THESIS FOR THE DEGREE OF LICENTIATE OF ENGINEERING

Energy Efficiency and Preservation in Our Cultural Heritage: EEPOCH

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Gothenburg, Sweden 2011

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Cover:
The view taken on the buildings reviewed in the EEPOCH project shown in Figure 1 on page 5.

Chalmers Reproservice
Gothenburg, Sweden 2011

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ABSTRACT

The project EEPOCH concerns our built heritage and the complex set of problems that exist between energy efficiency and preservation perspectives. New legislation demanding efficient energy use is predicated on the documented potential of energy efficiency on both national and international levels. Due to the severe environmental impact of energy consumption and diminishing fossil energy sources, energy efficiency is considered a key action. Concerns have been raised, however, as to whether the historic value of our built heritage will be lost, to the advantage of energy efficiency actions. There is a need for models directed towards the application of an integrated balancing of energy and preservation demands. The aim of this study is to find a way to design such theoretical models.

Three cases with objects restored in the 1990s have been studied by analysing and comparing their energy performance and their different historic and architectural values. In doing so, a case study methodology of pattern-matching has been used for literal and theoretical replications.

Transdisciplinary and interdisciplinary approaches have been used in the research. The multiple case study and issues concerning both energy performance and conservation have been discussed in workshops. Academics and practitioners participated, some of them providing facts on the cases and all of them contributing with their knowledge, expertise, experience and advice to root the study in approved practice and theory.

The results show that some energy efficiency actions may be carried out without diminishing their different historic values, but these have low impact on the energy consumption. The results also show that energy efficiency actions that are too small may result in a poor indoor climate.

This study also highlights unforeseen issues. The impact of a new legal and regulatory framework on alterations in existing buildings had to become an embedded unit of analysis, showing that concerns for lost heritage values are justified. The traditional way of assessing the different historic values proved to be insufficient from an architect's point of view and a complementary way is presented. Moreover, new ways of assessing historic value are currently being tested by the Swedish National Heritage Board and the National Property Board. The case where energy efficiency actions and preserved historic value can be balanced is dependent on this assessment. A thorough evaluation is recommended.

Keywords: energy performance, preserved built heritage, historic and architectural values, laws and regulations, collaboration through workshops, interdisciplinarity, transdisciplinarity, multiple case study and indoor climate.

FOREWORD

This work has been carried out at Chalmers Architecture and is mainly financed by the Swedish National Energy Agency, which started the programme Save and Preserve where a number of projects are carried out in relation to energy issues and conservation. Several local companies have also funded some of the work, enabling the implementation of the workshops in which they have also been participating. Many thanks to Eksta Bostads AB, Varberg Energi AB, Falkenbergs Bostads AB, Region Halland; a special thank you to HEM-Halmstads Energi och Miljö, Industristaden AB, SHK and Kraftaktörerna, Laholmshem AB and the municipality of Laholm. A special thank you to the Forsberg family, owners of Tyreshill, and to the architectural firm Arket for sharing the future plans for another one of the studied objects.

The work was carried through in cooperation with Heritage Halland where archivist Lennart Nordqvist has been especially helpful, as has antiquarian of built heritage Britt-Marie Lennartsson who helped with assessing historic values. Thank you also to Krister Svensson at Energirådet Halland, who provided statistics on degree days in Halland, and Simon Pallin PhD student at the Department of Building Physics for temperature calculations, and Enno Abel and Bengt Bergsten at CIT Energy Management AB. I am very grateful for the many discussions that took place in the courses and seminars with professors and other PhD students at Chalmers, at Lindholmen and at the University of Gothenburg, and to all visiting PhD students. I also owe a lot of gratitude to my family and a special thank you to Lars-Erik and Erik for discussions on philosophical matters.

Apart from those named in the expert group and reference group below, there were teachers, professors and supervisors who took part of the work, discussing all or part of it. Some invited me to lecture in their courses. They must also be mentioned so thank you Lena Falkheden, Erika Johansson, Pär Meijling, Alessandro Roveri, Barbara Rubino, Jan Olof Dahlenbäck, Claes Caldenby, Liane Thuvander, Paula Femenias and Inger Lise Syversen. Last but certainly not least I want to say thank you to the main supervisor Michael Edén who with his vast experience and deep knowledge has guided me.

Reference group
Prof Carl-Eric Hagentoft, Building Physics and Prof. Fredrik Nilsson, Architecture, Chalmers University of Technology; director Christer Gustafsson and antiquarian of built heritage Maja Lindman, Heritage Halland; and officer Kenneth Asp, Swedish National Energy Agency.

Expert group
Prof. Em. Jan Rosvall, GMV center for Environment and Sustainability; Prof. Stefano Della Torre, Politecnico di Milano, BEST Building and Environment Sciences and Technology; Jan Sundquist, engineer and certified energy expert, Varberg Energi AB, consultant Lars Tobin, Anneling Tobin Consult AB with subsidiaries Approvus, head of training prior to certification of energy experts and the certification of inspectors of cultural values, and Tor Broström subject coordinator for cultural heritage preservation, Gotland University.

Thank you all for invaluable contributions to the workshops and for your time and good advice.

Own interest and experience

Ever since childhood, an awareness that we are influenced by our surroundings physically, socially and psychologically, has been present. An insight finally evolved that we also have an impact on our environment, and becoming an architect was a way to learn how this mutual impact works. When Hans Eek[1] spoke of energy and passive houses in 1990 at a course in Lund, the crucial issue of energy became a focus, mainly due to energy's environmental impact e.g. through mining and through combustion but also from a resource perspective. As it turned out the energy issue is also crucial when it comes to caring for and making use of the existing resources which form our built environment. If we cannot ensure reasonable running costs, including energy costs, people will not take care of our built heritage.The knowledge gained was made use of, working with our built heritage at a museum in the 1990s and, in the 2000s, with energy issues at a regional energy agency and in my own practice in new low energy houses and energy efficient extensions and refurbishments.

The project EEPOCH encompasses these knowledge fields and is a continuation of this path. One cultivates one's interests.

[1] The architect Hans Eek co-developed the passive house technology at Passivhaus Institut in Darmstadt, Germany and made the drawings for the first official passive houses in Lindås, Sweden.

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'If you live long enough in a place you become the place'

Quote from the film 'Rocky Balboa' by Sylvester Stallone 2006.

I BACKGROUND, PROBLEMS AND RESEARCH QUESTIONS

I.I THE ARCHITECTURAL STANCE

Most of us like a varied and diverse built environment – not a monotonous one – and this is also what environmental psychologists say. We want a rich and stimulating architecture with a strong gestalt (form, character). When discussing renewal of our cities' periphery, built in the latter part of the 1900s, variation seems to be a key issue. In a report from Boverket[1] on social and sustainable urban development, variation is one of five themes and includes urbanity as a positive notion with a variety of environments for living and activities, like workplaces, different forms of housing with different ownership categories, meeting places and a variation of services et cetera; and design variations in the built environment are seen as something desirable. The ideal, according to the text, is the city around the year 1900. It seems that the bustling inner city with its diversity, complexity and vitality could serve, to some extent, as a model, even in changes in large-scale suburban districts.

Architecture is a design for culture, a place for human life as well as a form of culture, a symbolic expression for human life.[2] Our built environment is a condition for the social environment and our common history is part of it. 'The city consists of relationships between the measurements of its space and the events of its past' to quote Calvino.[3] Preserving the different time layers ensures diversity and the meaning or soul of a place, 'genius loci'[4] and moreover engaging people when a built environment is transformed for new needs is an important process which must be carried out in our work even though it takes time. The latter point is also stated in the Swedish Planning and Building Act.[5]

Our physical environment should have proportions which we humans can perceive as pleasant. It should be built of materials which are pleasant to look at and to touch in addition to being functional. Our built environment must be possible to maintain, and with the passage of time have a certain patina. Our common space should be designed to promote social life. This is essentially consistent with the text in the Swedish Planning and Building Act.[6]

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[1] Boverket (2010a). *Socialt hållbar stadsutveckling - en kunskapsöversikt.* Karlskrona: Boverket. pp. 45-52.
[2] Caldenby, Claes & Waldén, Åsa (ed) (1986). *Forskning om arkitektur och gestaltning G16:1986*. Stockholm: Byggforskningsrådet.
[3] Calvino, Italo (1974). *Invisible Cities.* London: Harcourt Inc.
[4] Norberg-Schulz, Christian (1980). *Genius Loci. Towards a Phenomenology of Architecture*. New York: Rizzoli International Publications Inc. p. 18.
[5] Boverket (2011a). Regelsamling för hushållning, planering och byggande 2011. *SFS 2010:900 PBL*, *Kapitel 3 och 5.* Karlskrona: Boverket.
[6] Boverket (2011a). *SFS 2010:900, PBL, Kapitel 8.*

I.II GENERAL APPROACH IN AND TO THE FIELD

The qualities mentioned above are often but not always found in our older existing built environment. Taking care of and exploiting what we have already manufactured and invested both time and money in, is important from a resource and techno-economic perspective. This includes all existing built environment which is our built heritage, not only the monuments protected by law.

Natural and renewable materials are notions used for describing sustainable materials on a local level, and these have no negative environmental impact on the wider world i.e. other countries and continents. The historic building sector tries to recycle as much as possible on local level for local use. Construction parts from one site can be used in another site and even be of higher value. This is especially true for buildings where it has traditionally been the case that parts of the building have been recycled. This was made possible through modular construction of e.g. the log house which is the most common example. This is more of a cradle to cradle[7] approach than a cradle to grave one - upcycling instead of recycling. Use of the 'precautionary principle'[8] is inherent and new or unknown harmful materials are seldom or never added in historic buildings. Not all old and traditional materials and techniques are healthy, though. For example, the heritage sector[9] has stopped using old fashioned toxic paint, adopting modern standards of non-toxic paint to avoid pollution of our ecosystem. Renewables and energy efficiency are always part of the building preservation work for low environmental impact.

In 'Historically valuable buildings, Background report to the detailed evaluation of Good Built Environment 2007'[10] by Boverket, is stated that 'A rapid rate of change, whether it's about regression or expansion, impedes long-term sustainable management of cultural values'. At times of weak economic growth, valuable but superfluous buildings are left for decay since there is no use for them. On the other hand, strong growth can trigger the need for new development areas, leading to large transformations or demolitions. Long term sustainable management of cultural values presupposes change. The changes need to be done at a moderate pace however, so that the new can enrich the existing environment. There must also be an economy for maintenance of existing values and new functions for the buildings. If there is no demand, there are no resources to maintain cultural heritage.

Looking upon it pragmatically, if you can no longer live in or work in a building because of high running costs or insufficient design or space for the functions required of the building, then there is no incentive for preserving it. Avoiding loss of built cultural heritage and keeping the desirable diversity and complexity in our built environment demands cautious transformation. Finding new functions for people to use is a priority. And people, living and working, need a good indoor climate apart from pure shelter. 'A good indoor climate is a basic functional demand and is what gives legitimacy to construction on the whole. [...] All buildings are expected to modify strongly varying local exterior

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[7] McDonough, William and Braungart, Michael (2002). *Cradle to Cradle, Remaking the Way We Make Things.* New York: North Point Press.

[8] http://en.wikipedia.org/wiki/Precautionary_principle.

[9] The heritage sector is to be understood as the National Heritage Board who are responsible for national monuments, built heritage and artefacts and archaeology matters, and handle national legislation; furthermore, the universities and museums on national, regional and local levels, and the branch of conservation officers, architects, archaeologists, entrepreneurs and all others interested, and volunteers engaged with cultural heritage on a national, regional or local level.

[10] Boverket (2007). *Kulturhistoriskt värdefull bebyggelse. Underlagsrapport till fördjupad utvärdering av God bebyggd miljö 2007.* Karlskrona: Boverket. pp. 16-18.

climate to significantly more consistent interior climate.'[11] Hence the indoor climate is in the centre of figure 1. Putting people first demands a good indoor environment and comfort. This approach is shown in figure 1 and it also represents the view taken on the buildings reviewed in the EEPOCH project.

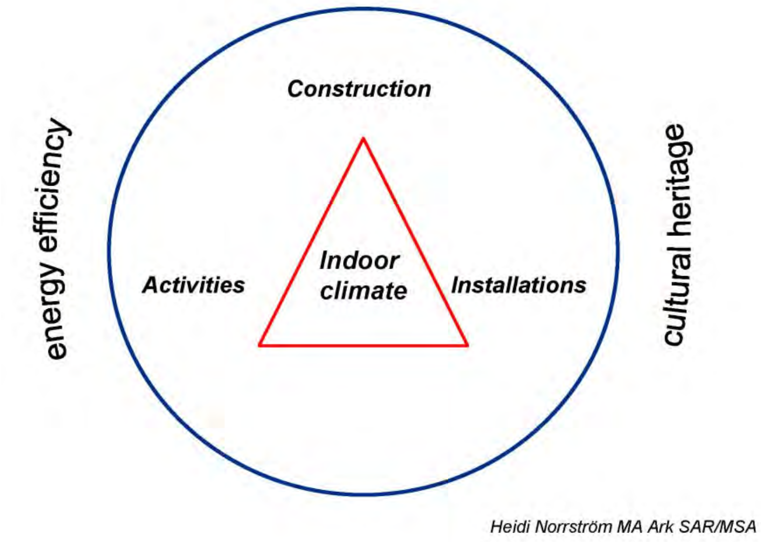

Figure 1 View taken on the buildings reviewed in the EEPOCH project

A wider view or notion related to this can be described as a holistic approach. This is well depicted in The Royal Academy of Engineering's print 'Guiding Principles[12] on engineering for sustainable development'. Their structure for a holistic approach has three pillars: environmental, social and techno-economic, shown in figure 2. This also applies for the EEPOCH project.

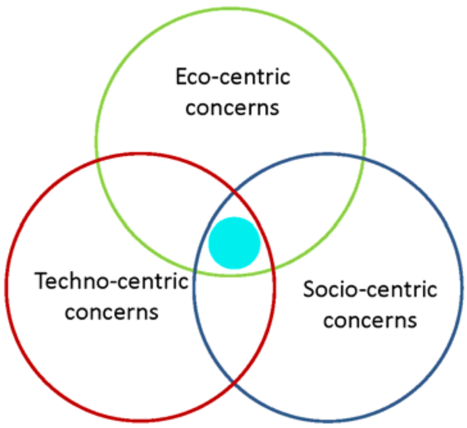

Figure 2 The three pillars according to the Royal Academy's Guiding principles for sustainable development.

[11] Edén, Michael (2007). *Energi och byggnadsutformning*. *Skrift nr 54*. Stockholm: Arkus. p.11.
[12] The Royal Academy of Engineering (2005). *Engineering for Sustainable Development: Guiding Principles.* London: available at: http://www.raeng.org.uk/events/pdf/Engineering_for_Sustainable_Development.pdf.

The Eco-centric concerns natural resources and ecological capacity, the socio-centric concerns human capital and social expectations, the techno-centric concerns techno-economic systems. 'Sustainability can be thought of as the region in the centre of figure 2 where all three sets of constraints are satisfied, while sustainable development is the process of moving to that region.'

The resources we have to deal with are described by the Royal Academy as five capitals.

- Human
- Environmental
- Social
- Financial
- Manufactured

All these capitals are affected in one way or another when buildings are restored or refurbished and must have a design that results in as little negative environmental impact as possible, while being as efficient as possible, with techniques suitable for the purpose and socially suited for human needs. Retaining a sustainability focus on the intended outcome through a construction project is implicit today for architects and within the historic building sector. Sustainable development is what we are to work with, and to improve the sustainability of existing practices is a constant ongoing task as is shown in this research project and in other projects at Chalmers funded by the National Energy Agency, National Heritage Board, Boverket, Vetenskapsrådet and also, for example, in the construction industry's engagement in the national ByggaBo-dialogue[13].

I.III WHY IS THIS STUDY CARRIED OUT?

There has been a focus on energy production and supply in the latest decade, nationally, on the EU level and internationally. This is due to the environmental impact of energy use, increasing greenhouse gas emissions and diminishing fossil energy sources. The issue of renewable energy sources is addressed in Directive 2009/28/EC[14] with the objective 20 % renewable energy sources by 2020. In Sweden today we have 50 % renewables in the energy system. In an EU-perspective the need for imported fossil fuel is a problem, and the 50 % of today will have increased to 70 % in 2030 if actions are not taken, according to the European Commission[15].

Now the emphasis and focus is on the user side, as opposed to the earlier focus on energy production. Energy efficiency is considered a key action within the EU as stated in the European Directive 2006/32/EC[16] on energy end-use efficiency and energy services, and the ban on incandescent light bulbs will make an impact on electricity use. But the issue of energy efficient buildings is quite different.

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[13] Boverket (2010b). *Bygga-bo-dialogens kompetensutvecklingsprogram för hållbart byggande och förvaltande – slutrapport.* Karlskrona: Boverket.

[14] The European Parliament and the Council of the European Union. *Directive 2009/28/EC on the promotion of the use of energy from renewable sources.* Availalble at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:en:PDF.

[15] Meddelande från kommissionen till Europeiska Rådet och Europaparlamentet. KOM(2007) 1 slutlig. *En energipolitik för Europa{SEK(2007) 12}.* Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0001:FIN:SV:PDF.

[16] The European Parliament and the Council of the European Union. *Directive 2006/32/EC on energy end-use efficiency and energy services.* Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:114:0064:0064:en:pdf.

Sweden's total energy use is about 400 TWh/year and about 36 % is used in the residential and service sector[17]. On European basis the sector is consuming 40 % of the total energy use. At least 90 % of our existing built environment will still be here in 50 years. The potential for energy efficiency is pointed out in the existing building stock. The Directive 2002/91/EC[18] on Buildings' Energy Performance was altered 2009 and 2010 and the 17 articles are now 31, with 5 appendixes in Directive 2010/31/EC[19]. For Sweden this means alterations in the law SFS 2006:985[20] and regulation SFS 2006:1592[21] on energy declarations. Swedac[22] previously handled the accreditation of companies with certified energy experts in Sweden but the new directive only demands certified persons, not companies, to make it easier for professionals to get certified. In the 2006:1592 regulation it is now stated that the energy expert shall visit the building in question and make cost effective recommendations for energy efficiency measures 'Thereby shall the indoor environment and the building's cultural values and other essential property requirements be taken into account'. Making it easier to become a certified energy expert while raising the requirements for the expert's task in the field, may seem discordant.

I.IV LEARNING FROM HISTORY

For many people Sweden has a murky history of demolished buildings dating back to the 1960s and 1970s. Housing constructed before 1945 amounts to about 33 % [23] of the total of residential buildings and hence Sweden has a young residential building stock. We implemented the 'million programme' building one million apartments in ten years, and at the same time carried out the urban renewal of our deficient and unsanitary cities[24]. The special programme for repair, reconstruction and extension financed by the state was carried out in the wake of the oil crisis of 1973 and many mistakes were made concerning existing built heritage. Our Swedish stock of insulated and metal-covered buildings emanates from these years. An evaluation made later by Boverket, i.e. 'The National Board of Housing, Building and Planning'[25] shows that projects financed by this programme premiered huge reconstructions and added insulation without consideration of the cultural and historic values in our built heritage. There is an obvious need for guidance now with the extended law on Energy Declaration and many measures and actions on energy efficiency will be put forward in the years to come.

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[17] Energimyndigheten (2009). *Energiläget 2009 ET 2009:28.* Eskilstuna: Statens Energimyndighet.
[18] The European Parliament and the Council of the European Union. *Directive 2002/91/EC on the energy performance of buildings.* Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:001:0065:0065:EN:PDF.
[19] The European Parliament and the Council of the European Union. *Directive 2010/31/EC on the energy performance of buildings.* Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF.
[20] Boverket (2006a). *SFS 2006:985 Lag om energideklaration för byggnader*. Karlskrona: Boverket.
[21] Boverket (2006b). *SFS 2006:1592 Förordning om energideklaration för byggnader*. Karlskrona: Boverket.
[22] http://www.swedac.se/en/.
[23] National Board of Housing, Building and Planning, Sweden and Ministry for Regional Development of the Czech Republic, eds. (2004). *Housing Statistics in the European Union 2004.* Karlskrona: Boverket.
[24] Caldenby ed. (1998). *Att bygga ett land. 1900-talets svenska arkitektur. T9:1998.* Stockholm: Byggforskningsrådet och Arkitekturmuseet.
[25] Boverket (2003). *Bättre koll på underhåll.* Karlskrona: Boverket.

