain for similar products. For example, the comparison of conventional and passive house building chains show that responsibility for environmental burden shifts from district heating companies to residents. These shifts only become visible with an actor analysis and not in a technical comparison. This shows how dependent the results are on the actors within the chain.

With a green choice scenario it was possible to analyse how green choices by different actors influence the buildings total environmental impact, both directly and indirectly. With actor analysis it was possible to trace environmental impacts to each respective actor and their options.

5.3 Using LCA in environmental management studies

The environmental perspective of LCA has been taken into environmental management studies (together with a more detailed understanding of housing management). This has been done in two ways in Paper IV. One way is using the LCA flow model to detect actions relevant to environmental impacts, such as renovation measures in housing management. Comparing these relevant actions with actions performed within the routines of environmental management makes it possible to detect where general management and environmental management go separate ways. Another way is using the distinctions of direct and indirect, foreground and background system in LCA terminology; to structure not only the environmental effects, but also the organisational causes (see table 3 in Paper IV). Adding environmental reduction potentials to each action in the foreground and background

systems makes it possible to describe environmental consequences and decide about relevant choices.

5.4 Conclusions and implications

Organisational LCAs aim to identify organisational causes to environmental impacts and to support discussion about alternative organisational arrangements; hopefully leading to smarter environmental organising. This requires knowledge of both qualitative and quantitative research methods. The inclusion of a study of actors and their actions into the LCA framework is possible both in a detailed way, as was shown in the housing management studied (Papers II and III), and in a more general way as was shown in the LCA study on passive and conventional housing (Paper V). Vice versa, taking the environmental perspective of LCA into EMS (together with a more detailed understanding of housing management), shows that the LCA environmental perspective can be introduced into site-specific environmental management (Paper IV).

More specifically, organisational LCAs can be used to identify, explore and interpret organisational features in internal operational actions, e.g. a company's work routines. It can be used to compare operational actions and compare these with technical/material actions, e.g. to compare routines with insulation measures. Organisational LCAs thereby reflect the environmental consequences of both technical/material and organisational actions. Organisational LCAs can be used for the study of any product life-cycle, which means that instead of the building sector, for example, the textile sector can be studied. Since material and energy flows are important in the modified LCA methodology, other material/energy related environmental systems analysis tools might be used, such as Material Flow Analysis (MFA).

One of the drawbacks is that ordinary LCAs encapsulate too many assumptions about actors' choices and actions in the organising of production, operation and whole product chains. This might underestimate the roles of various actors and actions. With the modified LCA the life-cycle is understood as chain of actors and LCA results can be thought of as the sum of actions within the chain. By putting the light on organisation instead of on just the technical systems, I hope to clarify certain dimensions of environmental problems. One concerns the risk of using solely technical actions and forgetting about the organisational dimension. The other concerns the role of various actors' actions in the context of single processes and the life-cycle as a whole. This will allow people to make better-informed value choices. In order to solve the environmental problems that we cause, we need structured ways to think for thinking about the environmental consequences of technical systems, but we need structured ways for thinking about organisational causes as well.

6. CONTRIBUTIONS TO EMS AND ENVIRONMENTAL INDICATORS

Environmental Management Systems have been used for more than a decade as an environmental management tool and environmental indicators were introduced shortly after. However, have they brought us managerial solutions in favour of the environment? In the everyday life of companies there might be external stakeholders that steer more, which brings the company to work for a better image instead of real environmental solutions. According to repeated studies (Ammenberg 2003, Zobel 2005), there is still some confusion about indicators, and EMS does not necessarily lead to better environmental performance.

6.1 Challenges in Swedish housing management

Experiences from studies in four Swedish housing management organisations (Papers II, III) have not only resulted in descriptions of organisational relationships to the environment. Insights into these organisations have shown examples on how general management and environmental management can go separate ways. An example of this with major environmental implications is found in the study of departments in the municipal housing management company. The study revealed that renovation practice in general management and the environmental programme in environmental management operate relatively separately from each other (Brunklaus 2005). While the environmental coordinator was occupied with its environmental management system, the renovation department planned a large refurbishment of their building stock by raising the material standard of the apartments rather than adopting energy-efficient solutions. At the same time the operational department was trying to control energy use

through regulating properties energy systems. This resulted in a 30% higher energy use compared to another company where environmental management was more integrated into general management (Brunklaus 2005, Paper II). This has brought up an interesting question: How is environmental management related to general management?