According to the Swedish government's national environmental objective Good Built Environment[26] the cultural, historic and architectural heritage of buildings and built environments with special values should be protected, developed and identified by 2010. Earlier in the 1980s when national financing was available, about 3 000 objects/buildings were identified in the county of Halland, and the new inventory finished 2010, points out over 10 000 buildings[27]. The inventory concerns the residential and service sectors as well as industry and others. Similar results will most likely appear in the other regions. At the same time as the buildings and objects are protected they must be given reasonable running costs. For an economist, a building's lifecycle is 40 years. During this time span about 85 % of the total energy use[28] and 50 % of the total cost lie within the management phase. There is a demand for a model/guidance on how energy efficiency can be managed without negative impact on the cultural and historic values of our heritage. Preserving the past for the future is not a risk but an obligation.

I.V WHAT IS THE HALLAND MODEL?

Objects for this study are chosen within a concept called the Halland Model, a regional joint venture, initially created for preservation of historic buildings, which started in the 1990s recession. Over 1100 construction workers and apprentices were trained in traditional building techniques and operated on about 100 historic buildings at risk, under the supervision of skilled craftsmen and conservation officers. Selected objects included, among others, castles, windmills, industrial sites, dwellings, warehouses, and theatres. 'Save the jobs, save the craftsmanship, save the buildings' was the first motto of the scheme. It soon developed into a regional cross-sector joint-action network, aiming at sustainable growth including strengthening competitiveness, use of renewables, recycling of materials and development of building conservation. Probably the last object restored and rebuilt within the Halland Model, in Sweden, was an old fire station which was transformed into The Drawing Museum of Laholm in 2005.

In Christer Gustafsson's dissertation on the Halland Model[29] an application-oriented theoretical platform and a new model, providing adequate approaches to solve boundary-spanning challenges, is presented. A generic and entrepreneurial concept or model is developed where the 'trading zone' is defined as an active arena for negotiations and exchanges of services or a field of force corresponding to the actors' policies, values and resources.

After the completion of each conservation work, the improved premises made new functions available. They were seen by entrepreneurs as resources to be taken advantage of and to develop. This is one of many additional values which have come out of the Halland Model. About 1500 contractors and suppliers have been involved and about 400 new jobs have been created directly depending on the execution of the Halland Model, plus about 200 more indirectly.

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[26] Environmental Objectives Council (2009). *Sweden's Environmental Objectives in Brief.* Stockholm: Environmental Objectives Council. Available at: http://www.naturvardsverket.se/Documents/publikationer/978-91-620-1273-1.pdf.

[27] The Halland inventory was carried out by antiquarian of built heritage Björn Ahnlund at Heritage Halland and will be available at the County Council's website.

[28] Adalbert, Karin (2000). *Energy use and environmental impact of new residential buildings*. *Rapport nr 1012*. Lund: Byggnadsfysik, Lunds Universitet.

[29] Gustafsson, Christer (2009). *The Halland Model: A Trading Zone for Building Conservation with Labour Market Policy and the Construction Industry, Aiming at Regional Sustainable Development.* Gothenburg: Chalmers University of Technology.

The Halland Model has been exported e.g. to the Baltic Sea Region, Russia, Poland and Iceland in regional projects for sustainable development and experience from the Halland Model has been widely disseminated. The Halland Model is a good example of the tendencies or trends within the heritage sector throughout Europe and the world today, where the sector is focusing on reuse, use value and social sustainability and adaptation to the economic market.

Both preservation and energy efficiency have been taken into account in the conservation work. The Halland Model provides examples on the management of energy performance without diminishing cultural value and social history. Thus the Halland Model is appropriate for further research. It is the built environment from the epoch of craftsmanship and constructed before 1945 that is studied in the research project EEPOCH.

I.VI THE RESEARCH QUESTIONS

Our officially protected monuments such as the royal castles or national museums are quite well managed and energy efficiency is of minor interest considering their high historical and cultural values. But there are several unprotected built environments serving as time-documents of a city history and as cultural layers of its development. Our built environment is our cultural heritage. Are these values protected when the energy experts carry out the Directive on Buildings' Energy Performance? There is a complex set of problems from energy efficiency and preservation perspectives and the initial questions in EEPOCH are:

– Will intangible values in our built cultural heritage be lost in favour of measurable and tangible energy efficiency actions?
– Is there a risk that over- cautiousness about our built cultural heritage may prevent actual efficiency potential from being realised?
– Is it possible to explore this duality, which is the combination of preserved built heritage and energy conservation?
– Can the combination of preservation and energy efficiency actions be performed in a way that both conservation officers and energy counsellors can accept?

II INTRODUCTION

II.I THE CHOSEN OBJECTS

The idea was that the EEPOCH's research questions could be exemplified in a survey consisting of objects restored within the Halland Model. The three buildings chosen were (1) Fattighuset in the municipality of Halmstad, a brick construction with a general plan and great preserved historic values. Fattighuset is actually two buildings because an attached wing is built in the backyard. The second building is (2) Teatern in the municipality of Laholm, a plastered brick construction with a specific plan, a theatre, and an interior mainly restored to its former grandeur. (3) Tyreshill in Rydöbruk is the smallest building. It is situated in the municipality of Hylte and is owned by a family who both live and work there. It is the only wooden construction, and a solid one, and it has added interior insulation. These buildings exemplify some of the most difficult conditions in older buildings to work with and find solutions for, when it comes to improving their construction from an energy efficiency perspective. The issues with heating, ventilation and air conditioning are general and do not differ much from new buildings except for difficulties finding the space for these systems in old buildings. These buildings are hereinafter referred to as the objects.

II.II THE OBJECTIVE AND AIMS

The overall objective in the EEPOCH project is to design theoretical models directed towards the application of an integrated balancing of energy efficiency and preservation demands in our built cultural heritage. The aim of this licentiate thesis is to find a way to design such theoretical models. The main idea for investigating and problematizing the initial questions was to use both generic and qualitative research in different surveys.

– Aim of the generic research: case studies will form a foundation for a theoretical model that is application-oriented for an integrated balancing of energy and preservation demands, without diminishing the tangible and intangible values in our built heritage.

– Aim of the qualitative research: methods used within and between connected professions and academics will be illuminated, especially their transdisciplinary and interdisciplinary approaches. These surveys could reveal good practises for further in depth examinations.

II.III THE INFORMATION SEARCH

In the beginning of this study a comprehensive information search was conducted on the new combined area, through databases at Chalmers Library. The aim was to find out if anyone else was working with the combination of energy efficiency, heritage and conservation. Finding a large enough reference in this new combined area was not likely, but an extensive search was done to see if someone or some others had tried to create a theory or model of the kind that this project is aiming at. To sift among the hits the following questions were asked. Are there good examples appropriate for case studies in other parts of the world? Have such case studies been performed? If they exist, have any clear conclusions been drawn from them? There were very few hits altogether and most of them emphasizing just one aspect, e.g. energy use in old buildings, without discussing their historic values. In other cases restoration problems were emphasised without giving any answers on how to implement energy efficiency measures. And some specifically emphasised sustainability problems, of which some may have relevance and be applicable to heritage issues. In some cases the articles concerned interesting material issues connected to refurbishment. Some of the articles were of a scientific nature e.g. for conferences but most hits were small articles in magazines and about e.g. won competitions with no details.

The search shows that the new combined area of balanced energy efficiency measures in built cultural heritage has not been explored to any great extent and is still not established. It demonstrates the need for and reinforces the decision to invest in and focus on this type of research project. This is based on the problem in finding written material with relevance for the new area. Individually there are some reports and articles available, but material where the combination occurs is relatively rare and is found, if there is any, mainly in newer, short articles. Regarding searches of databases, you can get over 100 hits dependent on which keywords are used but on closer examination there are very few that are wide enough for the research perspective, as established in this project.

The answer to the questions asked at the beginning of the search is that there are others working in the same area with the combination of energy efficiency and heritage area, but not many. It is not likely that there is someone else who is trying to create a similar model. There are examples of case studies carried out elsewhere, but not an in-depth study of the new combined area and hence not any conclusions about how to obtain a balanced assessment of both energy issues and conservation issues. There are no established theories to use and to verify. In light of this, theory building for development of useful and applied methods is the aim of this project.

II.IV THE FOLLOWING CHAPTERS

This new combined area described in the introduction incorporates a complex set of problems, and different methods are needed to approach the various parts, as described in chapter three. Facts and values are assessed within a multiple case study using both technical and analytical means and methods. The outputs from the workshops are also described and the results are to be found in this chapter. Conclusions made in the study are reported in chapter four.

Chapter five contains three papers. The first is a conference paper presented at the Heritage 2010 International Conference in Evora, a world heritage city, in June 2010. It presents the first case study and the two different traditions of conservation and of energy efficiency work in Sweden. There is also a summary on the history of laws and regulations concerning energy issues in Sweden. The second paper was presented at the international conference Energy Efficiency in Historic Buildings, February 2011, in Visby. This paper concerns the impact of new laws and regulations and two of the cases are compared. The former was unforeseen and had to become an embedded unit of analysis, showing that concern for lost heritage values is justified. The third paper presents a small pilot study on management and working climate in conservation teams working within the Halland Model and was presented at the ESA 10th Conference in Geneva, September 2011.

Chapter six summarises the discussion and ideas and plans for continuation of the work are presented. This includes further method for validation of the case study findings in this study and assessment of historic values in general. A possible schedule and necessary components for designing weighted evaluations are presented. Moreover a qualitative study is suggested to develop this. Figures on the three objects are separately presented in the appendix.

III METHODS

III.I PLANNING THE RESEARCH

A scheme for implementing the project, figure 3, was designed for the research. The scheme outlines the participants and the relation of the different research activities and units of analysis. The participating professionals, the workshops and the case are the core of the study. Evaluating the energy issues is pure empirical work with numbers and figures but to see the cause and effect of different measures and in the co-operating systems in a building demands experience and practice. How to interpret figures on consumption or calculation of transmission losses demands a solid base in theory. Evaluating cultural and historical issues demands knowledge as well as experience. Finding objects for evaluation implies finding companies and organisations to involve in the study. All this was crucial for the performance of this study and that is why the reference group, the expert group and the companies are placed on the top of figure 3, together with the project group.

On the next row in figure 3 you have the workshops where all professionals could meet for discussion. Their contribution to Workshop I on setting the research project, to Workshop II on the Energy issue and to Workshop III on the Heritage issue in the historic environment sector, were invaluable. This interdisciplinary and transdisciplinary approach rooted the study in approved practice and theory.

The oval with the multiple case study is in the centre, below the row of workshops. Around the case study the different subtopics are arranged. Some of them were planned from the beginning and some evolved during the workshops. Architectural values, actions and effects of proposed actions, laws and regulations became new embedded units of analysis due to the workshops. These subtopics, or units, are grey in figure 3. Professionals from the groups at the top of the figure were consulted in the research work with all the eight units. Facts and results established from this study of the objects form the basis for the summary and conclusions in the box to the right.

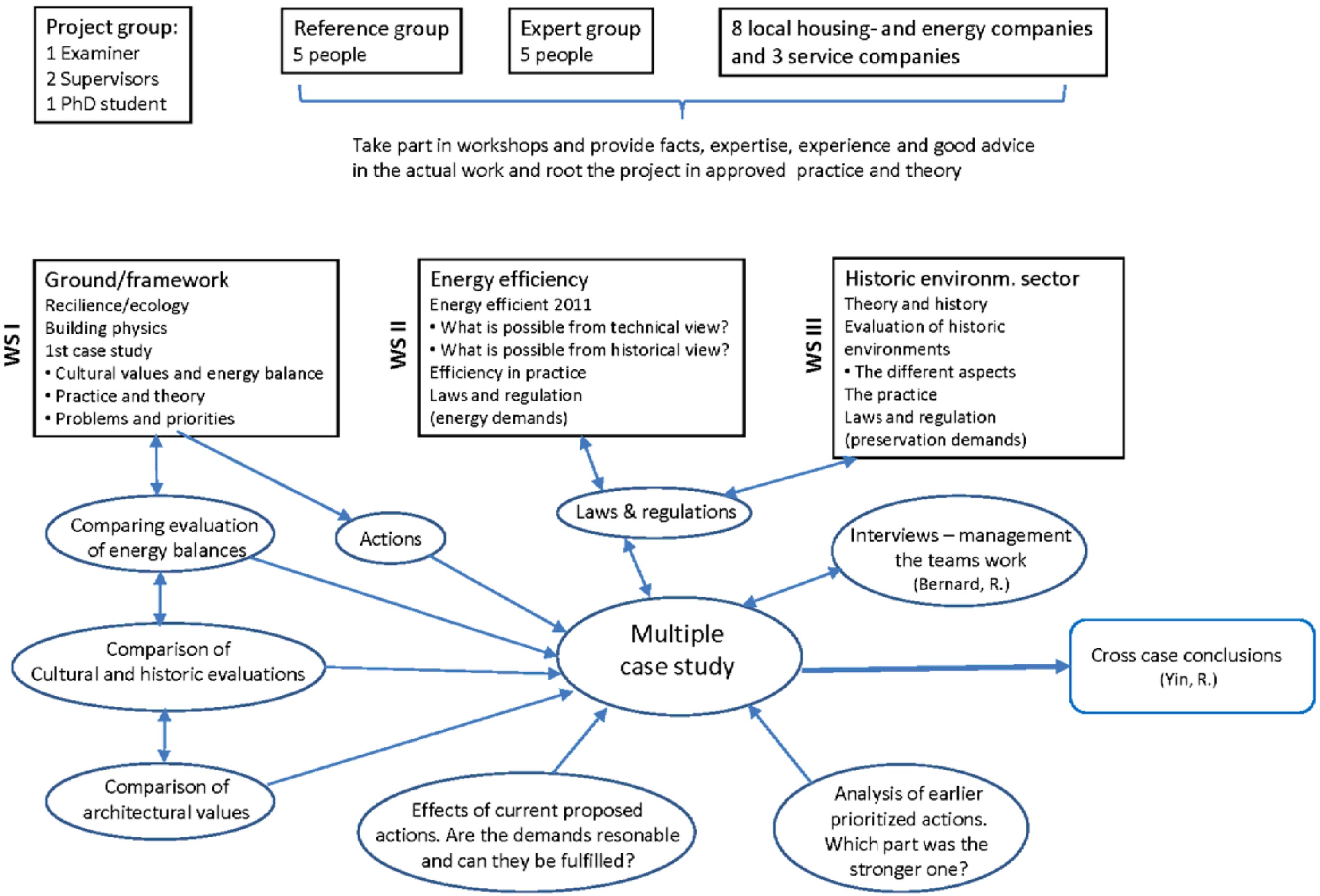

Figure 3. Overall scheme on EEPOCH for planning and communication of the research.

III.II MULTIPLE CASE STUDY

A case study can be used when the questions how and why are asked and can, according to Robert K. Yin,[30] be of use for exploratory, explanatory and descriptive research. For this project a multiple case study is appropriate. The case study is used to describe the work with the restored buildings, both the actual artefacts and the people working on them, and methods for assessments. This is to be understood as a case study with mixed methods, because all different methods can be included in case studies.

The objects chosen for the multiple case study are as follows. Fattighuset in the municipality of Halmstad is a solid brick construction with an attached wing built in the backyard. It is used for shops, workshops and offices. Teatern is a theatre with a plastered solid brick construction, in the municipality of Laholm. Tyreshill in Rydöbruk in the municipality of Hylte is the third and smallest object. It is used by one family both for living and for a workshop. It has a wooden construction, and a solid one. These buildings exemplify some of the most difficult conditions in older buildings to work with and find solutions for, when it comes to improving their construction from an energy efficiency perspective. The screening to find them included local archive studies in Halmstad of all hundred objects restored within the regional Halland Model project.

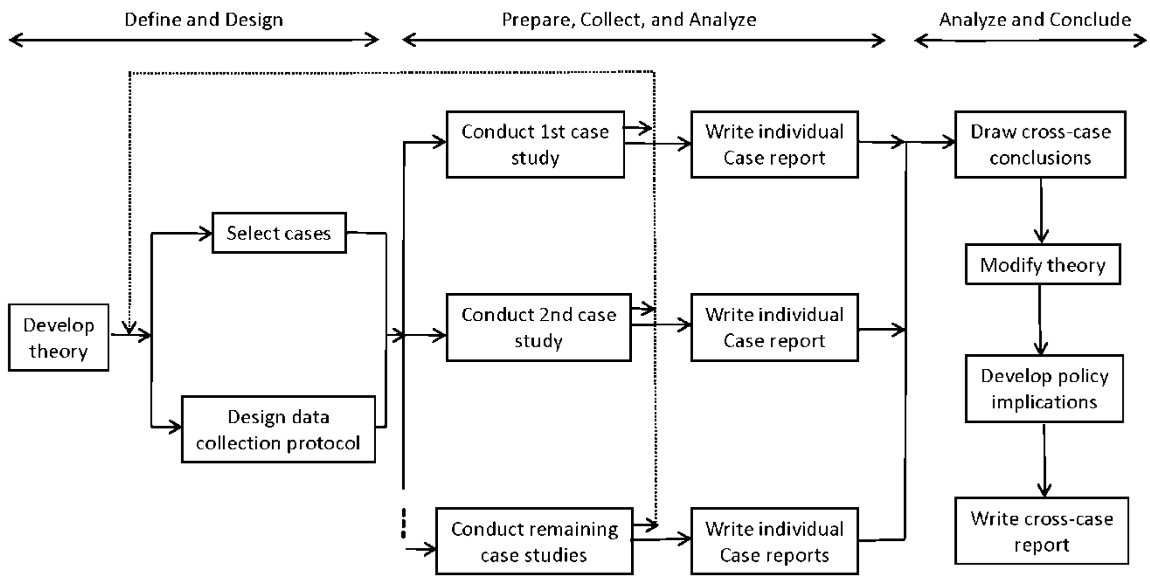

Figure 4 Schedule for the implementation of a case study method with its different phases, freely sketched from Yin 2009. Case Study Research, Design and Methods, p. 57.

The chosen methodological framework is a multiple-case design with embedded multiple units of analysis according to Yin's definitions. The theoretical model for balancing demands emerges from the cases, some of which show similar predicted results, a literal replication, while some show predicted contrasting results for anticipatable reasons, a theoretical replication. The main units of analysis are the restored objects, their energy performance and their historic and architectural values and the people, organisation and methods in use during the conservation work. In brief it is about using pattern matching and analytical means to generalize a set of results to explore a possible hypothesis or broader theory.

[30] Yin, Robert K. (2009). *Case Study Research. Design and Methods — Fourth Edition.* Thousands Oaks: Sage Publications Inc.

There are two structures for the case study composition. A linear-analytic structure is used for explanatory, descriptive and exploratory purposes, which is a standard approach. A theory-building structure is used for explanatory and exploratory purposes,[31] for examining the various facets of causal arguments and showing the value of further investigation of various hypotheses.

Structure of methods

The main sources in this study are the restored objects and the people who have been working on them. The main aspects are the work on energy efficiency and preservation of cultural values, the architectural view, and the teams' work. Understanding of and impact of laws and regulations became an embedded unit of analysis when an owner showed plans for coming alterations in one of the objects. Assessment of preserved values is done in situ. Assessment of energy efficiency is measured in situ and calculated. Archive studies, literature studies and workshops concern almost all aspects. Assessment of management i.e. methods within and between, approaches to, and processes in the teams' work, has been carried out with a few interviews as a tentative study or pilot study. The aspects have been addressed as presented in the following table.

Main aspects to explore, describe and analyse	Methods and base for survey
Energy efficiency ➢ measures ➢ approaches ➢ accomplishments ➢ results	• archive studies and search • measures in situ • calculation of energy balances • literature studies • workshop I-III
Cultural and historic values ➢ estimates and assessments ➢ approaches ➢ accomplishments ➢ results	• archive studies and search • assessments in situ • literature studies • workshop I-III
Architectural values and use value ➢ estimates and assessments ➢ approaches ➢ accomplishments ➢ results	• archive studies and search • assessments in situ • literature studies • workshop I-III
Management, teamwork ➢ strategies, methods and processes ➢ approaches ➢ accomplishments ➢ results	• archive studies and search • literature studies • interviews • workshop I-III
Laws and regulations ➢ content and meaning ➢ impact of ➢ approaches	• literature studies • interviews • workshop I-III

Table 1 Main aspects investigated in this study and the methods and base that were used for it.

This research project should be understood as an architect's method where the evaluation of the objects, i.e. restored buildings, is an empirical study in the positivist tradition, pure facts so to speak, and possible to interpret for analysis. This also applies to the assessment of historic and cultural

[31] Yin (2009). pp. 175-179.

values but the base is the humanities and their historicism. The architectural values or performance are primarily estimated based on a number of functions and are based on the two traditions mentioned. The other part of the research, where people are interviewed on the conservation work to find answers to questions on organisation and methods, is part of the tradition of social science. Workshops have also been carried out with participants from different professions from both practice and academy, and that is a variant of action research with interdisciplinarity and transdisciplinarity approaches. These are some of the methodologies with different philosophical stances which an architect can make use of, and different methodologies have been considered to find the ones relevant for theory building and to get to the core of the research questions. A number of courses in methods were taken and, to use professor Atkin's words,[32] 'A detailed case study or studies, supported by in-depth investigations involving practitioners, seems like the best way, possibly the only way to attack the problem. I am not sure how else you would get to the heart of the problem.'

According to Yin[33] there are three principles of data collection to construct validity and reliability of the case study evidence and for convergence of evidence; use of multiple sources, creating a case study database, and maintaining a chain of evidence. These principles have been followed in this study. Triangulation by using multiple methods and bases has been used for every aspect in table 1 above. Corroboration was also achieved by consulting professionals. To get other perspectives on the data and interpretation of the material was necessary in the assessment of historical and cultural values and investigator triangulation was performed. Assessment of these values and the architectural values was simultaneously very easy and very difficult to carry out, and this phenomenon needs some comments.

Descriptive methods for analysing the objects' cultural values emanate from the humanities and historicism and from the development of architecture, sociology, society and technology. Authenticity, patina, continuity, symbol value, rarity and other values are considered in the evaluation. In a way this can be related to (post)structuralism, due to the evaluation of the qualities and values which is done in relations to meanings and the 'readers' understanding of them. Every individual 'reader' creates a new purpose and meaning, and the task in this study is to be able to use a variety of perspectives to create a multifaceted interpretation. This implies that there is no common objective truth which, on the other hand, Schleiermacher believed there is. He defined hermeneutics as the art of avoiding misunderstanding[34] but contemporary hermeneutics is about different kinds of understanding and interpretation. Making use of general hermeneutics would be appropriate in this study. This can include interpretation of built form and both written and verbal information. In the assessment an interpretive-historical approach[35] was needed when archival data, investigations in situ and interviews with involved professionals were analysed.

To see and interpret, understand and assess built environment is to make an evaluation. Moving around in architecture means that the view alters constantly and how it is experienced depends on the viewer's perspective. In this aspect the value in architecture is a subjective matter. In a report on

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[32] Written response 23 May 2011 from Prof. Brian Atkin on a course assignment concerning research methods in this study.
[33] Yin (2009). pp. 114-125.
[34] http://en.wikipedia.org/wiki/Hermeneutics.
[35] Groat, Linda and Wang, David (2002). *Architectural Research Methods*. New York: John Wiley and Sons.

architectonic qualities,[36] however, it is stated that we have some common notions about what good architectonic quality is. Usually it means that a building is designed and shaped to adapt to its surroundings, with originality in design, and thoroughly worked through down to the details. Traditional values like sustainability, authenticity, professionalism, wholeness, aesthetic honesty, beauty or artistic design and legibility are value-laden. Another way of assessing is in terms of effectiveness, functionality, usability and economy in a certain context. Architectonic values or qualities are open notions according to the author. This means they are revised, reinterpreted and can be discussed. Good new architecture occurs all the time and there is no final definition.

III.III CALCULATING ENERGY BALANCES

The energy balances are primarily made in order to compare the three objects' energy performance as achieved after restoration, and to set it in relation to the degree of preservation of cultural and historic values that was achieved.

In all buildings heat is transferred by heat conduction, convective heat transfer and radiation. Heat must be supplied to balance these losses - the heating always equals the loss. From this it follows that heating can be reduced by minimising loss. This is what the Kyoto pyramid[37] is based on.

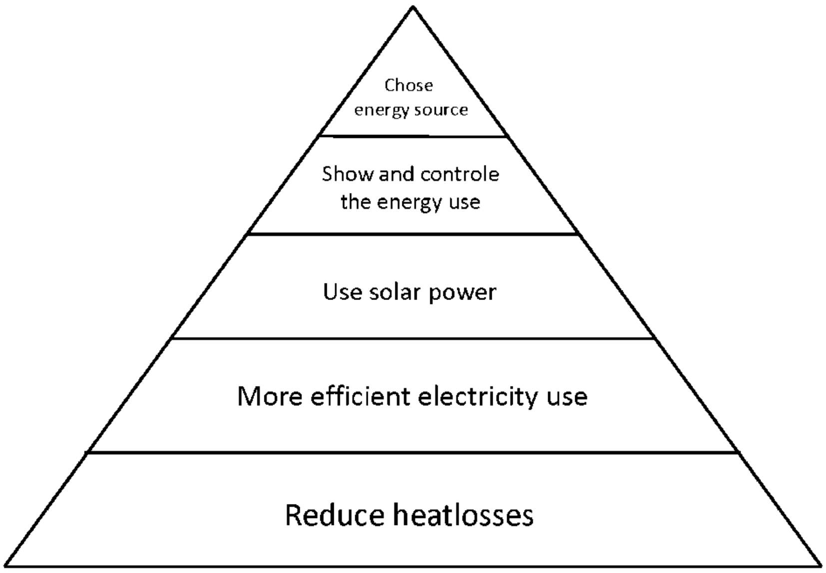

Figure 5. The Kyoto-pyramid emphasizes the reduction of heat losses.

In new constructions the reduction of heat loss through an envelope with low U-values is no problem. In existing constructions a well insulated façade can be as good. Exterior insulation is preferable as thermal bridges are built in and covered and it keeps the wall warm. This will not do if the façade is protected for its high cultural and historic values. Insulation on the interior side could be an option but could also cause problems. The wall gets cold and moisture from precipitation cannot evaporate. At cold outdoor temperatures this can cause damage to the exterior façade

[36] Rönn, Magnus, ed. (1998). *Aspekter på arkitektonisk kvalitet*. pp. 3-8. Stockholm: Institutionen för arkitekturens form och teknik, Kungliga tekniska högskolan.
[37] The Kyoto pyramid is an interpretation of the Kyoto protocol and it is often used to illustrate the basic principles for low energy constructions like the passive houses.

material when the captured moisture freezes. The thermal bridges at joists or concrete slabs and inner walls adjoining the outer walls become exposed areas [38] [39]. These are important basic facts when evaluating existing buildings' energy balances and performance, and possible improvement.

The evaluation of the objects' energy performance was carried out in three ways: with IR (infrared) camera in situ in winter time; with manual calculations of their energy balances; and by measuring actual energy consumption. Differences in these figures could be of value in showing that the building was maintained very well but could also detect problems indicating actions needing to be taken, and could show what could be improved. In *Achieving the Desired Indoor Climate,*[40] it is stated of energy balance that 'A complex software should not be used when a simple one can adequately address a specific building or energy conservation measure. Complex software does not necessarily yield more accurate results'. The aim here was to use a simple method of overarching nature, without going too far into details. No calculation model – cursory or thorough - is without flaws but the strength was in using the exact same procedure in every object for an accurate comparison between them, ensuring the reliability of the case study. The method used is a simple old school one. According to the different books and guides that were used for drawing the outline of the energy survey, not so much has been changed. The books and guides used for preparing the manual survey were: Abel and Elmroth[41], Adalberth[42], Adamson[43], Anderlind[44], Boverket's handbook[45], Boverket[46], Elmroth[47], Petersson[48] and Wärme[49]. They were read to compare different methods for calculating energy balances and to check if there was an even simpler method. All methods use the same basic principle. What differs is how much data is processed; the simpler the method, the less data. Some of the books were checked for finding the λ-values and to determine whether or not the estimated U-values for old window constructions varied. For new windows the U-value is always known but for old ones it has to be estimated. Calculating U-values was made using the usual lambda value, equation no. 1, to find the thermal resistance so that the U-value in no. 2 could be obtained. Correction values for moisture and wet environment, for small cracks in the constructive structure, and for general correction and some special thermal resistances were added as stated in the books.

[38] Åhström Michael, et al. (2005). *Rätt murat och putsat*. Stockholm: Svensk Byggtjänst. pp. 71-81.
[39] Hoppe, Michaela (2009a). *Improving the energy efficiency of historic buildings* in Detail Green 02/09 English Edition. München: Institute für internationale Architektur-Dokumentation GmbH & Co. pp. 48-51.
[40] Nilsson, Per-Erik, ed. (2003). *Achieving the Desired Indoor Climate.* Lund: Studentlitteratur. p. 357.
[41] Abel, Enno och Elmroth, Arne (2008). *Byggnaden som system.* Andra reviderade upplagan. Stockholm: Forskningsrådet Formas.
[42] Adalbert, Karin and Wahlström, Åsa (2008). *Energibesiktning av byggnader – flerbostadshus och lokaler.* Stockholm: SIS Förlag AB.
[43] Adamson, Bo and Hidemark, Bengt (1986). *sol energi form. Utformning av lågenergihus. T2:1986*. Stockholm: Byggforskningsrådet - Statens råd för byggnadsforskning.
[44] Anderlind, Gunnar and Stadler, Claes-Göran (2006). *Isolerguiden Bygg 06*. Väring: Swedisol.
[45] Boverket (2009a). *Energihushållning enligt Boverkets byggregler 2009. Handbok.* Karlskrona: Boverket.
[46] Boverket (2009b). *BBR 2008. Supplement februari 2009. Regelsamling för byggande. 9 Energihushållning*. Karlskrona: Boverket.
[47] Elmroth, Arne (2009). *Energihushållning och värmeisolering, Byggvägledning 8.* Stockholm: Svensk Byggtjänst.
[48] Petersson, Bengt-Åke (2009). *Byggnaders klimatskärm. Fuktsäkerhet Energieffektivitet Beständighet.* Lund: Studentlitteratur AB.
[49] Wärme, Peter et al. (1991). *Energisparboken. Halvera elräkningen–men behåll din standard!* Solna: Teknografiska Institutet.

$$R_T = R_{si} + \frac{d_1}{\lambda_{p1}} + \frac{d_2}{\lambda_{p2}} + R_{se} \qquad U = \frac{1}{R_T}$$

(Equations no. 1 and 2)

λ_p = heat conductivity, practical, W/m ˚C
d = thickness of the materials, m
R = thermal resistance, m^2 ˚C/W
R_{si} = thermal resistance, transition at interior surface
R_{se} = thermal resistance, transition at exterior surface
U = heat transfer coefficient, W/ m^2 ˚C

In the standards today, from Boverket's mandatory provisions, the thermal bridges χ and Ψ-values, are added and this is the biggest change compared with old standards. For calculating thermal bridges and the heat accumulating capacity of the brick walls, different ISO-standards are required, according to Boverket's handbook. And according to Abel and Elmroth these calculations are laborious and should be performed with computer software. Using all these data is beyond the limit of the simplicity stated for my manual calculation.

Solar heat is not included. The uncertainty about how much of the solar contribution can really be of benefit can justify neglecting this effect in simple calculations according to Elmroth[50]. Boverket also recommends using degree days or degree hours for simple manually performed calculations, which is the choice made here. Neither the heat loss through thermal bridges nor compensation through the wall's heat accumulating capacity will be referred to in the manually performed calculations.

The first thing to do is always to measure the building's plan and façade from prints. The areas and surfaces for Fattighuset were measured using the software programme Auto Cad. Measuring the other two objects was done with pen and paper using a ruler, which was easier. This part is the most time consuming and has to be done whether or not a computer will be used in the next step. For floor area the notion A_{temp} was measured, defined as the indoor part heated to +10 ˚C or more. A U-value for all different areas and surfaces of all construction parts had to be calculated, except in the case of the old windows for which the values were obtained from the books' different lists. Indoor temperature was measured at several different points on site and the mean value was calculated for use in the balance. This work is summarised in tables A, C and E in the appendix. To get the total loss of heat transmission through the envelope the figures were multiplied with the degree hours specific for the current geographic municipality and these data can be bought from SMHI[51].

The lowest acceptable recommended air circulation in workplaces[52] is 7 litres per second per person plus 0.35 l/s and m^2 floor area. For buildings other than residential ones the air circulation can be reduced when no one is working in the building. To get the heat demand for ventilation some very simple formulas were used, just to get an idea how large heat losses can be. For flow one multiplies the room air volume by the air circulation needed, formula 1. For heat, the flow is multiplied by air density and the heat capacity of dry air, formula 2. By multiplying the heat with degree hours one gets the heat energy demand or in this case the loss, formula 3.

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[50] Elmroth (2009). p. 82.
[51] SMHI is the Swedish Meteorological and Hydrological Institute, situated in Norrköping.
[52] Arbetsmiljöverket (2000). *AFS 2000:42 Arbetsplatsens utformning*. Stockholm: Arbetsmiljöverket.

These rules of thumb give slightly higher figures for heat losses through ventilation and are suitable for use in older buildings which often have involuntary ventilation i.e. leaky building envelopes, and are experienced as draughty. All figures used for these rule of the thumb formulas are in tables B, D and F in the appendix. So are the figures for heat demand for hot tap water, and the internally generated heat.

$$\text{Flow} = \frac{V \times \text{air circulation}}{3600}$$ *(Formula 1)*

$$\text{Heat} = \text{Flow} \times \rho \times c$$ *(Formula 2)*

$$\text{Heat energy loss} = \text{Heat} \times Q$$ *(Formula 3)*

Flow has the dimension 1/h
V = room air volume, m^3
Air circulation, m^3/h per m^2
Heat, kJ/s per ˚C
ρ = air density, kg/m^3
c = heat capacity for dry air, kJ/kg and ˚C
Heat energy loss, MWh
Q = degree hours, k˚Ch

The electricity use was divided into two end uses: the operational electricity for the running of the buildings' systems of fans, pumps, lifts, lighting, cooling and other fixed installations (i.e. for common purpose regardless of what function that could fulfil in the building); and for household or business purpose. The division of electricity use was roughly calculated by measuring and counting the number of people working or living there and the installed equipment, lighting etc to get figures for the operational electricity. The figures were compared with key figures from the guides and books and adjusted.

FATTIGHUSET


1

Photo 1. Fattighuset's north façade facing Lilla Torg in Halmstad. Photo Eva Gustafsson.

FATTIGHUSET, Drottning Kristina 2, in the municipality of Halmstad is owned by a municipal real estate company, Industristaden AB. It has been rented to different tenants and in the attic in the main house to a museum and a computer software company. The first floor is occupied by an office and the ground floor is rented by six different shops and workshops. On the ground floor in the back wing there is a café. The first floor is one big conference room.

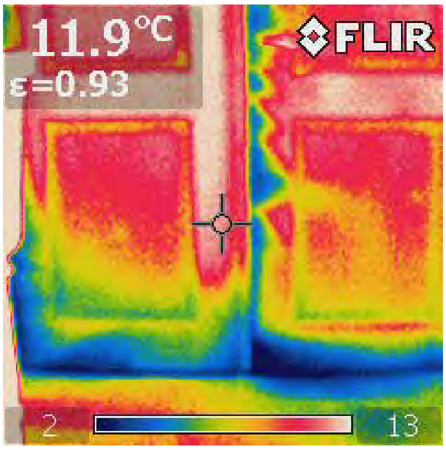
Construction

The main building is a two storey building of 1 ½ brick-stone construction, with an attic. It was erected in 1859 and 1879. The tin covered span roof construction with a hipped roof on the gable is wooden and 175 mm of insulation was added in 1996. The wing back in the yard has the same construction but no attic and was erected in 1891. Doors and windows are wooden. The windows have ordinary glass in coupled double glazing; single glazing; and single glazing with an added single-glazed sash. The skylights are of wood and aluminium and glazing with lowemission coating. The doors have single glazing. The foundation is of granite. The main house has a small air space under the ground floor's wooden joists. The boiler room has a concrete floor. Dry rot fungus was discovered in the foundation in 2001 and was removed by excavating the space. Two dehumidifiers were installed and there is continuous measuring and control of the thermal conditions and humidity in the foundation. The back wing has an unheated cellar. The total area heated to +10°C or more, A_{temp}, amounts to 1062 m^2.

Heating and hot water

The heating system is supplied by district heating with 95 % renewable energy sources. The distribution system in the buildings is hydronic heating with a radiator system. Average use of water in the last four years is 600m^3/year of which an estimated 33 % is heated for hot tap water use. Bought district heating is 186 MWh/year. Hot tap water accounts for 12 MWh/year of this and the calculated heat loss through the ventilation is 47 MWh/year. The key figure for district heating is 176 kWh/m^2 per year. Calculated total demand is 173 MWh/year and the key figure should be 163 kWh/m^2 per year. The difference in figures is likely due to infiltration of air into the building envelope. Using an IR camera gave some possible answers.

2a

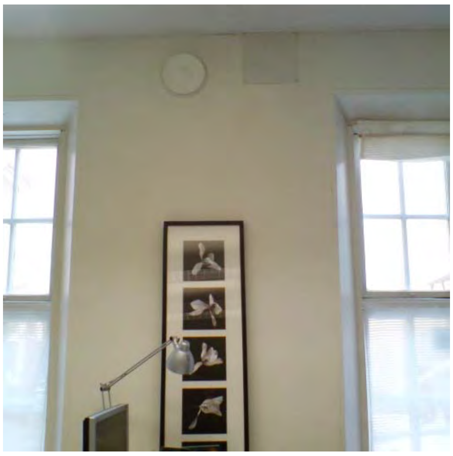


2b

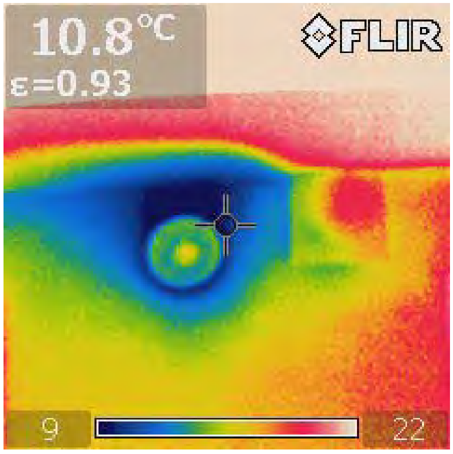
Photo 2a and IR photo 2b. The main entrance door on the east façade is not airtight and the IR photo shows the lack of draught preventers. The temperature outside is 0˚C and at the coldest spot +2˚C on the inside of the door. Photos Heidi Norrström.

Electricity

The figure for total average electricity bought, based on the last four years, is 90 MWh/year. By subtracting the energy use for business purpose the figure 30 MWh/year is left for running of the building which gives 28 kWh/m^2 per year. This includes two continuously running air conditioners installed in the attic, two continuously running dehumidifiers with fans and electric radiators in the foundation of the main house, pumps and valves for the district heating and heat exchanger and for the heat distribution system and water distribution system, continuous running of the mechanical ventilation which has no heat recovery, a lift, lighting fixtures and other fixed installations.



3a



3b

Photo 3a and IR photo 3b.The supply air is distributed by fresh air vents in the external brick walls in Fattighuset. Photos Heidi Norrström.

Indoor climate

The main building has mechanical ventilation for exhaust air and the supply air is distributed by fresh air vents in the outer brick walls. The ventilation is operating with variable air volume which is determined by continuously measured outdoor temperature; the lower the temperature, the less exhaust air volume. The back wing has natural ventilation but exhaust air ventilation can be turned on if and when needed. The tenants are experiencing a very poor level of comfort. It is cold during winter, especially in areas near the fresh air vents and around windows and doors. The temperature on the walls on the inside by the fresh air vents was measured as +9˚C and simultaneously the temperature outdoors was measured as 0˚C in winter 2010. The temperature zone that was suitable for use was 1.5-2 metres away from the wall. The windows are not airtight and are causing draughts. In addition there is the sensation of a cold draught from the cold window surfaces that causes the air to move when meeting the air heated by the radiators. The indoor temperature had a range from +17.1 to +22.2˚C measured in the middle of the rooms. During the summer the offices on the attic floor are overly heated and at worst +30˚C according to the tenants. This figure has not been checked but the owner of Fattighuset is aware of the inconvenient surplus heat which is why the air conditioning units were installed. None of the tenants have made complaints that could be connected to the dry rot fungus.