An interview study on environmental data availability (on awareness of LCA and on time perspectives) held with technical and environmental managers at twelve Swedish property management organisations revealed that data reflecting a life-cycle perspective and data with continuity over time hardly exist in most housing management companies (Brunklaus and Thuvander 2002). The production of energy or water as well as the treatment of wastewater is not mentioned. In the municipal housing companies, the production of district heating energy is seen as being 'green' and therefore energy use does not have to be reduced (Brunklaus 2005). Another Swedish researcher has studied the use of EMS in environmentally ambitious housing management companies (Malmqvist 2004, Malmqvist and Glaumann 2006) and made an attempt to develop indicators based on LCA. She found that indicators are not chosen with relevance to environmental aspects in the first place. They are rather with relevance to their availability. This has brought up another more concerned question: How is environmental management related to the environment?

6.2 The literature on environmental indicators

In order to learn more about how environmental management is related to the environment in the form of indicators a literature study has been carried out and this is presented in Paper IV. The environmental management literature suggests various frameworks for indicators e.g.

separating between operational, managerial and environmental condition indicators. The literature study revealed indicators in these frameworks have been developed and used separately depending on the type of literature. Operational indicators are widely used in companies. Managerial indicators are more seldom used and tend to be specific and business-oriented in sustainability literature, whereas reactive and process-oriented in the EMS literature. Environmental condition indicators are mainly used by local and regional authorities for monitoring environmental goals, but seldom internally in companies. The literature study also revealed that these indicators are seldom related.

To obtain a better contextualisation, the literature on environmental indicators was reread in the light of organisational theory and the life-cycle approach. Organisation theory and the environmental indicator literature use the term 'operational' with very different meanings. In the environmental indicator literature, 'operational' is misleadingly used to indicate general 'technical' indicators, whereas the organisational theory literature also points to the importance of company-specific indicators, adapted to translating strategic goals into operational goals. The organisation theory literature also focuses on the importance of specific indicators, while in the environmental indicator literature there is a movement towards generality. In addition, the life-cycle approach has put some light on other misleading terms in environmental indicator literature, such as 'significant aspects', which can be interpreted as significant for the environment or significant for the organisation.

Our analysis in paper V shows that indicators are often based on a corporate top-down management approach, while it is seldom that approaches inside the company are used. However, management inside the company is needed for setting achievable environmental goals and devise leading environmental indicators. Guidelines give little help on

devising leading environmental indicators, relating them to environmental effects or to business goals. Studies of housing management (Malmqvist 2004, Brunklaus 2005) have shown that general management and environmental management might operate relatively separately of each other and that a life-cycle approach is seldom used. We also show that significant indicators in housing management companies are those that are available. Environmental impacts outside the organisation are seldom recognised, even though they might be environmentally relevant.

6.3 Conclusions

In order to achieve an environmental management for the environment, it is important for indicators used to be relevant for both the organisation and for the environment. Organisational relevance is reached through company specific operational and managerial adaption. Every company has their own strategy and way of working. Therefore their operational and managerial indicators need to a large extent be company specific. Only then an effective control can be reached. This differs a lot from literature about environmental indicators that seek generality. Environmental relevance is reached through LCA-adaption. Indicators need to consider not only direct environmental effects of a company, but also indirect environmental effects related to the company's influence on other operations upstream or downstream. Indicators also need to be specific for the environmental context in which they are being used. This differs a lot from literature about environmental indicators that do not focus on company's influence on other operations.