Evaluation

The key figure for energy consumption is 204 kWh/m^2 per year. This is considered high for an old building in this category, type code 826, according to the comparative key figure given, statistic interval 144-200 kWh/ m^2 per year, when calculating the buildings' energy performance at Boverket's web site[53]. A high key figure was expected due to earlier experience of solid brick constructions. The corresponding key figure is 191 kWh/m^2 per year for heating, hot water and electricity for running in the manual calculation, and this will be used for comparison with the other objects.

There are some energy issues in Fattighuset which have to be seriously considered now when the owner is making plans for a major renovation. Fattighuset was discussed at the first workshop and a list on possible actions was made[54]. The indoor climate, draught and thermal conditions must be addressed.

Closing the wall openings in the masonry where the air vents are today is a prerequisite for installation of a combined exhaust and supply air ventilation system with heat recovery. The doors and windows should have new draught preventers mounted and could have a third sash on the interior side with low emission glazing to prevent the sensation of a draught through convection, and to lower the U-value for the whole construction.

Other infiltration, air leakage or air permeability through the envelope is limited by increased airtightness. The most effective way to address this issue would be to insulate, and preferably on the exterior side, but the façade may not be altered. The alternative with internal insulation must be carefully considered and a hygrothermal simulations programme, e.g. Wüfi, should be used to analyse moisture behaviour in different insulation alternatives. There is a non-dimensional temperature value 'f', used by Hoppe[55] [56]to assess the risk of condensation at the dew point and mould growth inside a construction. The f factor is always between zero and one, $0 < f < 1$. To avoid the risk of mould the value of this factor f must be at least 0.7 at the most unfavourable point, which is often where the thermal bridge is. To calculate the f factor three temperatures must be known: the internal surface temperature Θ_{si}, the outdoor temperature Θ_e and the indoor temperature Θ_i [57].

$$f = \frac{\Theta_{si} - \Theta_e}{\Theta_i - \Theta_e}$$

(Equation no. 3)

When using some of the measured temperatures in Fattighuset in this equation it becomes evident that there is a risk for mould growth as it is today. For the conference room the temperatures in ˚C were Θ_{si} = +12˚C, Θ_e = 0˚C and Θ_i = +17.3 giving f = (12 – 0) / (17.3 – 0) = 0.69 which is slightly lower

[53] The calculation programme is available at: http://www.boverket.se/Bygga--forvalta/Energideklaration/Mer-information/Berakning-av-energiprestanda/.

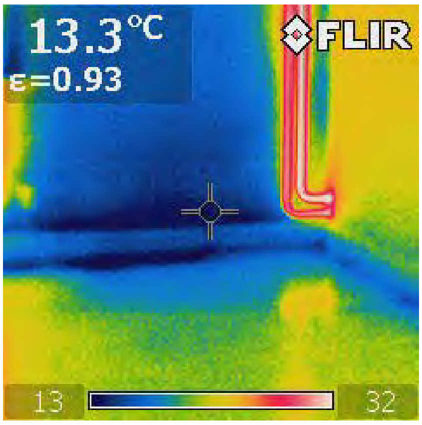
[54] The list of possible measures is to be found in paper no. 2.

[55] Hoppe (2009a).

[56] Hoppe, Michaela (2009b). *Wärmeschutz für Sonderfälle. Abschlussbericht.* Online-Publikation. Nr. 01/2009. Berlin: BBSR Bundesamt für Bauwesen und Raumordnung, Bundesministerium für Verkehr, Bau und Stadtentwicklung. p. 47.

[57] Hauser, G., Schulze, H. und Wolfseher, U. (1983). *Wärmebrücken im Holzbau. Bauphysik 5*. pp. 17-21; pp. 42-51; Bauen mit Holz 86 (1984). pp. 81-92; Schweizerische Schreinerzeitung 98 (1987). pp. 936-946. München: TUM Technische Universität München.

than the 0.7 that is stated as the lower limit. On the ground floor in a room facing west, the following temperatures give f = (13 – 0) / (19.5 – 0) = 0.66. This value is also lower than 0.7. The interior wall temperatures measured by two of the air vents on the east walls were +8˚C and +9˚C which indicates that there is a risk. f = (9 – 0) / (22.2 – 0) = 0.4 and f = (8 – 0) / (17.1 – 0) = 0.46 which both are below 0.7. The outcome of adding a thin layer of lime plaster or nanogel/aerogel or vacuum insulation could be calculated with regard to the outer walls' ability to handle heat transmission and moisture.



4

IR photo 4. The thermal bridge where the floor adjoins the wall, at the ground floor, has a low surface temperature giving f = 0.66 and indicating that there is a risk for condensation and mould growth in the construction. As seen at the slightly lighter blue shade on the moulding mounted where the floor and the wall meet, it is trying to mitigate the impact of the thermal bridge as it should do.

The mentioned measures are the most important on the list and when counting the pros (+) and cons (-) from four aspects — preservation, energy efficiency, comfort and economy — the adding of a third glazing has six pros and only two cons, the interior insulation has five pros and three cons and the complementary ventilation system has got six pros and five cons. Still the assessment must be that the renovation of the ventilation is top priority. Fattighuset is also described in paper no. 1, paper no. 2 and paper no. 3.

TEATERN

5

Photo 5. The south façade of Teatern facing Hästtorget in Laholm. Photo Eva Gustafsson.

TEATERN, Laxen 5-8, in the municipality of Laholm is owned by the municipality. It has been used as an auditorium, a theatre and concert hall, and for the town council's meetings and all other events requiring space for many participants. On the ground floor is a shop.

Construction

Teatern is a two storey building of 2 ½ brick-stone construction, with an attic, and was erected in 1913. It is attached to the hotel Stadshotellet. The tin covered span roof with hipped gables is wooden with a second inner construction of steel over the auditorium, and here 300 mm insulation was added at the restoration in 1995. Teatern was renovated in the 1950s and at that time the external façades got cement based coating. Doors and windows are wooden. The doors have single glazing and the windows have ordinary glass in coupled double glazing. The foundation is of granite and has a cellar. The floors have wooden joists. There are signs of moisture problems on the interior walls. The total area heated to +10°C or more, i.e. A_{temp}, amounts to 885 m^2.

Heating and hot water

The heating system is supplied by a boiler for natural gas placed in the cellar. The distribution system is hydronic heating with a radiator system. The theatre and hotel have had the same meter for many years. The amount of natural gas, water and electricity bought is estimated from an energy declaration made by HEM in Halmstad. The estimation of A_{temp}, in % of the different parts has been used as a base for modification when dividing the total use of heat, water and electricity. Separate and individual measuring in Teatern should have started in November 2010 so that the calculated figures could be compared with the actual measured ones, over six months, but the meters are just about to be mounted in August 2011. The A_{temp} for Teatern and the shop is 35 % of the total in the energy declaration and hence 35 % of the heating. For water use and electricity the figure 35 % is modified to 28 % of the total because of the theatre's property as an official auditorium, therefore less occupied, and because it has no electrical equipment in continuous use as the hotel has. The use of water is calculated at 200 m^3/year, of which an estimated 33 % is heated for hot tap water use.

According to the energy declaration the estimated quantity of natural gas bought for Teatern and the shop, 35 % of total, is 100.4 MWh/year. The key figure for natural gas is 114 kWh/m^2 per year.

The calculated total demand is 122 MWh/year. Of this, 4 MWh/year is for hot tap water. The calculated heat loss through ventilation is 11.3 MWh/year and the key figure should be 138 kWh/m^2 per year. The difference in figures may be caused by the way heat loss through ventilation is calculated, by m^3 and litres, which disadvantages rooms with high ceilings like the theatre with its height of 6.9 metres and its big balcony. Another reason may be an unfortunate division of areas/space and proportion of energy use. Only the actual measured figures can give an answer to this.

Electricity

The figure for the amount of electricity bought is based on the energy declaration and the total 133 893 kWh/year is divided into 24 800 kWh/year for running of the building and 109 093 for business purposes. 28 % of 24.8 MWh is assigned to the theatre and shop. This gives 6.9 MWh/year for running and the key figure 8 kWh/m^2 per year. This includes the ventilation with fans for exhaust and supply air, heat exchanger and electric heating, pumps and valves for the gas boiler and heat distribution system, water distribution, a lift, lighting fixtures and other fixed installations.

Indoor climate

The shop on the ground floor has separate mechanical exhaust ventilation units with continuous running and no heat recovery. The indoor temperature varies from +18 to 22°C in the different parts of the shop. The shopkeeper does not have any comments on the indoor climate except for the chill draught in wintertime when customers arrive and open the entrance door. An internal wind catcher with an extra door to open could be built to ease the cold draught. This would not alter the exterior façade but would reduce the usable floor area in the shop.

The indoor temperature at the theatre in daytime when it was not in use varied from +15.7 to 20.1°C and inside the main entrance it was as low as +9.4°C. At the back stairwell it was +4.5°C. The outdoor temperature at the time was measured as +0.5-0.6°C. Teatern has mechanical ventilation with exhaust and supply air and heat recovery with a rotating heat exchanger and 13 kW electric heating. The original masoned ventilation shafts were used for the installation in 1995. An asynchronous motor with frequency converter controls the fan motors to keep a continuous air pressure in the ducts for balanced ventilation in five different cases of running, ranging from 500 l/s to 1800 l/s. The air handling system is only intermittently in operation which is estimated to 600 hours /year.

The fact that the ventilation was turned on only when needed was not known when paper no. 2 was written, hence the diverging figures on energy consumption. The first calculated results presented in paper no. 2 presupposed running of the air handling system all 8760 hours of the year.

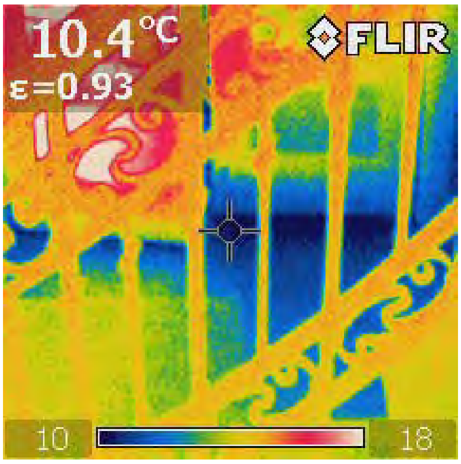
Evaluation

The estimated key figure for energy consumption is 122 kWh/m^2 per year for heating, hot water and electricity for running. This is considered low for an old building in this category, type code 826, according to the comparative key figure given, statistical interval 123-185 kWh/m^2 per year, when calculating the building's energy performance at Boverket's web site.

The corresponding key figure from the manual calculation is 146 kWh/m^2 per year for heating, hot water and electricity for running. This figure will be compared with the calculations for the other objects. The 146 kWh/ m^2 per year is still average compared with the category, type code 826, statistical interval 123-185 kWh/ m^2 per year.

The entrance doors are not airtight and measures have to be taken to ease the cold draught. There is an internal wind catcher with extra doors to open and a radiator is placed inside the outer doors. The doors could be adjusted and draught preventers mounted. The temperature between the outer and inner doors was +9.4˚C and on the inside of the building it was +10.4˚C. Outside temperature was +0.6˚C.


6a

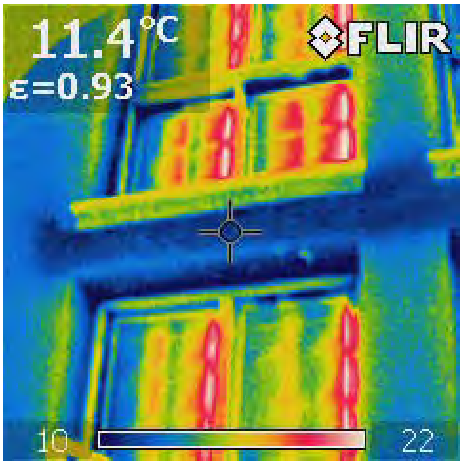


6b

Photo 6a and IR photo 6b. There is a constant draught from the main entrance doors at Teatern which has to be taken care of. Photo Heidi Norrström.

The signs of moisture problems on the interior walls are not good. They appear on the west wall and the north and also in the ceiling up on the balcony in the theatre. Using equation no.3 for checking the risk of condensation at the dew point and mould growth inside a construction shows that there are no risks on the south façade but on the ground floor to the west the temperatures in ˚C were Θ_{si} = +15.5˚C, Θ_e = 0.6˚C and Θ_i = +22.0 giving f = (15.5 – 0.6) / (22.0– 0.6) = 0.69 which is slightly lower than the 0.7 that is stated as the lower limit. In the theatre foyer on the first floor, west wall, the temperatures in ˚C were Θ_{si} = +11.1˚C, Θ_e = 0.6˚C and Θ_i = +15.7 giving f = (11.1 – 0.6) / (15.7– 0.6) = 0.69 which also is slightly lower than the 0.7 that is stated as the lower limit.


7a



7b

Photo 7a and IR photo 7b. Severe damage has appeared on the first floor and the low surface temperatures is giving f = 0.71 just above the limit of risk for condensation and mould growth in the construction. Photo to the left by Maja Lindman and photo to the right by Heidi Norrström.

The temperatures at the walls and in the back stairwell, north façade, are very low. The f values are 0.2 and 0.45 at two measured spots of thermal bridging. Between two of the windows placed above each other on the west wall is a severely damaged area which they have tried in vain to mend. The f value is calculated to f = (11.4 – 0.6) / (15.7– 0.6) = 0.71 and this is just above the limit. One reason could be precipitation drawn into the structure from the outside causing moisture damage. Since it appears in only one place, below one of the windows, it is possible that the window construction itself is part of the cause. A slight discolouration is also visible on the interior surface as if a steel or iron reinforcement has rusted inside the wall. Another reason or cause could be moisture emanating from the inside.


8

Photo 8. The paint is flaking off in one of the staircases on the north side of Teatern.

The cement based plaster on the outside surface of the façades is a problem. The material layers are in the reverse order to the proven way. The weakest material should always be placed on the outside to facilitate moisture migration or diffusion from the inside and outwards. The percentage of vapour in the air is higher inside than outside most of the time, which causes diffusion towards the outer surface of the wall. As the cement has stronger chemical bonding and a higher density than the brickwork and the lime mortar in the building's structure, it acts as a vapour barrier and can cause accumulation of moisture inside the construction[58] and the wall can only dry out from one side-the inside. This principle also applies for a plaster layer. 'The lime-plaster should gradually decline in strength towards the outer surface'.[59] Maybe this is a sign that Teatern has not been heated enough but nevertheless a thorough investigation by an expert on materials and moisture damage in constructions using some of the methods described in Formas' book about humidity measurement[60] is recommended.

Teatern is also described in paper no. 2 and in no. 3. In paper no.2 the figures for total energy use and the key figure differ from the ones presented here because it was not known that the ventilation was turned on only when needed. For the first manual calculation it was presupposed that the ventilation was running all 8760 hours of the year which it actually was not.

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[58] Åhström et al. (2005). p. 79. pp. 186-189.
[59] Malinowski, Ewa (1989). *Restaurering av putsade fasader. Rekommendationer för projektering av putsarbeten. Rapport 1.89*. Göteborg: Forskningsstiftelsen för Samhällsplanering Byggnadsplanering och Projektering. p. 41.
[60] Nilsson, Lars-Olof and Sjöberg, Anders and Togerö, Åsa (2006). *Fuktmätning i byggnader*. Stockholm: Formas. Formas is The Swedish Research Council. http://www.formas.se/default____529.aspx

TYRESHILL


9

Photo 9. Tyreshill's façade towards southeast. Photo Eva Gustafsson.

TYRESHILL, Rydö 3:20, Rydöbruk, in the municipality of Hylte is owned by a private family which lives and works there. The ground floor is used as a studio and a pottery and the kiln for burning of ceramics is placed outside on the southwest façade.

Construction

Tyreshill is a two storey solid log house with exterior wood panelling, erected in 1907. At the restoration in 1998 the timber walls got 90 mm insulation on the interior side. The two stairwells have an ordinary wood frame with 120 plus 45 mm added insulation. A shed in the courtyard has the same design. The tiled span roof is wooden and on the attic floor 250 mm insulation was added at the restoration. Doors and windows are wooden. The doors have single glazing and the coupled windows' double glazing has one ordinary pane and one with low emission on the interior side. The foundation is of granite; at the restoration it was filled up with light clinker material and a concrete floor was cast. The first floor has wooden joists. Using IR camera gave a positive view of the state of the façades. There are problems in the winter with ice forming on the ground at the northwest façade facing the mountain. Total area heated to +10°C or more, A_{temp}, amounts to about 235 m^2.

Heating and hot water

The heating system is supplied by a boiler for wood pellets which is a 100 % renewable energy source. The boiler room is in the shed together with the pellets storage and the accumulating hot water tank and the heat is distributed into the main building by a well insulated culvert. The distribution system in the building is hydronic heating with pipes for under floor heating. Average use of water is 200m^3/year of which an estimated 33% is heated for hot tap water use. Two original chimneys are used for two wood stoves, but there are no data on how much wood is burned so it is difficult to say how much they contribute to the building's heating. The average amount of pellets bought in the last four years is 7.3 tons with an energy content of 4 800 kWh/ton giving 35 MWh/year. Of this is 4 MWh/year heating for hot tap water use and the calculated heat loss through the ventilation is 18.8 MWh/year. The key figure for heating and hot water bought is 149 kWh/m^2 per year. The calculated total demand is 38.9 MWh/year and the key figure should be 166 kWh/m^2 per year.

The difference in figures could be due to a very good standard of building envelope and actual ventilation that is less than the calculated. The wood stoves could of course be another cause. The difference 38.9-35=3.9 [MWh] equals the energy content in 3 m^3 of chopped wood.

Electricity

The figure for total average electricity bought, based on the last three years, is 10.4 MWh/year. By subtracting the electricity use for household and business purposes, including electricity for the operation of the kiln, the figure 2 MWh/year is left for the running of the building, which gives 8 kWh/m^2 per year. This includes the local exhaust air fans, pumps and valves for the pellets boiler system and heat distribution system, water distribution, lighting fixtures and other fixed installations.

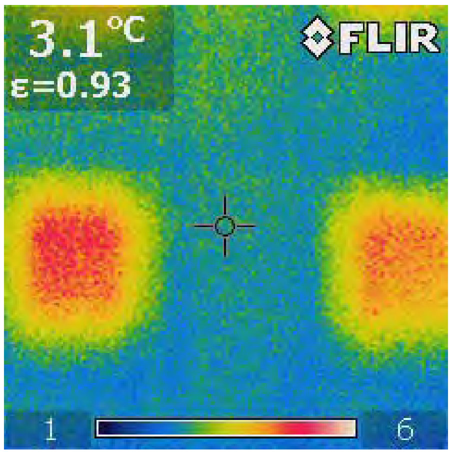
Indoor climate

Tyreshill has natural ventilation through masoned shafts and local mechanical units for exhaust air placed in the kitchens and bathrooms are also connected to the shafts. The mechanical units are only used when needed. The supply air is distributed by fresh air vents in the outer walls. The indoor temperature varies from +18.4 to 22.4°C in the different parts of the main building. The outdoor temperature was measured as +2.3°C at the same time. The result of the restoration is a very comfortable house, warm with no draught. The owners do not have any comments on the indoor climate except that they find it very comfortable.

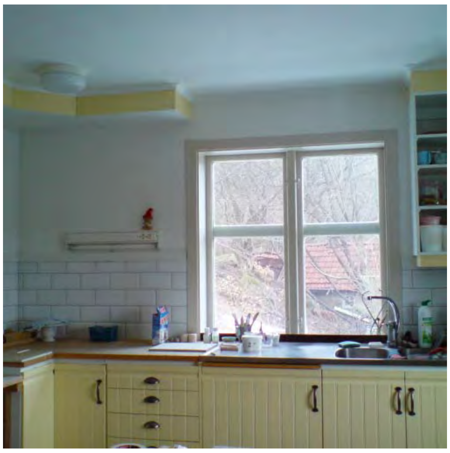
Evaluation

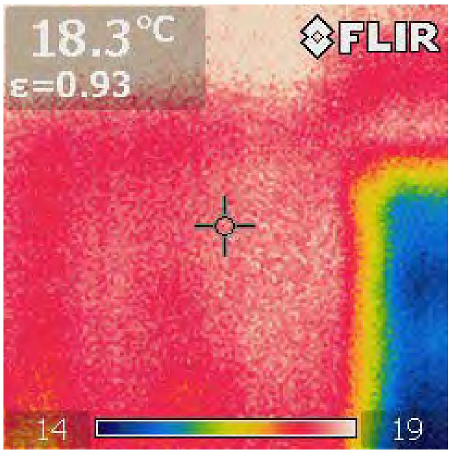
The key figure for energy consumption is 157 kWh/m^2 per year for heating, hot water and electricity for running. This is considered low for an old building in this category, type code 826, according to the comparative key figure given, statistic interval 170-208 kWh/ m^2 per year, when calculating the building's energy performance at Boverket's web site. A low key figure was expected due to earlier experience of solid log constructions. The corresponding key figure from the manual calculation is 174 kWh/ m^2 per year for heating, hot water and electricity for running. This figure will be compared with the calculations for the other objects. The 174 kWh/m^2 year are more in line with the category, type code 826, in the statistical interval.


10a



10b


11a



11b

Photo 10a and IR photo 10b shows the exterior, photo 11a and IR photo 11b shows the interior. All four photos are taken on the ground floor. The northeast façade of Tyreshill show favourable, but energy consuming, conditions in the building's structure. Photo Heidi Norrström.

In this object the IR camera gave a positive view of the state of the façades. Up to the left is the northeast façade and the picture to the right shows the surface temperature on the wall between the two windows on the ground floor. Down to the left is the same spot seen from the interior side and the picture to the right shows the interior surface temperature. The indoor air temperature on the ground floor was +18.4 and the outdoor temperature was +2.3°C. The construction seems to be dry and healthy but too energy consuming.


12

Photo 12. To the left in this picture the ice forming on the ground is shown. The hillside is leaking water which freezes in winter. Above the ice is a bridge leading to the garden at an upper level in the terrain. Photo Heidi Norrström.

The problem with ice forming on the ground at the northwest façade was probably the cause of the bad conditions in the foundation before the restoration in 1998. When melting in the spring the water penetrates into the foundation. One possible solution could be to install an electric cable outside in the ground to prevent freezing and to arrange proper drainage. Tyreshill is also described in paper no. 3.

Comparison of the three objects

Calculated	key figures				
Object	Calculated heating kWh/m² and year	Electricity for running kWh/m² and year	Total key figure for energy use kWh/m² and year	Boverket type code 826 statistic interval kWh/m² and year	Boverket's new demand in BBR kWh/m² and year
Fattighuset	163	28	191	144-200	110-132
Teatern	138	8	146	123-185	110-132
Tyreshill	166	8	174	170-208	110-132

Table 2. Calculated key figures for the three objects including the statistical interval taken from Boverket's database for buildings of this type, age and use. The coming energy use demanded in BBR when alterations are made in existing buildings is also shown for comparison.

Comparing the manual calculations for the three objects it is evident that Teatern should be the most energy efficient, depending on its intermittent use and ventilation adjusted to this and with heat recovery. This was expected and is verified by the actual figures, or the figures from the energy declaration. The conclusion is that flexible and energy efficient installations adjustable to the activities and the use of the premises are the key to low figures. Fattighuset and Tyreshill are equally good, or bad, as regards heating but differ in electricity use which was expected due to different activities on the premises. If Fattighuset had been heated to achieve the same favourable conditions for the construction as in Tyreshill, then the total key figure for Fattighuset would have differed more.

The measured figures for Fattighuset and Tyreshill actually differ even if the wood burned in the woodstoves in Tyreshill should have been accounted for—which it is not. This is a possible further indication that there are problems with moisture in the structure of Fattighuset and that it is not only air leakage that causes the high figures. To vaporise an amount of 1000 kg of water demands about 700 kWh of heat energy[61]. Both the calculated key figure and the measured one for Fattighuset are high according to the statistical interval for this kind of building in type code 826, and the owner is planning for a new restoration. If the building permit for alteration and/or transformation is handed in when the new BBR has come into force, there will be a demand for an energy use of 110 kWh/m^2 and per year with an addition of 20 % up to 132 kWh/m^2 per year. This will be very difficult to obtain in a building like Fattighuset.

The calculated and the measured key figures for Teatern are average and low compared with the statistical interval for this kind of building in type code 826. There are some problems with moisture and draughts but if a new restoration were to be carried out it would probably be possible to reach the demanded 110-132 kWh/m^2 per year.

[61] Hagentoft, Carl-Eric (2002). *Vandrande fukt Strålande värme*. Lund: Studentlitteratur. p. 132.

Corresponding figures for Tyreshill are low and very low compared with the statistical interval for this kind of building in type code 826 but it would still be hard to reach the new demands on energy use in the coming BBR if a new restoration should be carried out. Looking at the indoor climate, Tyreshill is doing well while Fattighuset faces difficulties. The final comment must be that air tightness and control of air humidity and temperatures are crucial to avoid discomfort also in existing buildings.

Measured	key figures				
Object	Calculated heating kWh/m^2 and year	Electricity for running kWh/m^2 and year	Total key figure for energy use kWh/m^2 and year	Boverket type code 826 statistic interval kWh/m^2 and year	Boverket's new demand in BBR kWh/m^2 and year
Fattighuset	176	28	204	144-200	110-132
Teatern	114	8	122	123-185	110-132
Tyreshill	149	8	157	170-208	110-132

Table 3. Measured key figures for the three objects including the statistical interval taken from Boverket's database for buildings of this type, age and use. The coming energy use demanded in BBR when alterations are made in existing buildings is also shown for comparison.

Figures for calculating the CO_2 emissions from the heating and hot tap water are taken from the Swedish Environmental Protection Agency[62]. Fattighuset's energy use consists of district heating and the figure for emission per MWh in national statistics is 90 kg. The district heating in Halmstad uses renewable energy sources to a large extent. For Teatern in Laholm the figure 204.5 kg/MWh is used for natural gas. The wood pellets used in Tyreshill are a 100 % renewable energy source and the emission is carbon dioxide neutral. This means that the amount of CO_2 emitted during combustion is exactly the same amount as the tree got from the atmosphere while growing up. If it had continued growing and then decayed and rotted in the forest it should have emitted exactly the same amount. This is a balanced use of CO_2. Even though Fattighuset has the largest energy use it is Teatern that has the biggest environmental impact as regards greenhouse gas and climate change due to the fossil energy source.

	Fattighuset	Teatern	Tyreshill
Heat energy	186 MWh/year	100.4 MWh/year	35 MWh/year
CO_2 emission	16.74 ton	20.53 ton	0

Table 4. Carbon dioxide emissions from the heating and hot tap water.

[62] The emission factors are available at: http://www.naturvardsverket.se/sv/Start/Klimat/Utslappsminskning/Berakna-utslapp/Emissionsfaktorer-koldioxid/.

III.IV ASSESSMENT OF HISTORIC AND CULTURAL VALUES

When the evaluation of preserved historic values in the restored objects in a hermeneutic sense was performed, the Swedish National Heritage Board's handbook[63] for assessment, and their book on guidance[64] for good building conservation were used to avoid arbitrary/subjective evaluation. The two books have been in use for more than a decade in conservation courses at universities in Sweden. These books are hereinafter referred to as the Handbook and the Guide. Data for analysis was collected from archive files, reports, documents and photos, from the physical artefacts in situ and from interviews with people engaged in conservation work. In situ valuation was performed by the investigator and an antiquarian of built environment to enhance the construct validity by using multiple sources of evidence. Basic and reinforcing motives were registered and compared with archive material on earlier inventories.

The assessment of the buildings' cultural and historical values is based on a division of basic motives for identification, and reinforcing and overall motives for the processing of the values according to the National Heritage Board's (NHB from now on) Handbook. From these an evaluation and balanced motivation can be defined. The basic motives are structured into document values and experienced values. This division clarifies and facilitates the understanding and assessment, and makes it more communicable.

The document values are based on historical knowledge and are in that sense perceived as impartial or objective but are still dependent on the assessor's knowledge and professional orientation. The experienced values are aesthetic and socially engaging properties and have special demands e.g. to be discussed with others or assessed by more than one analyst.

The motives and values are presented in a table for use as a checklist in the Handbook, for evaluation in three steps, linked with two steps for choice of level of preservation and follow-up. The two latter steps are not shown in the table below as they are not topical here in the study.

The patina appears as document value as well as experienced value because of its properties of documenting traces of the past while at the same time it mediates a sense of time and aging, often as an aesthetic dimension. Almost all the motives are described in the Handbook with details and examples, along with how they usually are, or can be, connected to each other. How, in what way, they can be reinforced in the processing and analysis of data in the next step is also clearly articulated. On architectonic value and artistic value some notions like design and proportions are mentioned, and are related to history or historical architects, but there is nothing on the analysis. From an architectural point of view this was a deficiency found during the work.

[63] Unnerbäck, Axel (2002). *Kulturhistorisk värdering av bebyggelse*. Stockholm: Riksantikvarieämbetet.
[64] Robertsson, Stig (2002). *Fem pelare – en vägledning för god byggnadsvård*. Stockholm: Riksantikvarieämbetet.

IDENTIFICATION BASIC MOTIVE		PROCESSING REINFORCING / OVERALL MOTIVE		VALUATION BALANCED MOTIVATION
1. Document values (historic properties) • building history value • historical building technology value • patina • architectural historic value • societal historic value • historical social value • historical personage value • techno-historic Value	2.Experience values (aesthetically and socially engaging properties) • architectonic value • artistic value • patina • value for surrounding environment • identity value • continuity value • value of tradition • symbolic value	• Quality • Authenticity, genuineness • Pedagogical value, legibility	• Rareness • Representativeness (national, regional, local)	• MAIN MOTIVE (the dominant basic motive) • ADDITIONAL BASIC MOTIVE • REINFORCING/ OVERALL MOTIVE

Table 5. Translation of the checklist for evaluation in the National Heritage Board's Handbook Kulturhistorisk värdering av bebyggelse by Unnerbäck (2002), for assessment of cultural and historical values, pp 24-25.

NHB's Guide deals with different approaches based on five aspects called pillars. These are knowledge, cautiousness, management, approach to history and, finally, material and technique. It gives good guidance on theory, laws and performance of the practical work but not much on how to estimate architectonic values. The value motives from the Handbook are summarised in the Guide[65] and advice is given that this system should be complemented with other value types when necessary. The architectonic values which were found in the three objects are reported in the next subsection.

To get an overview and comparison of the three objects, a table was made in which the cultural and historic values found are presented. A found document value or experienced value is marked with an X on each object. This is not how it is usually done. Standard procedure is to visit the object, take photos and make notes, write down the first impression, and then go to the archives, and to interview people, to find out what you have missed, and then check again on the site. Finally you compare with another opinion and make the report. In this study though, it helps to break down data to get a clear overview and comparison of the values found.

[65] Robertsson (2002). pp. 48-52.

IDENTIFICATION BASIC MOTIVE							
1. Document Values	FATTIG-HUSET	TEATERN	TYRES-HILL	2. Experienced values	FATTIG-HUSET	TEATERN	TYRES-HILL
building history value	X	X	X	architectonic value			
historical building technology value	X	X	X	artistic value		X	
Patina	X	X	X	patina	X	X	X
architectural historic value	X	X	X	value for surrounding environment	X	X	X
societal historic value	X	X	X	identity value	X	X	
historical social value	X	X	X	continuity value	X	X	X
historical personage value				value of tradition	X	X	
techno-historic value		X		symbolic value	X	X	

Table 6. The basic motives divided into document values and experienced values according to NHB's Handbook. Each motive found in one of the three objects is marked with an X.

At a quick glance it seems as if Teatern is somewhat more valuable, or has more values, due to its extra document value and experienced value compared with Fattighuset. Both Fattighuset and Teatern own higher properties of experienced values than Tyreshill. The table above does not give a clue as to what the document or experienced values really are for someone who has not visited the objects, read about them or seen pictures of them. This is the basic assessment and according to the Handbook next step is to process and analyse the reinforcing and overall motives.

PROCESSING	
REINFORCING MOTIVE	OVERALL MOTIVE
Quality – high, medium or low	Rareness
Authenticity, genuineness – high, medium or low	Representativeness (national, regional, local)
Pedagogical value, legibility – high, medium or low	

Table 7. These motives for processing are colour coded for use in table 8 below. The notions high, medium and low for graded valuation are added here but are not found in the NHB's Handbook.

The reinforcing motives are quality, authenticity and genuineness, pedagogical value and legibility. The overall motives are rareness and representativeness on national, regional and local levels. Everything has a quality, be it high, low or even bad quality. The three objects must have some good qualities otherwise they would not have been restored with public funding.

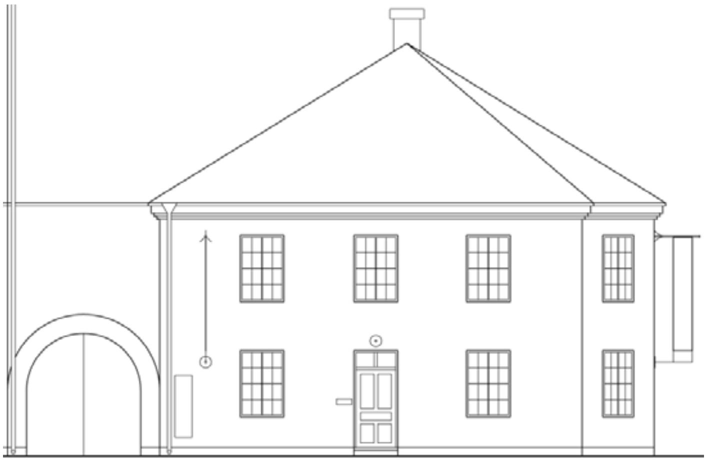
To sort out the quality issue, three levels, high, medium and low were added. The same was done to the other reinforcing motives. This made it possible to decide which reinforcing motive was dominant and hence to choose. This was necessary while one value actually can be both legible and rare with a high degree of authenticity. This gives a more complex picture of the historic values. In the table above, the reinforced and overall motives have been given different colours to identify them. The found motives/colours have been added to table 8 below, showing basic motives.

IDENTIFICATION BASIC MOTIVE							
1. Document Values	FATTIG-HUSET	TEATERN	TYRES-HILL	2. Experienced Values	FATTIG-HUSET	TEATERN	TYRES-HILL
building history value	X high	X high	X medium	architectonic value			
historical building technology value	X high	X high	X medium	artistic value		X high	
Patina	X high	X high	X low	Patina	X high	X high	X medium
architectural historic value	X medium	X medium	X medium	value for surrounding environment	X high	X high	X medium
societal historic value	X regional local	X local	X local	identity value	X high	X high	
historical social value	X	X local	X medium	continuity value	X high	X high	X medium
historical personage value				value of tradition	X high	X high	
techno-historic value		X medium		symbolic value	X high	X high	

Table 8. The basic motives according to NHB's Handbook. Motives found in the three objects are marked with X's. The colours and text illustrate the added reinforcing or overall motives listed in table 7.

Even though table 8 gives a more complex picture it still does not give an evaluation of the objects. To understand the table, at least a description of the objects is needed. The specific cultural and historic values and motives listed in the table have been applied in the following texts - making these summaries of the reports on the three objects shorter - and showing more distinctly the main values and motives.

FATTIGHUSET



1

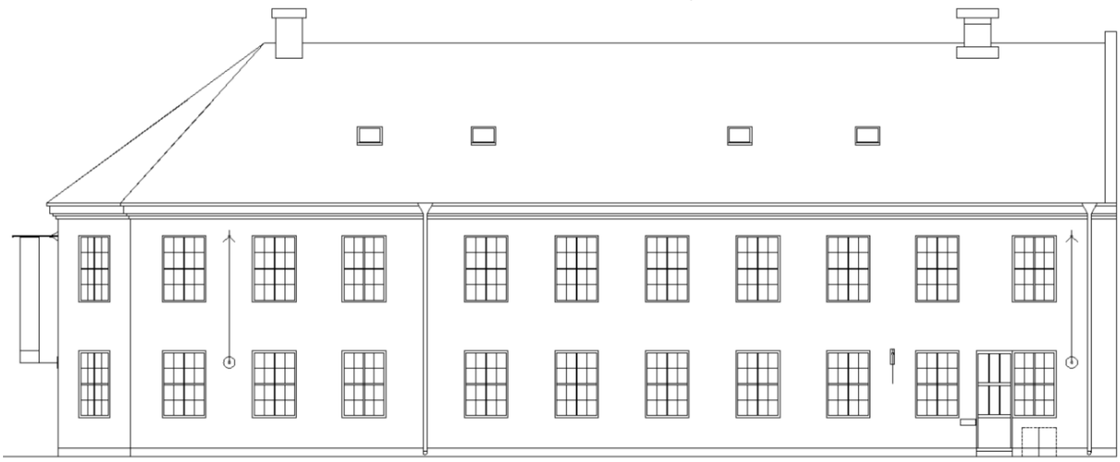
Drawing 1. North façade, Lilla Torg.

2

Drawing 2. North façade, courtyard.

3

Drawing 3. East façade, courtyard.



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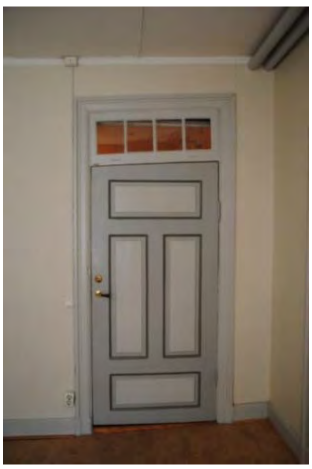
Drawing 4. West façade, Köpmansgatan. All drawings are from Industristaden AB. Scale 1:250.

FATTIGHUSET, Drottning Kristina 2, in the municipality of Halmstad
The basic motives are the two buildings' high degree of well preserved historic values in both construction and technology and patina, both in document value and experienced value, reinforced by a high level of authenticity. Fattighuset is a corner house by a square in the old town. The brick construction is typical for the 19th century, being built in 1859 and 1879, but without the lime-plaster which would have been used on the exterior if the residents had been of higher social rank or status. It was built as, and served as a poorhouse for over 40 years. As such it has a very high value for society and social history representing the changes due to the emergence of and breakthrough for liberal politics in Sweden during the 19th century. In 1847 Sweden had its first complete law for poor people stating that every parish and town should take care of those who lacked the ability to provide for themselves. Buildings of this type of construction for this specific purpose, in the middle of the city and so well preserved, are rare on both local and regional levels. The drawings for Fattighuset are by Hans Strömberg, head architect in the city of Gothenburg at the time.

When the fire brigade moved in 1903 a hose-tower was built up from Sven Gratz drawings. The original plan is almost fully preserved. In the exterior as well as the interior, many old doors, windows, stairs, floor and roof cornices and more of old date with patina, have been preserved. In this way the physical and experienced authenticity is high both in details and in the whole.



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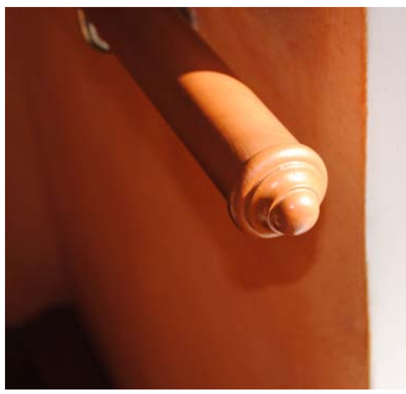

14

Photo 13. A door in Fattighuset that has been adjusted to fit in the doorway. Photo 14. Detail on the woodwork. Photos Maja Lindman.

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16

Photo 15. Original woodwork and painting in the staircase. Photo 16. A close up of the painting. Photos Maja Lindman.