7. CONCLUSIONS AND RECOMMENDATIONS

This thesis has been aimed at the understanding of the *relationship between organisation, more specifically housing management, and the environment*. This understanding was sought mainly through environmental field studies of housing management (Papers II and III), but also through environmental studies of buildings (Paper V). An organisational approach was used to explore *how* organisation and management influence environmental performance, in other words, *how* the daily work and actions in companies lead to environmental impact. A life-cycle approach was used to explore *how* environmental effects of organising can be studied. The combination of an organisational and life-cycle approach has in turn required the development of LCA methodology (Paper I). The modified LCA methodology is based on the concept of Environmental Assessment of Organising EAO (Baumann 2004) and was tested in the field of housing management. Other concepts and theories that have influenced the work are: the grounded research approach (Glaser and Strauss 1967), the symbolic-interpretive perspective (Hatch 2002/2006), and action nets (Czarniawska 2005), and the life-cycle approach (Baumann and Tillman 2004). However, most of the methodological work has been explored within the field of housing management. Within the field of housing management the relationship between organisation and the environment has been understood through looking at the handling of technology within the context of buildings. In the following sections central lessons from studies of housing management and their implications for related research fields are presented.

7.1 Studies of housing management

The studies of housing managements demonstrated some central lessons:

- *It is possible to study the relationship between organising and the environment.* It is possible to identify relationships by centring the organisational study and the environmental study on their meeting point, the handling of technology. It is possible to explore their relationship with a simple comparative study design in which technology and other circumstances (e.g. natural and type tenants) are kept similar.

- *Organising is influencing the environment through the combination of many actions.* The pattern formed by the many actions has been called 'management style'. Organising in housing management can be described as the daily work and actions of people managing buildings. It is the specific combination of actions on a building that is characteristic for the management of that building, and thereby manifesting the link between organising and environmental impact.

- *Actors and their actions are influencing the environment.* Many think that environmental differences depend on technology. Yes, there are technical actions, but these are embedded in a pattern of many actions performed by actors in the organisation. It is the combination of these many technical actions on building and its technical systems that have environmental consequences (in form of energy and water flows).

- *A form of organising that pays close attention to the building and its physical flows seems to be important for a better environmental performance.* The studied on housing management have shown two green management styles: the 'caring' and the 'professional' management style. First, the 'caring' management style is integrating economic constraints and tenants

demands and still pays close attention to the buildings and its energy and water flow. Second, the 'professional' management style is integrating time constraints and still pays close attention to the buildings and its energy flow.

Some of the central lessons from the field of housing management have been used in the additional studies. The possibility to study organisational-environmental *relationships* has led to look for such relationships in environmental management and to think about the use of indicators (Paper IV). The importance of *actors and their actions* have led to the introduction of an actor perspective in the environmental studies on buildings (Paper V).

What else does this knowledge imply for related research fields? In the following findings and recommendations are presented for the fields of buildings, LCA and environmental management.

7.2 Buildings and the environment

The LCA study on buildings (Paper V) has highlighted some controversial findings:

- *Passive housing is not always better than conventional housing.* Saving energy with help of passive house technology seems to be embraced as solution to the energy and environmental problem of the building sector in Sweden (Brunklaus et al 2008, Byggvärlden 2008). Life cycle studies on passive housing have so far focused on energy (Thormark 2002/2007, Joelsson 2008). However, the results of our LCA studies show that passive housing is only better than conventional housing when it comes to energy use, but not for broader environmental impacts, such as global warming or acidification. This can be observed from an ordinary LCA.

- *Energy use is not the same as environmental impacts.* Since Adalberth's influential study (2001) energy use in buildings is interpreted as a proxy for environmental impact. However, the results of our ordinary LCA study show that energy use in buildings cannot be understood as environmental impact, since the environmental impact depend on the source and the production of energy. This can be seen with an ordinary LCA.

- *Residents and other actors in building chains influence the overall environmental impact of buildings.* Since Adalberth's influential study (2001) building constructors are considered to be the most important actor for reducing energy and environmental impacts. However, in order to accomplish a green building, several actors need to make choices. The results of our LCA show that especially that the household's choice of green electricity matters. This can only be observed from an actor analysis.