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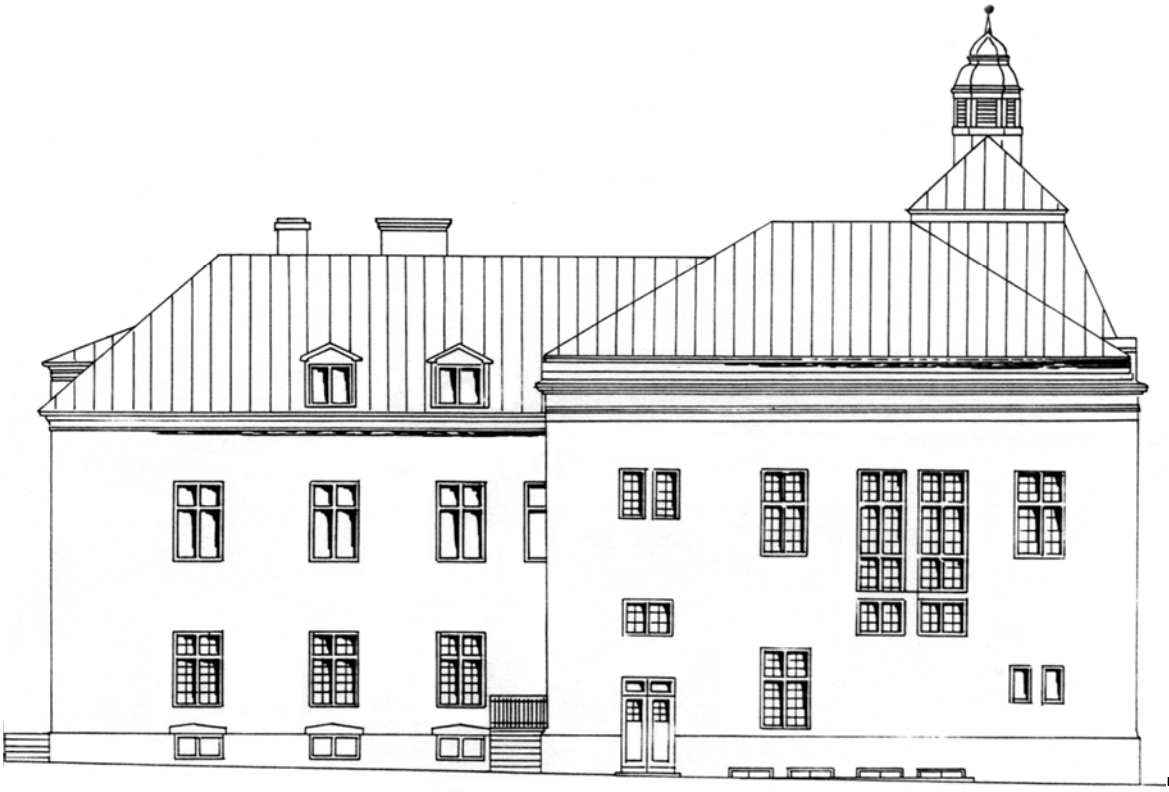
18

Photo 17. The gymnasium is now used as a conference room. Photo 18. The door to the second staircase on the east façade. Photos Maja Lindman.

The identity value and symbolic value are legible with high pedagogic value situated on the corner and with the clearly visible tower linked to it. Local organisations have used the buildings before the restoration in 1997 and the museum for local sportsmen is still a tenant. The use of the buildings for societal care, responsibilities and activities has been ongoing, which gives it high value of tradition and continuity value. Together with the other old, characteristic buildings they form a varied and specific architecture on the south side of the square, and constitute an inalienable part of the surrounding environment.


5

Drawing 5. West façade, Teatern.


6

Drawing 6. North façade, Teatern.

7

Drawing 7. North façade, Teatern.

8

Drawing 8. East façade, Teatern. All drawings are from the municipality of Laholm. Scale 1:250.

TEATERN, Laxen 5-8, in the municipality of Laholm
The only object of the three with techno-historic value is Teatern. The stage with its machinery for scenography and curtains and hoist system for the ceilings' chandeliers in the theatre's auditorium has a reinforced system of joists. A steel construction supports the wooden one and can be seen together with the machinery in the attic.


19

Photo 19. Teaterns vaulted ceiling and balcony from below. Photo Maja Lindman.


20

Photo 20. Teaterns vaulted ceiling as seen at the attic showing the wooden construction and steel construction and the added insulation. Photo Maja Lindman.

Head architect in the city of Kristianstad, Per Lennart Håkansson, made the drawings for Teatern and it was built in 1913 with a neoclassical exterior façade but with an interior in art nouveau style. It is a solid brick construction with a plastered façade which was altered when it was refurbished in the 1950s. Exterior cornices and mouldings were demolished to get a smooth façade without decorations, more in keeping with the ideal style of the time. In 1995 only the interior was restored to its former grandeur. Nevertheless the theatre has a high quality of construction and building technology values. Gold decorated cornices and balcony balustrade with great patina and artistic value were uncovered when the plasterboards were removed in 1995. The preserved parts have a patina that is highly authentic, as is the experienced patina.

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Photos 21 and 22. Decorations from the foyer, and framing of the scene at Teatern. Photo Maja Lindman.


23


24

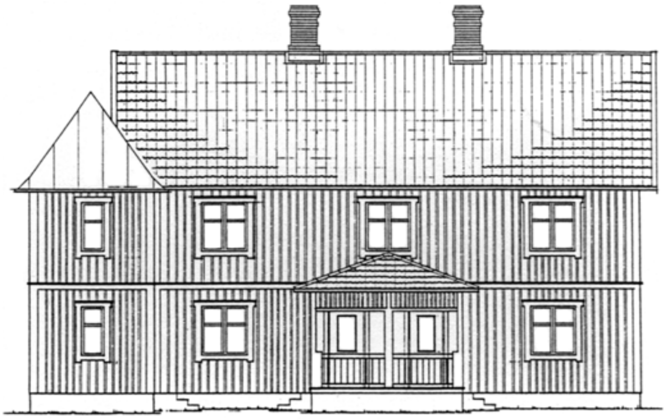
Photo 23 and 24.Original lamps in Teatern. Photo Maja Lindman.


25

Photo 25.Modern equipment mounted in the old theatre. Photo Heidi Norrström.

Laholm is the oldest town in Halland and was never an industrial community with characteristics of that kind. People have had occupations as landowners and burghers, merchants and farmers or fishermen, and most initiatives have been private, like the theatre was. It is situated in the medieval town at Hästtorget, the place for the cattle and horse market, and is originally an extension of the hotel. The theatre’s value for society and social history is representative for a small rural market town. Teatern has a distinct identity value with its three big vaulted windows looking down onto the square and with its ridge turret on the top of the roof, and is a clear and genuine bearer of the town’s tradition. It also has genuineness as a symbolic value. It is an important part of the town’s growth and continuity and with its legibility it contributes highly with its value to the surrounding environment.

TYRESHILL



9

Drawing 9. Southeast façade, Tyreshill.

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Drawing 10. Southwest façade, Tyreshill.

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Drawing 11. Northwest façade, Tyreshill.

12

Drawing 12. Northeast façade, Tyreshill. All drawings are from architect Håkan Larne. Scale 1:250.

TYRESHILL, Rydö 3:20, Rydöbruk, in the municipality of Hylte
Tyreshill was constructed in 1907 as a private house by Per Olsson, who has the same surname as the owner of the new paper mill built at that time. Tyreshill was named after Per Olsson's daughter Tyra, born in 1906. The Olsson family moved to Göteborg in 1916. Tyreshill was sold and altered for housing three families. In 1949 it was altered again for five families.

Tyreshill has great historic value for the community of Rydöbruk, as one of the very first buildings in the young industrial community. It is a typical log house with exterior red painted wood panelling and white corners. Most of the exterior is original despite the house's overall poor condition before the restoration. The staircase shaped like a tower is the most prominent feature of the building's exterior along with the porch. Exterior doors have been preserved as blind doors to show the building's history and function, as home to several working families. Only one family resides there today.

Much of the building's structure and interior woodwork had to be remanufactured with the old woodwork as a model at the restoration in 1998. People experience great authenticity in the building today because of this skilled work although there is not so much of the patina left in the interior. The construction and building technology's historic values are determined by this. The planning is preserved to some part and is still legible, and the two chimneys are original.

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Photo 26. Tyreshill with the porch, tower and shed. Photo 27. The entrance door to the flat on first floor is in the tower on the back side.

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29

Photo 28. The south west façade of Tyreshill. Photo 29. Part of the court yard setting with the shed and root cellar.

30

Photo 30. Tyreshill with the bridge to the upper level of the garden. Photos Heidi Norrström.

31

Photo 31. Tyreshill with the porch. The entrance door to the left is a blind door, and the new windows have glazing reminding of the old ones. Photo Heidi Norrström.

The building as a whole interacts nicely with the traditional shed and root cellar, and at the back of the building there is a bridge leading to a terraced garden at an upper level in the terrain. Together they form an authentic courtyard setting which in a pedagogical way shows how working class families lived in the early 1900's. This is part of social history and also contributes value to the surrounding environment. In the illustration of the historical emergence of the industrial community, the building has played an important and early part and it thus has a legible continuity value as well as representativeness for the local community's history.

The evaluation

Summing up the balanced motivation in Fattighuset, the dominant basic motives are: the rareness and representativeness on a regional level of historic value for society and social history, together with the patina and high authenticity in construction and technology, and in details. The rareness and representativeness on a national level has not been examined. The additional basic motives are the legible identity and symbolic values and its constituting an inalienable part of the surrounding environment. All the reinforcing and overall motives are represented.

In the balanced motivation for Teatern the restored interior with its high authenticity and patina in its preserved artistic parts are the first, dominant basic motives. Second is its techno-historic value together with the high quality of construction and technology values. The additional basic motives are its representativeness for the social history and the society of Laholm, carrying continuity and tradition. Its representativeness on a regional level has not been examined. Additional basic motives are legible in its identity and symbolic values, thus contributing to the surrounding environment.

The balanced motivation for Tyreshill consists of its representativeness and local historic value for the community, as Tyreshill is one of its oldest buildings. This is shown in the quality of its typical log construction and technology, and its experienced authentic patina. These are the dominant basic motives. The legible social signs in both the building and courtyard setting contribute to the continuity of the community's history and to the surrounding environment. These are the additional basic values.

III.V ASSESSMENT OF ARCHITECTONIC VALUES

To evaluate or define the architectonic values in the three objects an English publication *Design Review- How CABE evaluates quality in architecture and urban design*[66] has been helpful. An unforeseen issue, resulting in this embedded unit of analysis, turned up during the evaluation of historic values. In accordance with the National Heritage Board's Handbook on how to assess cultural and historic values[67], the architectonic values should be assessed, which is again emphasised in their guidance for building conservation[68] . The two books contain little about what to look for, what the architectonic values are and how to define them. This issue has partly been met by using the British CABE[69] *Design Review.* The *Design Review* is a tried and tested method of promoting good design and is hereinafter referred to as the *Review*. There is no Swedish handbook or guide on how to make an overall assessment of architectonic qualities or values.

Architectural values pertain to style and history which are intimately connected, and architectonics pertains to architecture and to construction/tectonics, but architecture is always part of a larger context and must at the same time work for various human activities. In this simplified sense architecture consists of five main aspects, all of which will in some sense be addressed here.

The first sentence in the *Review's* introduction is 'CABE starts from the belief that architecture affects everyone, every hour of every day.' Further on 'Design is a creative activity, and definitions of quality in design are elusive. […] However, it is possible to distinguish good design from bad design. By good design we mean design that is fit for purpose, sustainable, efficient, coherent, flexible, and responsive to context, good looking and a clear expression of the requirements of the brief. We believe that assessing quality is to a large extent an objective process. […] What matters is quality, not style.'

Usually there are a number of different design approaches which work in response to a given set of circumstances when designing for a new site. All these approaches can be of use when analysing an existing building and its context. In this study only the most basic and common aspects are addressed. The guidance delineated by CABE is used here to avoid a subjective selection of aspects.

The *Review* is designed for assessment of new projects and the guidance set out has some relevance to most projects. The EEPOCH study concerns existing buildings but the *Review* also applies in these cases. Architectural qualities are signs of value as well as physical properties, and when they are considered to be good they are desirable both in planned and in existing buildings. All design can be assessed. Some of the aspects are already determined, are not relevant or hard to translate to

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[66] CABE, the Commission for Architecture and the Built Environment (2006). *Design Review. How CABE evaluates quality in architecture and urban design.* London: CABE.
[67] Unnerbäck (2002).
[68] Robertsson (2002).
[69] From 1999-2011, the Commission for Architecture and the Built Environment, CABE, was the English government's advisor on architecture, urban design and public space. As a public body one of CABE's tasks was to encourage policymakers to create places that work for people and e.g. seek to inspire the public to demand more from their buildings and spaces. From 1 April 2011, CABE is merging with the Design Council. The CABE website is preserved by The National Archives. The permanent archive of the CABE website is to be found at: http://webarchive.nationalarchives.gov.uk/20110118095356/http:/www.cabe.org.uk/.

conditions in existing sites and objects, and have been left out. The word project has been changed to object for coherence with previous subsections in this study. The aspects to consider are also presented in tables, to get an overview and comparison similar to the previous evaluation of historic and cultural values.

When evaluating design the *Review* is discussing the context, the object in its context and the planning of the site. The architecture is addressed in asking what makes a good project. The *Review* contends that through an urban design analysis and a historic analysis, an understanding of the objects' physical context is achieved. These are necessary for a new project but using both is not necessary for existing environments. These complex tasks need a work of their own, and this issue is neither topical nor the aim of this study. The objects' physical contexts and histories are partly mentioned in the previous summarising description. Some aspects of form are suggested in carrying out an urban design analysis – in the *Review* –and are shown in the table 9 below.

Urban structure	– the framework of routes and spaces
Urban grain	– the pattern of blocks, plots and buildings
Landscape	– shape, form, ecology and natural features
Density and mix	– the amount of development and the range of uses
Scale	– height and massing
Appearance	– details and material

Table 9. Suggested aspects of form to be considered in carrying out an urban design analysis according to CABE's Design Review. p 10.

Some objectives of urban design are suggested for the object in its context. These objectives can be considered general and desirable qualities or values to look for in existing environments too.

Character	– a place with its own identity
Continuity and enclosure	– a place where public and private spaces are clearly distinguished
Quality of the public realm	– a place with attractive and successful outdoor areas (that is, areas which are valued by people who use them or pass through them)
Ease of movement	– a place that is easy to get to and move through
Legibility	– a place that has a clear image and is easy to understand
Adaptability	– a place that can change easily
Diversity	– a place with variety and choice

Table 10. Suggested objectives of urban design as per CABE's Design Review. p 11.

The next issue in the *Review* is planning the site, which is not applicable when the site is already planned in existing built environment. The suggested aspects to consider, however, could be perceived as general qualities and values of functions or properties to assess, and some of them are mentioned in the summarising description when applicable.

Movement hierarchy	– people first, cars second
Parking provision	– is it well planned and convenient to use, for pedestrians as well as drivers?
Service access	– is it carefully considered so that it does not cause conflict with other functions and is not visually intrusive? Have refuse storage and collection been dealt with satisfactorily?
Control of vehicle movements	– and service provisions so that they do not cause inconvenience
Sustainable development	– these principals should be integrated into the masterplan as well as individual buildings
Boundary treatment	– does the project occupy the site in a way which makes sense in relation to neighbouring sites? Relationships with the differing site boundary conditions and with adjoining sites
Variety	– design of individual building, by different architects, responding to changes in needs, uses and technologies
Orientation	– does the layout take account of solar orientation so that internal and external spaces benefit? (e.g. daylight reaching into the buildings)
Landscape design	– does the landscape design make sense as a response to the nature of the site and its context? Is it recognised as an integral part?

Table 11. Aspects of site planning to consider as per CABE's Design Review. pp 12-13.

A number of qualities in architecture are mentioned in the *Review*. The main qualities here are Vitruvius' classic ones: commodity, firmness and delight. Many of the aspects of an object which need to be taken into account when evaluating it will touch on all three. If one looks at the antique Vitruvius' ten books[70] one will see that he also ranks health and wholesomeness first, and convenience, durability and avoiding discomfort[71] very high. As an answer to the question on what makes a good project[72] - asked by CABE - fourteen aspects are listed and shown in the table 12 below together with the three main qualities. Do the objects in this study have these qualities in a good sense? If they have this is marked with an X. There has not been any grading of the qualities. The X merely shows if they are there in the context or exterior or interior or not.

[70] Vitruvius (1989). *Om arkitektur. Tio böcker.* Stockholm: Byggförlaget.
[71] Vitruvius (1989). pp. 17, 158.
[72] CABE (2006). pp. 14-15.

Aspects of architecture		Fattighuset	Teatern	Tyreshill
Commodity		–	X	–
Firmness		X	X	X
Delight		X	X	X
Clarity of organisation, from site planning to building planning		X	X	X
Order		X	X	X
Expression and representation		X	X	X
Appropriateness of architectural ambition		X	X	X
Architectural language		X	X	X
Scale		X	X	X
Conformity and contrast		X	X	X
Orientation, prospect and aspect		X	X	X
Detailing and materials		X	X	X
Structure, environmental services and energy use		–	–	X
Flexibility and adaptability		X	–	X
Sustainability	– economically	–	X	X
	– environmentally	–	–	X
	– socially	X	X	X
Inclusive design		X	X	–
Aesthetics		X	X	X

Table 12. Qualities and values that make a good project according to CABE's Design Review. pp 14-15.

At a quick glance it seems as if Tyreshill has rather more good qualities, when counting the Xs. Both Fattighuset and Teatern are lacking environmental sustainability in one sense or another. The table above does not give a clue in what way. It does not give an evaluation of the objects. It could be called a basic evaluation but a description of the objects is needed.

There are suitable scientific methods to make in depth investigations into almost all of these qualities and values. The aim of this study is to carry out a general assessment for comparison of the objects. The different aspects to consider are described briefly in the *Review*. Their importance for the context and the design as a whole is sketched, and key questions are asked which help with understanding. The authors also refer to other of their publications for examples and further guidance.

The aim for processes of design, construction and maintenance is ultimately use. For existing buildings, their attainable future is often determined by the possibility of different uses, which is mentioned in chapter I. One could speak of usability but the notion usability has been adopted in computer science and ergonomics and a theoretical framework has been developed. This has advanced into an ISO standard, 9241-11:1998[73] of usability in the human-computer interface. Morgan Andersson has written a comprehensive review of the notion in his licentiate thesis[74].

[73] International Organization for Standardization (1998). *ISO 9241-11:1998. Guidance on Usability*. Genève: International Organization for Standardization.
[74] Andersson, Morgan (2011). *Användning och användbarhet i särskilda boendeformer för äldre.* Göteborg: Institutionen för Arkitektur, Chalmers Tekniska Högskola. pp. 8-11.

Though usability actually has been investigated in buildings' performance it was focused on the user perspective and how a building's performance affects human activities, and the ISO 9000's series are about quality perspective in organisations' activities and processes.

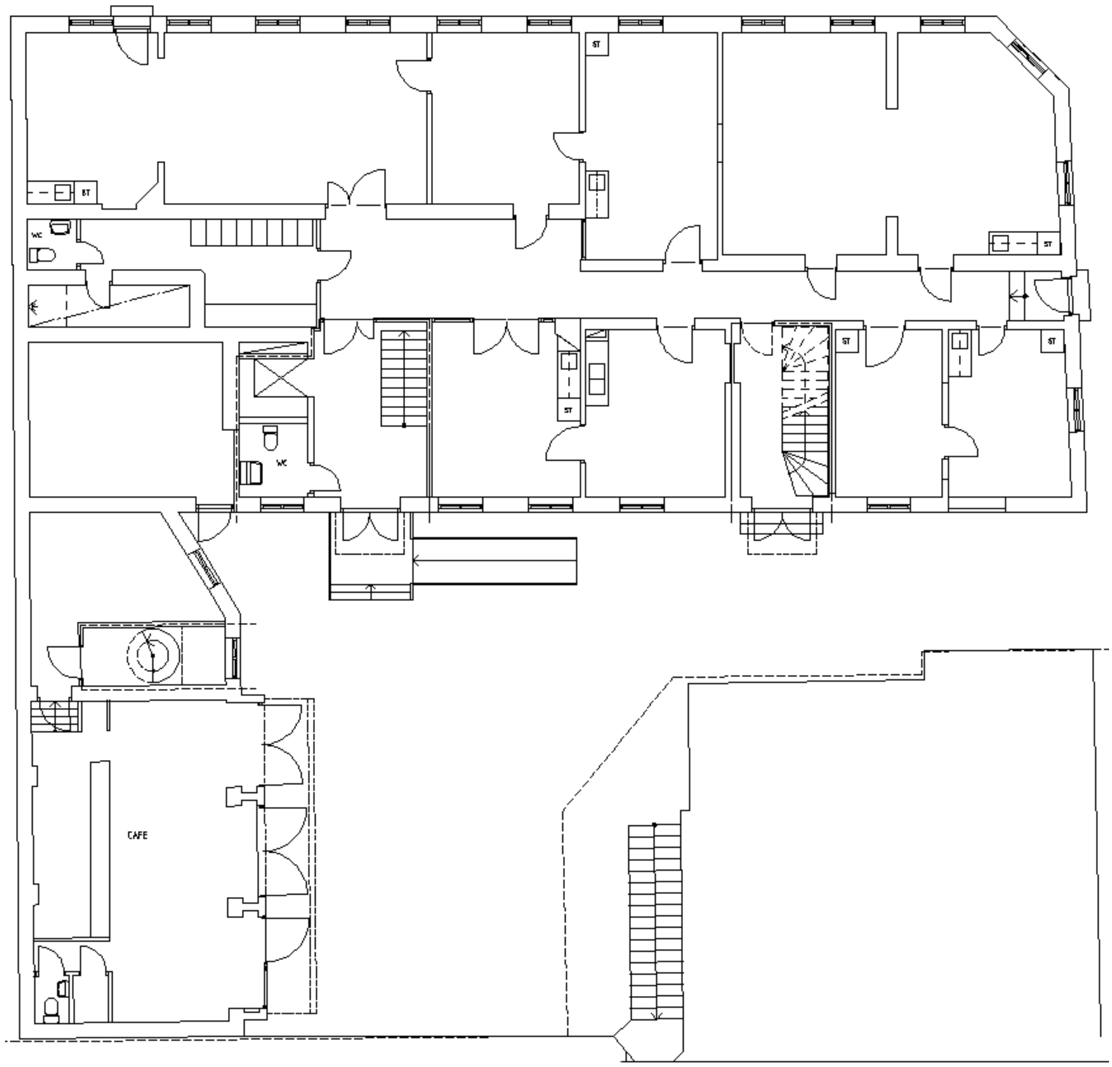
The choice in this multiple case study is to investigate the constructions and structures and the organisation of them, to determine if they are usable for more than one purpose or in multiple ways; simply to evaluate their specificity, adaptability or universality. A building which is designed for a specific purpose and no other activity and which it is not possible to change possesses specificity. A building, whose functions and properties can potentially be changed to meet the demands of new activities, possesses adaptability. A building whose functions and properties can be maintained, and still be used for a variety of activities, possesses universality.[75] With these definitions the aspects of flexibility and adaptability in the list above become less important while a building that possesses specificity can be designed for and also be extraordinary well suited for a certain purpose but lack flexibility to be adapted to other purposes.

Other important qualities are the intangible values of architecture. These values are not easily measured but they were discussed in Workshop III and are mentioned in the subsection on workshops.

In analysing architecture there are two main methods. With a starting point in the interior's details and plan you can gradually work your way out to the façade, the site and the whole context. This is quite a common method when designing new constructions. The other way starts with the context and the processing down to detail. This is the usual way when the site and context have already been defined, as is the case with existing buildings. In reality it is a constant process of interaction and the tool to use for it is the sketch and model which is part of the architect's practical reality.

[75] Ahrbom, Nils (1983). *Arkitektur och samhälle*. Stockholm: Arkitektur Förlag AB. On definition of function. p. 15.

FATTIGHUSET



Drawing 13. Plan, ground floor, Fattighuset. Drawing from Industristaden AB. Scale 1:250.

FATTIGHUSET in the municipality of Halmstad

Halmstad is the county town in Halland by the mouth of the river Nissan, and has about 58 600 inhabitants today. The medieval town centre in Halmstad is defined by the castle in the south, to the east by the river Nissan, by the old town gate Norre Port to the north, and in the west by a road named Karl XI väg. Remnants of ancient fortifications are still legible and can be found in several places, and some have been restored. Within the area there are some 19th and 20th century constructions of three and even five storeys but otherwise the scale height and massing are low. Most parts of the town centre are pedestrianised and car access is allowed at four points for those who live there and others to reach the multi-storey car parks. Public transport by bus has its own access with bus-stop at the main square, Stora Torg.

Fattighuset in Halmstad is well situated in the southwest corner of the old square for the cattle market, Lilla Torg, on the corner of Bankgatan and Köpmansgatan in the medieval town centre with its shops, cafés and restaurants. The square is in the north part of the town centre. Fattighuset dates from the 19th century and was converted into a fire-station in 1903. A hose-tower and a coach-house of brick construction were added to the buildings, and the back wing in the yard became a stable for the horses. The arched portals facing Lilla Torg are opened up towards the square in the summertime. Half of Lilla Torg is occupied by car parking, but the other half is used by the restaurant in the old fire-station for serving their clients in the summer. Opposite Fattighuset, to the west, on the other side of Köpmansgatan is a separate parking lot but there is a wall of trees along the pavement to enclose the street space or street corridor.

32

Photo 32. The south façade of Lilla Torg with Röda Kvarn and the fire station with the hose tower and Fattighuset. Photo Heidi Norrström.

There is no traffic passing through since the town centre is free of cars and the only way for cars to access the square is from the northwest corner. The square is one of four car access nodes and the corner house Fattighuset is right in sight when entering the square. On the square's west side is the old telegraph-station from 1926, designed like a fortress of red brick masonry and an officially listed building protected by law. East of Fattighuset and the old fire-station on the south side of the square is the cinema, Röda Kvarn, which is also officially protected and one of the finest in Sweden, with its Greek temple façade of ionic stone-columns and capitals and gable motif. The façades of Fattighuset are two storeys high with a cornice and are constructed from handmade red-burned brick masonry and lime mortar, on a foundation of granite. The bricks, of second rate quality, make the façades very expressive, with many nuances and great beauty. The wooden windows are placed at intervals in a certain pattern which mirrors the subdivision of the interior plan. An entrance has been placed in the middle of the façade facing north. Two other entrances on the east façade give access to the building from the yard. All three can be used for public access but only one is accessible for disabled people. The dark green doors and windows reinforce the uniformity of the expressive gestalt and together with the red tin roof this emphasises the building's totality. Fattighuset expresses a great and well balanced simplicity. Together with the other buildings it forms a characteristic quality of variety in façades facing north, and as such forms the setting around Lilla Torg and gives it a strong identity. Fattighuset has become an appreciated part of its setting and has aged gracefully.


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Photo 33 and 34. Fattighuset at the corner of Köpmansgatan and Bankgatan. Photo 35 and 36. The portico into the courtyard and the main entrance on the east façade. Photo 37 and 38. The old stable/garage in the courtyard. The bricks, of second rate quality, make the façades very expressive. Photos Heidi Norrström except no. 35 by Maja Lindman.


39

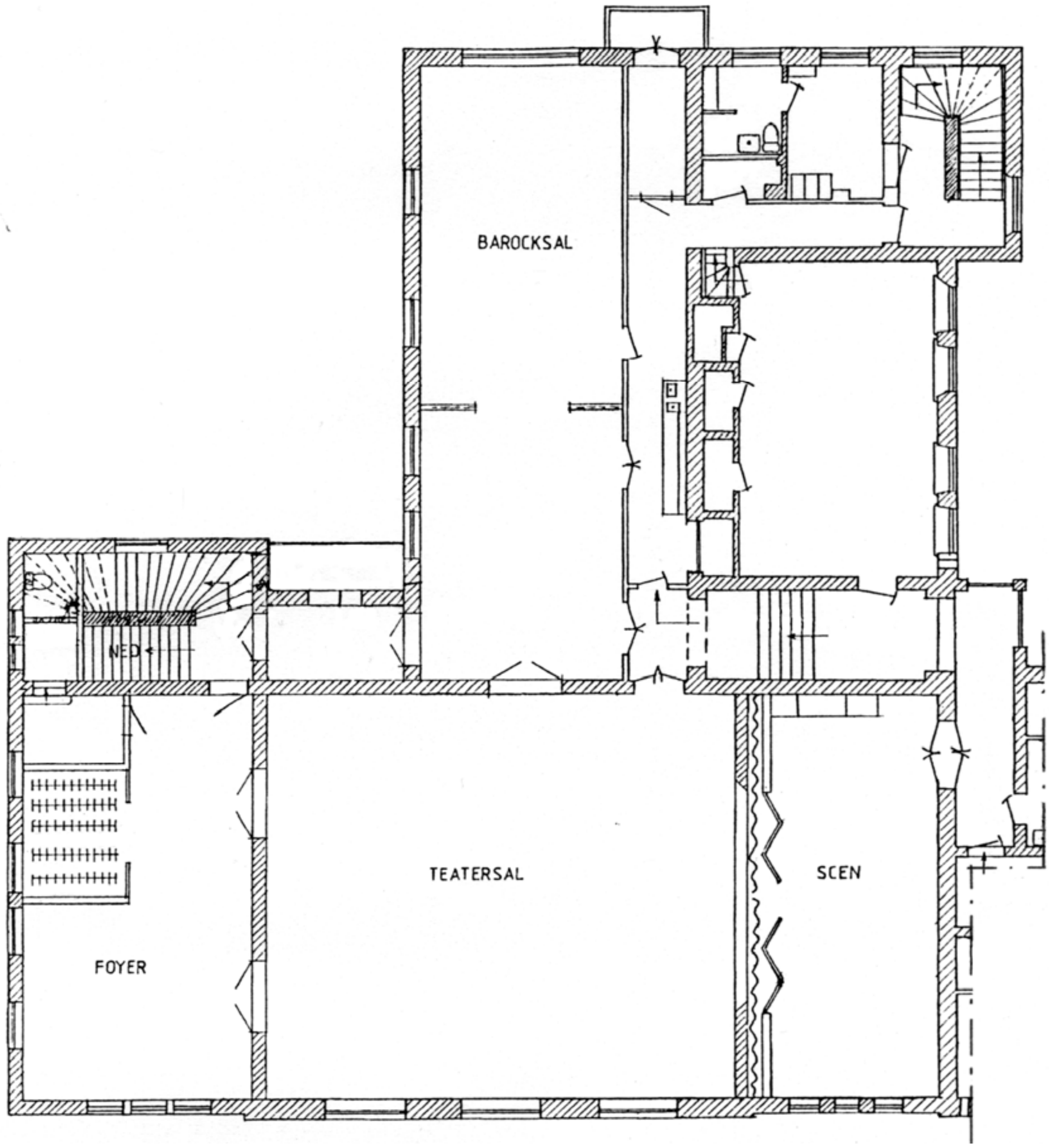
Photo 39. The old window and niche mediate the daylight into the room. Photo Maja Lindman.

The interior plan in the main building in Fattighuset is simple with corridors in the middle, along the roof ridge, and rooms grouped along them. There are two stairwells. The height in the rooms is generous. There is a firewall at the site's boundary towards the south so there are no windows. The only rooms with a varied daylight coming from two crossing directions are the ones on the corner that get daylight from the west and north. Through the solid brick walls, a niche is created at each window, mediating the daylight beautifully into the rooms. The interior woodwork and details are skilfully formed by craftsmen. The buildings' construction, structures and the organisation can be maintained and still be used for various activities, and thereby possesses universality.

The materials in Fattighuset are natural, locally manufactured, enduring and maintainable. There is mechanical exhaust air ventilation but no heat recovery. It is heated by district heating supplied mainly from renewable fuels and thus sustainable. The construction and ventilation, however, are not energy efficient so the consumption is too high with high costs, which implies that the object is not economically sustainable. There are problems with surplus heat in the summertime and with cold air leakage in the wintertime. The indoor environment is thus not good for human activities and hence not environmentally sustainable in this regard. The accessibility of the ground floor and first floor is good since a lift has been installed but only half of the attic floor can be reached. The other half of the attic has access from the other stairwell with no lift.

The fire protection is not satisfactory. In case of fire there are two ways to get out of the building except for the museum and software company on the attic floor which is separated in two fire cells. In case of fire in the stairwell there is no alternative way out from the museum or from the software company's office.

TEATERN



Drawing 14. Plan, first floor. Drawing made by the municipality of Laholm before the restoration. Scale 1:250.

TEATERN in the municipality of Laholm

Laholm is the oldest town in Halland, with a town charter from the early 1200s, and about 6 150 people live there today. The town is situated by the river Lagan on its south bank and surrounded mainly by agricultural land. On the island of Lagaholm are remnants of fortifications. Lagan is meandering as rivers do when reaching the lowlands and sea, and it partly encloses the medieval town centre to the north and west in a wide meandering form. The old city centre is called Gamleby and has a legible medieval street grid with cobblestone streets. The scale, height and massing is low and the buildings are set along narrow streets with gardens in the centre of the small blocks. The shops and other services are mainly to be found around the small squares. There is car access everywhere however sometimes only one-way.

Teatern is placed at the north part of Hästtorget, the old place for the horse market. The light grey plaster façade has no decorations since cornices and mouldings were removed when it was refurbished in the 1950s. Originally it was an extension to the hotel and was designed to harmonise the hotel's façade. The auditorium in Teatern has three big windows facing south and overlooking Hästtorget. It has a ridge turret on top of its tin roof and this distinguishes it from the other buildings around the square. On the west façade the high windows show where the stairs are and the smallest windows where the facilities like bathrooms are. Showing the building’s different functions in the façade is quite a modern design.


40

Photo 40. Hästtorget in Laholm, view to the west. Teatern is to the right.


41


42

Photo 41 and 42. Hästtorget with the fountin, and the west and south façade of Teatern. Photos Heidi Norrström.

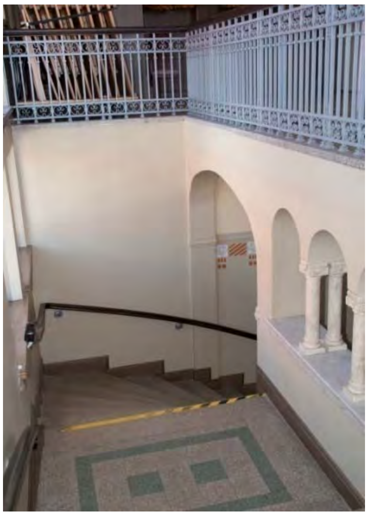
In the east part of the square is a sculptured fountain, but rest of it is used for car parking. On the south side are offices, a restaurant and a shop, and the cinema’s façade has no windows. The west side is dominated by an old house where the district doctor lived and practised. Today it is an office. Next to Teatern is the Museum of Drawings, the only museum in Scandinavia dedicated to the art of drawing, which consists partly of the old fire station and partly of a newly built extension. Most of the buildings have plastered or brick façades and represent the 19th and 20th century, in a nice and diverse mix of style and material.

Teatern was erected in 1913 and on the ground floor is a shop, originally a liquor store. The theatre is on the first floor with a balcony up on a second floor. The entrance door is placed by the side of the shop, yet with a welcoming sign above the vaulted portico, and around the corner is a door for access to a lift. The stairs and foyer are not excessively grand but tell you that you are entering a special place for festivity which is just what you expect.

43

44

Photo 43 and 44. The entrance door and the stairs leading up to the foyer of the theatre. Photo Heidi Norrström and Eva Gustafsson.



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46

Photo 45 and 46. The stairs and the theatre in Laholm. Photos Maja Lindman and Heidi Norrström.

47

Photo 47. Barocken. Photo Maja Lindman.

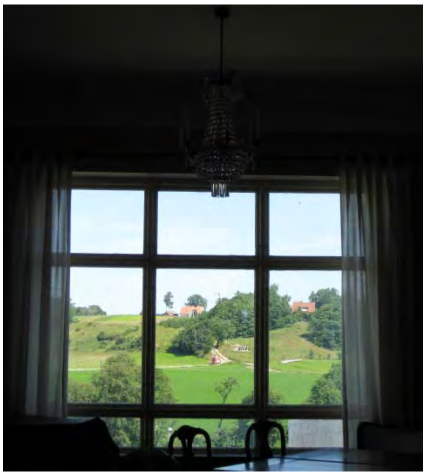

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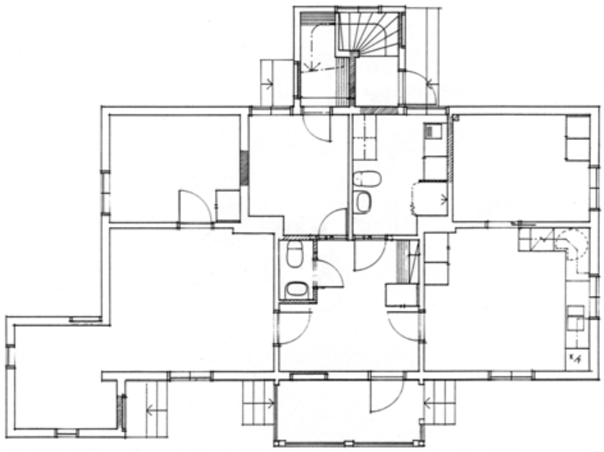
Photo 48 and 49. The view from Barocken towards the north bank of Lagan. Photos Heidi Norrström and Maja Lindman.

The golden decorations in the interior of the theatre raise the expectation of something spectacular waiting. In the interval of a concert or play, refreshments are served in Barocken with its big window, which offers a beautiful view of the river Lagan and its sloping north bank. Teatern is a place built for and working for festivity and hence possesses specificity. No one is excluded while disabled people can use the lift but it does not go all the way up to the balcony. Since the restoration in 1995 the theatre has become an appreciated part of the town's social life, and the New Year chorus show has got a stage.

The construction has solid brick walls and the materials are natural, locally manufactured, enduring and maintainable, but there are some moisture problems with the walls. Insulation has been added in the attic and the air handling system has heat recovery but the heating source is natural gas so it cannot be perceived as sustainable from this perspective.

TYRESHILL



Drawing 15. Plan, ground floor, Tyreshill. Drawing made by architect Håkan Larne. Scale 1:250.

TYRESHILL, Rydöbruk, in the municipality of Hylte
Rydöbruk is a very small industrial town on the border between the provinces Småland and Halland. It expanded at the beginning of 1900 but there is no big industry left, and about 400 people live there today. It is situated on the west edge of the southern Swedish highlands and the landscape is characterised as a high plateau with vast coniferous woods, bogs, wetlands and lakes. Valleys with rivers run through the landscape, like the river Nissan where Rydöbruk was established. Right here the landscape is hillier. Unlike the other municipalities in Halland there is not much agricultural land. Rydöbruk has grown as a typical industrial town at a river making use of hydropower. The small town has expanded in an east-west direction along the Nissan, the railroad and the old Nissastigen route. The industrial area is in the south on both sides of the river and the main residential area is north of the railway up against the hills. The scale, height and massing is low with detached houses in gardens and narrow streets. There is not much traffic and no services like shops.

One arrives at Tyreshill from the old Nissastigen route by moving up along the slope of Bergs väg. A welcoming porch on the south side greets the visitor. To the left is a typical shed and a root cellar and around the corner, on the north side, is a small bridge from the main building's first floor to a terrace garden at an upper level, and all this is part of the court yard setting. The different ground levels at the site are part of the experienced architectural value.

50

Photo 50. Tyreshill entrance façade, south east.

 51  52  53

Photos 51, 52 and 53. The porch, the bridge and the north east gable façade of Tyreshill.

The main building is a two storey solid log construction with red painted wood panelled façades with white corners, windows and woodwork. Decorative woodwork is typical for traditional, common Swedish wooden constructions where the details are important, defining the heterogeneous style. Traditional red burned tiles cover the roofs. The materials are natural, locally manufactured, enduring and maintainable.

 54  55

Photos 54 and 55. The bridge and the wooden patio on the higher level of the estate Tyreshill.
Photos Heidi Norrström.

Tyreshill is one of the oldest buildings in Rydöbruk and was built in 1907. The original floors are divided into six different rooms like a traditional big detached residence in the late 19th and early 20th century, but with the three bigger rooms placed along the entrance façade, facing south, due to the darker, north hillside. The rooms on the gables receive a varied daylight coming from two crossing directions.

Tyreshill was sold and converted to house three families in 1916 and it is likely that one of the most prominent features of the south façade, the tower, was altered into a staircase at that time. Tyreshill was altered again in 1949. The subdivision of the interior plan was transformed and the attic was used, to house five families. There is an extension for a staircase at the north façade as well.


56


57

Photos 56 and 57. The windows are produced to have the same appearance as the old ones, and the inner pane has low emission coating. Photo Heidi Norrström.