To conclude, many other studies of passive housing and conventional housing encapsulate assumptions about the environmental impacts of energy production and about actors in the building chain. I recommend including a broader environmental perspective and an actor perspective in studies of buildings. As a consequence of our results, I recommend building developers, municipalities and housing managers to place demands on green energy supply and to inform tenants about the important of choosing green electricity.

7.3 LCA reflecting the social nature of technical systems

The methodological development of LCA (Paper I) and LCA's combination with an organisational study raised other interesting findings:

- *Ordinary LCAs are not enough to find organisational solutions.* The Life Cycle Assessment methodology has been used for more than a decade in order to find environmentally better technical solutions (Baumann and Tillman 2004). However, it is the humans and organisational arrangements that are handling the technological systems. The inclusion of socio-material relationships in the modified LCA has been of help when comparing organisational arrangement in the study of housing management and buildings. With the modified LCA the environmental importance of various actions and organisational arrangements can be estimated.

- *The life-cycle may be understood as a chain of actor. The actions of these actors may be understood as handling the material flow that we know as life-cycle.* The Life Cycle Assessment methodology has modelled technical processes for more than a decade in order to find environmentally better technical solutions (Baumann and Tillman 2004). However, in order to find environmental better organisational solutions, the life-cycle can be understood as chain of actors along the life-cycle and LCA results as the sum of choices within the chain.

- *The actor analysis helps to analyse respective action and actor and to find organisational solutions.* The analysis commonly used in ordinary LCA studies is the dominance analysis. However, the dominance analysis in ordinary LCAs encapsulates too many assumptions about actor's choices and actions. Some aspects become only visible in an actor analysis, such as actor's direct and indirect influence over the life cycle or the shift of responsibility within the life cycle chain.

To conclude, in order to solve the environmental problems that we cause, clearly we need structured ways for thinking about the environmental consequences of technical systems, but we also need structured ways for

thinking about organisational causes as well. Thereby the focus on *socio-material relationships* may be of help.

7.4 Environmental management and the environment

A literature study on indicators (Paper IV) and experiences from housing management organisations have raised new insights into environmental management and the use of environmental indicators:

- *Work processes within a company are important for environmental management.*

The literature study on environmental management and indicators demonstrated that (operational and managerial) work processes within a company are important for reducing environmental impacts, instead of only following stakeholders' demands. Indicators need to be relevant for the organisation.

- *Environmental management along the physical environmental flows is important.*

Environmental management along the physical environmental flows makes it easier to identify the important environmental actions and effects beyond organisational boundaries e.g. in operations upstream and downstream.

- *Indicators need to be company specific and specific for the environmental context they are used.* Every company has their own strategy and way of working. Therefore their operational and managerial indicators need to a large extent be company specific. Only then an effective control can be reached.

To conclude, environmental management need to be related to both (operational and managerial) work processes and to the physical environmental flows along the life cycle. Indicators need to be company specific and specific for the environmental context they are used.

7.5 General conclusions

By putting the light on relationships between organisation and the environment, I hope to clarify certain dimensions of environmental problems. One concerns the role of various actors' choices and actions in the context of single processes and the life-cycle as a whole. The other concerns the importance of organising close to materiality, both regarding buildings and environmental flows, and by achieving this, allowing people to make informed value choices towards an environmentally smarter management.

8 REFLECTIONS AND FINAL REMARKS

I end the thesis with my research reflections; my suggestions for future work/research and give some final remarks.

8.1 Research reflections

During my doctoral research, I have had to come to grips with concepts such as 'organisation' and 'organising'. This has not always been easy being an engineer. The doctoral research also presented me with a new way of distinguishing between the terms *organisation* and *organising*. At the beginning I have described organisation as 'static arrangement' and organising as 'dynamic process' (Brunklau 2005). Through Hatch (2002) I learned to understand the term organisation as 'modernistic' and the term organising as 'social construction'. Andrews (2001) distinguishes between a 'neoclassical economic view' of the *organisation* and the 'new institutional economic view' of *collective actions*. Czarniawska (2004, 2005) has inspired me with her description of organisations as stories and action nets. However, similar to Korhonen (2002), I think the dominant description of organisations in research and practice is still the neoclassical view of the organisation.

Among the central areas in organisation theory (Hatch 2002), I came to study several of these in the first housing management study e.g. technology, social structure (conflicts and contrasts between units), and change. In organisation theory all of these areas can be studied from several different perspectives e.g. modernistic or symbolic-interpretative (Hatch 2002/2006). At the beginning I used a modernistic perspective, especially in the study of organisations' structure (Brunklau 2005), while I came to find the symbolic-interpretative perspective/social

construction/action nets and description of stories more useful in the study of organisational influence on environmental performance, which has resulted in Paper II. They are more useful, since they include actions and are not limited to only one organisation.

In the field of LCA, both the natural and the social phenomena are relevant (Baumann 1998). The combination of both natural and social knowledge traditions leads to the interdisciplinarity in the field of LCA. Since knowledge production is based on different grounds (e.g. theory-based versus empirically-based research approaches, quantitative versus qualitative methods, generic versus specific results), the researcher wanting to perform interdisciplinary research needs to learn many skills of knowledge production. It is not unusual that engineers do poor qualitative research (Mitchel 2007).

Of course I found some practical problems with interdisciplinary research. One concerns the problem of disciplinary languages and terms that can be understood in different ways. Terms used in my work, e.g. 'organisation', 'operational' and 'managerial' are interpreted in different ways within organisational theory and environmental management literature and among engineers. The other issue concerns the problem of a rather basic knowledge ground in each discipline. In this work basic knowledge in social science and organisational theory has been added to the study of buildings and housing management.

During this interdisciplinary work several decisions have had to be made. Social science tends to be published in the form of books, while natural science and engineering tends to be published in the form of papers. For this thesis, I have chosen to publish papers, since they make collaboration with other researchers possible and since the research tradition in my home department ESA involves 'papers, papers, papers...' However, it has not been easy to squeeze the rich stories from the field into 20 pages

in my papers. During this doctoral research I have seen myself as being on the borderland of the sciences and looking for interface arenas and translations.

8.2 Future research work

Using LCA in organisational studies has opened up a large variety of applications, from specific situations to the different areas described in Chapter 5.

The actor analysis within the modified LCA methodology may be applied to any product life-cycle. It might be interesting to study carry out further actor analyses, for example to perform an LCA of office buildings instead of residential buildings. Here professional tenants can make choices instead of private tenants. What are the similarities and differences?

It might also be interesting to study another industry, such as the textile industry. The textile industry is interesting because the focus has previously been on the use of water and chemicals in the production and washing of clothes during the usage, while organisational patterns 'behind' the material side have seldom been recognised. Consumers buy and store a lot of clothes in their homes. What are the environmental consequences of different organisational pattern?

It might be also interesting to study further socio-material analysis and combine other environmental systems analysis tools, such as Material Flow Analysis. Another interesting path could be a combination with economic features over a period of time, which is currently being discussed in the research programme 'Organising for the environment'. How are economic and material aspects related? What kind of conflicts and actions lead to economic and material changes?

And, it might also be interesting to work more with indicators and environmental management in other sectors. How specific do indicators need to be for different industries.

8.3 Final remarks

This thesis has demonstrated that it is possible to study social dimensions in LCA. It is possible to learn from including studies of humans in environmental systems studies. It is possible to describe the complex relationship between actors and the environment with help of actions. It is possible to learn about how organising influence environmental performance through a hybrid methodology.

This thesis has also demonstrated that so called 'green' technology, such as passive housing, or standardised environmental management systems (EMS) do not ensure better environmental performance. This means that there are building developers/municipalities and other organisations that both want to and are really trying to improve the environmental situation, but do not quite succeed. Therefore it is important to point out the complex relationships between actors and the environment. Otherwise, there is a big risk that the environmental potential of the measures, whether technical or managerial, will not be achieved and that good intentions and efforts will not be rewarded. The final message of this thesis is:

Organising matters for the environment.

If building researchers pay attention to actors and actions in the product chain and environmental managers pay attention to organisational relationships and environmental flows, this might lead to a more balanced understanding and actions towards environmental improvements.

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