The interior is commodious and the spatial relations can be altered and still have a good spatiality and be used for various activities. Today one family resides there and has a ceramic workshop and atelier in the building. With this structure and organisation of Tyreshill, it possesses adaptability. A disadvantage, however, is that neither the site nor the building provides accessibility for disabled people. Hence it cannot be said to have commodity and it has no inclusive design. There is natural ventilation with small fans for mechanical exhaust air in the kitchen and bathrooms. Insulation has been added in the attic and on the interior side of the construction, and the inner window panes have low emission glass. The indoor climate is good and the heating is provided by wood pellets, a renewable energy source and thus sustainable.


58

Photo 58. A wood stove in an old style makes use of one of the original chimneys. Photo Heidi Norrström.

III.VI THE INTERVIEWS

Discussions, interviews and conversations have been used for several purposes in this study. At the beginning of the work three conversations with antiquarians of built heritage were recorded in written notes which were then transcribed. They had all been involved in several projects within the Halland Model. The informants read the transcript afterwards looking for errors and for approval of the content. It is a very simple but effective method. This was carried through to get oriented on a) their experience of the Halland Model and b) their assessment or judgment of the actual results of the restoration work. The respondents were well aware of these issues and of the reason for asking the questions. All three had good experience from their work and participation in the Halland Model. They were also positive about the outcome in the buildings and about the craftsmen's work.

Two of the towers at Grimeton Radio Transmitter station were one of the 'big Halland restorations' carried out within this framework over a period of about ten years. The Grimeton station is now on UNESCO's World Heritage List. Today this kind of work is not financially possible. One thing mentioned about the Halland Model was that it worked very well for big projects but minor projects did not fit equally well. The most specific or unusual factor was that the antiquarians had been involved from the start and selected the objects and formulated the restoration actions. One could almost say that the conservation perspective was dominant, and they were always at the construction meetings. Not so today. The craftsmen's performance was generally high, in large part due to the supervisors who never chose a shortcut. All construction workers and craftsmen were involved. A kind of community was created. People were talking about it and it lifted the entire cultural historic building sector. Some started businesses of their own and some went to Da Capo[76] to acquire further education and knowledge about the preservation of built heritage. In the round the Halland Model was good and important according to the informants and no one had any suggestions about what could have been performed differently.

The second occasion on which conversation and discussion was used as a method, was when an inventory of laws and regulations was made, as reported in paper no. 2. Interviews and conversation were used as a complementary method alongside reading of law and regulation, mandatory provisions and general recommendations. Questions were asked of and answered by a civil servant and five municipal officials. The questions were written but not readable for the informants. In this way it was possible to make instant decisions on which complementary questions to use for follow up and to finish with. The work included three meetings and three phone calls during which short notes were taken and then transcribed, but the informants did not read these afterwards. The questions concerned which legal documents they were actually using and how they were interpreted for use in building permit matters concerning reconstruction, other alteration and extension.

The general opinion was that there are too many legal documents. In the municipalities there was a desire for clearer and simpler legislation. The reality showed the need for Boverket's decision on a new law, regulation and mandatory provisions. The new mandatory provisions have stringent requirements on energy use and causes concerns for lost heritage values. This is reported under a separate subheading.

When focusing on longer or deeper interviews the performance of analysis is crucial. Different models were considered for use. According to Nollaig Frost[77], the Labov model could help with structuring stories and their elements in the transcriptions, with Gees' model for stanzas. This qualitative research method is considered to be especially useful for findings on organisational dynamics which made it very interesting. Frost also mentions the importance of using reflexive awareness to reveal the influence of the author's 'presence and intervention on the informant'.

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[76] Da Capo is the School of Crafts at the Department of Conservation, University of Gothenburg. The programme for construction craftsmanship is in Mariestad.

[77] Frost, Nollaig (2009). *'Do you know what I mean?: the use of a pluralistic narrative analysis approach in the interpretation of an interview', Qualitative Research 2009;9 by Birkbeck.* London: University of London.

When reading Birger Sevaldson's[78] paper, grounded theory seemed to be the most appropriate method while the aim was to generate theories. Sevaldson made a good reflection 'Though Grounded Theory is criticised for its categorization, and because of its belief in disregarding preconceived perspectives when approaching a new field of research, it nevertheless shows a systematic way of building theory from within a practice.' The method includes both induction, to formulate hypotheses from specific data, and deduction, to draw specific conclusions from hypotheses. Usually it requires a large amount of data to finish such a study because you cannot stop until there are enough facts to be sure, and hence it is also a time consuming method and therefore could not be chosen within the framework of this thesis. Instead the traditional methods described by Russel Bernard[79] were used. The first interview was carried out as an unstructured one where the informant could speak freely without much interruption. It was sound recorded and notes were taken. This method gave a very wide picture and this interview formed the basis for the other interviews. These could be more structured and much shorter, verifying facts from the first interview but also adding some perspectives.

Finding out how people with different occupations managed to agree on actions required interviews. Through these the roles, methods and organisation would be determined. The interviews were analysed within a discourse where energy counsellors are usually considered insensitive and conservation officers are usually considered conservative. As it was the working climate in the groups and teams that was to be explored to reveal any methods and processes which could be connected to and have had an effect on the outcome of the restorations, the analysis focused on management and leadership. Three books[80] [81] [82]on leadership, management and teamwork provided guidance during the transcript analysis. This was an inductive attempt to generate a hypothesis. The results were reported in paper no. 3.

In brief, the interviews showed that the horizontal regional cooperation which is the common model in use today was developed with the concept of the Halland Model and was also transferred into the teams at the construction site. A strategy for managing the different teams working within the Halland Model was to choose dynamic and transformational leadership of a democratic type to create exclusive inclusiveness. A key action taken by the managers was making everybody in the projects on all levels be involved. Keeping the teams task-oriented helped in managing the differences between professional cultures. The priority was the quality of the work; in performance, materials and in details. Personal initiatives were invited for even further improvement. Introducing the vision or main idea was part of the apprentices' education. This included the importance of their work for the overall achievement. A kind of inclusive management was adopted to encourage the participants to share responsibilities. This required a transparent organisation which also created a good working climate. A horizontal organisation within the work was a strategy designed to create good communication within the teams. Altogether this resulted in efficient and responsible performance which was mirrored in the preservation work. The four informants mentioned that the

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[78] Sevaldson, Birger (2008). *Rich Design Space. Vol.1, Nr1,* Oslo: FORMakademisk. pp. 28-44.
[79] Bernard, Russel H. (2006). *Research Methods in Anthropology: qualitative and quantitative approaches*. Oxford: Alta Mira Press.
[80] Larsen, Rolf-Petter (2003). *Teamutveckling*. Lund: Studentlitteratur.
[81] Larson, Gerry och Kallenberg, Kjell (eds.) (2006). *Direkt ledarskap*. Stockholm: Försvarsmakten.
[82] Maltén, Arne (1998). *Kommunikation och konflikthantering en introduktion.* Lund: Studentlitteratur.

teams always tried to reach consensus and that the antiquarians' position always was respected. This is shown in the evaluation of the three objects chosen for this study but the one where deeper discussions took place during the work was also the one showing the most balanced result regarding energy efficiency and preservation.

III.VII REVIEW OF LAWS AND REGULATIONS

During the first workshop when the framework for this study was set, some questions came up regarding what kind of energy measures it is possible to perform in an old building, in practice and from a legal perspective. The discussion had the first surveyed object, Fattighuset, as a starting point. The owners were planning a refurbishment. This resulted in an inventory of laws and regulations and of a proposal on new mandatory provisions. This was made as an embedded unit of analysis. Opportunities and requirements for energy efficiency and for the preservation of historic values were examined by reading, and showing that concerns for lost heritage values were justified. Interviews were used as a complementary method. The results were reported in paper no. 2 which discusses the effects of the current proposal and answers the question of whether or not the new demands can be fulfilled. The interviews concerned which laws and regulations, mandatory provisions and general recommendations the municipal officials used. Questions were also asked about how they used them in reviewing building permits for alterations in existing buildings in their every day practice.

What did these steering documents imply for built heritage with regard to preservation and energy efficiency, and how where they interpreted? According to the interviews the general opinion was that there were too many legal documents and that some documents were not used at all. The general recommendations concerning built heritage, BÄR, did not come into use in practice. This was mainly because they were not mandatory and did not apply in a legal context, and hence there was no point in referring to them in case there should be a legal dispute. In the municipalities there was a desire for clearer and simpler legislation. Their reality showed the need for Boverket's decision on new law, regulation and mandatory provisions. On the 2nd of May 2011 a new law, PBL[83] and regulation PBF,[84] came into force and old ones were repealed on that date including BVL and BVF. The new law and regulation includes almost all of the content in the old ones.

[83] Boverket (2011a). Regelsamling för hushållning, planering och byggande. *SFS 2010: 900, Plan- och bygglag PBL.* Karlskrona: Boverket.
[84] Boverket (2011a). Regelsamling för hushållning, planering och byggande. *SFS 2011:338, Plan- och byggförordning PBF.* Karlskrona: Boverket.

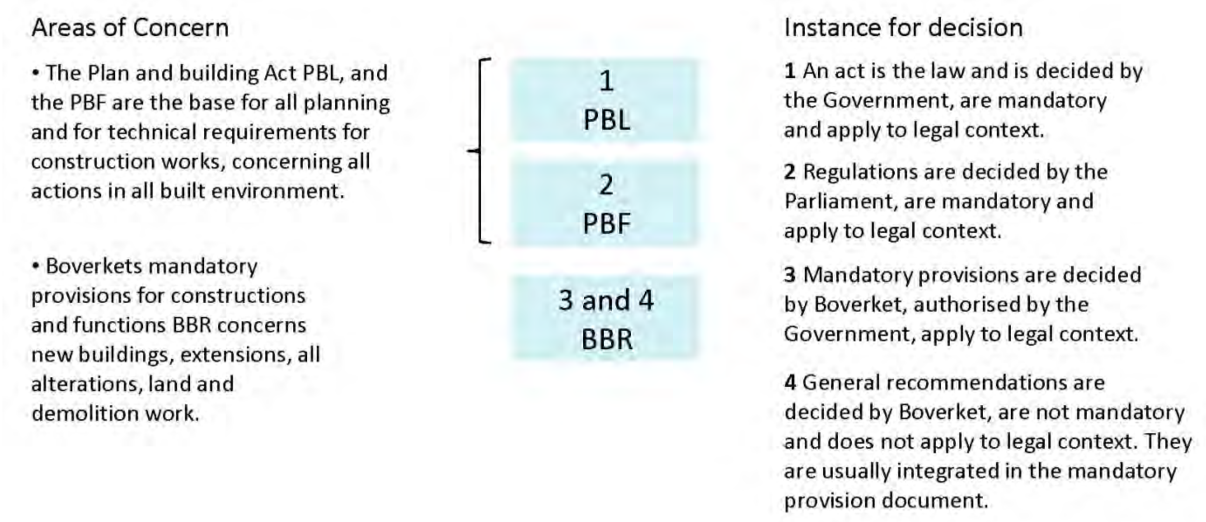

Figure 6. Hierarchical scheme on the new basic legal documents concerning energy efficiency and preservation demands in our built environment.

The new scheme concerning legal documents is showed here in Figure 6. The old general recommendations BÄR have now been integrated in the new BBR[85] proposal on mandatory provisions for higher status in a legal context. It has been sent to the EU level for approval and will come into force in the autumn 2011. The demand for cautiousness and preservation is hereby reinforced but not much easier to interpret than before. Simultaneously the energy efficiency demand will be very much higher and the demands are clear with specific key figures and U-values to fulfil when carrying out alterations in existing buildings.

There is an incommensurability mirrored in the new BBR mandatory provisions. When in theory comparing the studied objects with what is stated, it shows that the demands in BBR could be very hard to reach. If the demands on energy use are to be fulfilled then measures have to be taken that will severely damage the historic values and the time layers. The PBL's and BBR's requirement for caution would not be reached. On the other hand if historic values are preserved and no energy measures are carried out then the demands would not be reached either.

III.VIII THE WORKSHOPS

For further input and to root the case in approved practice and theory, a reference group, an expert group, and local companies were connected to the project. They participated in workshops, provided facts, and contributed with expertise, experience and advice. In these sessions solutions were discussed and suggested, and criteria for interpreting the data were developed. Thus the criteria are representative of the opinions of experts in the field. In this way EEPOCH includes both interdisciplinarity and transdisciplinarity.

[85] Boverket (2011b). *BFS 2011:6. Boverkets byggregler BBR*. Karlskrona: Boverket.

In this thesis the term transdisciplinarity is used as in the 'Handbook of Transdisciplinary Research' in sense of '[…] views of the transformation of science involving the transgression of disciplinary boundaries in addressing issues in the life-world in research'[86]. The view includes working jointly with practitioners solving real-world problems. Architecture has been boundary spanning throughout history and is transdisciplinary by nature.

The minutes from the three workshops are in Swedish and consist of 25 pages[87]. They are therefore not reported in this thesis although their outcome forms a basis for the work. Here follows a short summary, or rather highlights of the lectures, visits and discussions, and it all reflects a selection.

Workshop I

The study's main questions were discussed in the first workshop, WS I, when the framework for the study was set; the problems of old buildings and the moisture problems that often play a major role in both conservation and energy use. The workshop took place at Heritage Halland in Halmstad and eighteen people attended.

Professor Edén had his parting point in his book about energy and building design[88]. The system requirements are set early in the design process and to define them one has to know the context well, and to know the difference between a kWh and a kWh in energy. Edén had an explanation for this. Since the phase of maintenance including heating is the heavier, one must use more low-grade thermal energy and less high-grade electrical energy for this purpose in this phase. This is the crucial difference between different kinds of kWh. There are still too few evaluations of energy efficient building projects. A systematic inventory could be divided into the use of closed and open systems.

The architect works with design and with the users which implies work with processes, but also with technical issues as well as the site and other contextual issues. Anyhow, most of the building stock is already constructed and the built cultural heritage has a system of valuation of its own which also has to be considered. In general, the orientation of technology must become more directed at buildings as interacting systems, where the total performance is respected. Someone in the construction process has to bridge design, participation processes by clients and users, and technical issues and so on. Today there is a technical base for energy efficient buildings. As an architect one can start from this and exploit, develop, reinterpret, and reinvent new forms for the built environment and for the systems, together with all parties involved. The problem field is wide and the solutions of many different kinds. The local and global perspectives are equally important, where the local has a bigger effect on the physical context and the global a value as symbol and for overall impact of energy use.

Professor Hagentoft lectured on physical risks associated with energy efficiency in buildings. Functional requirements seem to have fallen out of focus today when society demands - and the economy seems intent on - minimising energy consumption. IEA, the International Energy Agency, has calculated an enormous potential for savings. What in general are the biggest risks, and cause

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[86] Hirsch-Hadorn, Gertrude et al (2008). *The Emergence of Transdisciplinarity as a Form of Research* in Gertrude Hirsch Hadorn et al. *Handbook of Transdisciplinary Research*. Dordrecht: Springer Science + Business Media B.V. pp. 19-39. Media B.V. pp. 19-39.

[87] The minutes, in Swedish, are available at: http://www.chalmers.se/arch/SV/forskning/forskningsprojekt/energy-efficiency.

[88] Edén (2007).

most damage in buildings today, are different sources of moisture and our various ways of trying to overcome them. We have to adjust constructions and materials for each and every new context. Moist indoor air always has higher humidity than outdoor air because about one bucket a day vaporises indoors. That is why the vapour barrier is extremely important for preventing diffusion and convection. In older buildings added interior insulation is a common measure which is a risk while the relative humidity, RH, rises indoors in these cases. The construction will be very sensitive to air leakage from within and will also result in a colder exterior side. It is of utmost importance to have control on joints and thermal bridges, like the attachment of floor joists to the façade, when using interior insulation, since problems can be built in and not be controllable. Risk calculations should be performed before actions of this kind are carried out. There are good programmes for risk analysis.

Pallin, a doctoral student, had looked into risks related to refurbishment and the upgrading of exterior walls in a residential building. His calculations showed that heat and humidity transport in the attachment of concrete floor slabs and walls and stud walls when adding exterior insulation could be a risk. Every object is unique and demands calculations but there is a rule of thumb about the vapour barrier. Seen from the inside it should not be placed deeper than 1/3 into the wall, which is extremely important.

During the first workshop, questions arose as to what measures it was possible to perform in Fattighuset. The object was visited and practice and problems were discussed with this first surveyed object as a starting point. The owner of Fattighuset was planning for a refurbishment. This had been needed since it was restored in the 1990s. The architect Schriever-Abeln had been engaged by the owner, for new alterations to facilitate new activities and businesses in the building. He suggested a new entrance and, to solve the accessibility problem for disabled people, ramps were needed. He also proposed a raising of the back yard area. This implied significant changes to the façades and the question was raised as to whether it was compatible with the existing values and the buildings' classification in the municipal preservation plan. It seemed to be a conflict of interest.

During the day the concepts of passive houses or zero energy and even plus energy houses came up and the discussion thus came to revolve partially around the production, distribution and sale of energy and energy services. The new services open up a diversified business for our energy companies. It was also established that the energy market is affected by possible energy supply, by our economic system, by taxes and subsidies and thereby also by politics. It seems that from whatever angle the energy issue is looked at, it has a high degree of complexity.

Workshop II

The second workshop, WS II, considered the energy issue; efficiency and also how an energy expert is trained and how he or she carries out an energy declaration. Fifteen people attended and it was held at Teatern in Laholm, one of the objects in this study. Tobin, an engineer and educator of energy experts, started with the definition of the different system boundaries, energy and exergy, and the ratio of the output to the input of any system, and established that the declaration had been adjusted to the mandatory provisions, BBR. There is a law[89], a regulation[90] and mandatory provisions[91] on what, when and how an energy declaration shall be carried out.

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[89] Boverket (2010c). *Regelsamling för energideklaration med kommentarer. Lag om energideklaration för byggnader*, *SFS 2006:985 med ändringar t o m SFS 2009:579.* Karlskrona: Boverket.

According to the law a declaration is needed when a new construction is erected, for all existing special buildings with a floor area over 1000 m^2 and for all existing buildings with tenancies, and when a building is sold. The certificate may not be older than ten years. All exemptions from the obligation to have an energy declaration made are listed in the regulation. These are regional and national notable/listed historic buildings, industry, farm buildings and those in forestry, holiday cottages, buildings with floor areas of less than 50 m^2, temporary buildings, secret military buildings, and those for religious use.

There are mandatory provisions on what is required and how an energy expert should be certified[92]. There are extensive requirements and a large knowledge test must be performed before certification. Nevertheless the assessment of possible cultural and historic values in a building is best performed by another expert, preferably certified according to *BFS 2011:15 KUL2.* The first mandatory provisions for certification of experts on cultural and historic values came into force in 2005, and have recently been updated. In one of Tobin's companies they have education and courses for this too, which is an advantage and makes for good cooperation.

All data needed for the declaration should be provided by the owner. The results after processing should be reported to a national database. The aim of the declaration is not only to promote energy efficiency but also to promote a good indoor environment. All proposals for improvement of energy efficiency should be put forward if they are economically justified. The proposals should be given with estimated costs in sek/kWh and pay off time in years but it is actually not compulsory to implement them. We do have another law - The Environmental Code[93] - which can be interpreted in such way that energy efficiency measures should be carried out if it is possible to do so. The different laws are not yet harmonised. New laws are always evaluated and it has been shown that an energy declaration can lead to very different outcomes, depending largely on whether the building has been visited or not. It will likely soon be mandatory for the energy expert to visit the building in question.

Tobin also mentioned the advantage of using IR camera and other various aids, and different ways of performing the energy declaration, and the difference between a declaration and an energy analysis. At windows with very low, i.e. good, U-values where no cold convection should appear, it can appear anyway if the height of the windows is more than 1.5 meters. He had many more examples and in the end when comparing calculated and measured energy demand the potential of savings becomes clear. Tobin also talked about strategy and strategic choices and thinking in systems, which must always must be included.

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[90] Boverket (2010c). *Regelsamling för energideklaration med kommentarer. Förordning om energideklaration för byggnader*, *SFS 2006:1592.* Karlskrona: Boverket.
[91] Boverket (2010c). *Regelsamling för energideklaration med kommentarer. Boverkets föreskrifter och allmänna råd om energideklaration för byggnader, BFS 2007:4 BED med ändringar t o m BFS 2010:6 BED 3*. Karlskrona: Boverket.
[92] Boverket (2010c). *Regelsamling för energideklaration med kommentarer. Boverkets föreskrifter och allmänna råd för certifiering av energiexpert, BFS 2007:5 CEX med ändringar t o m BFS 2010:7 CEX 2.* Karlskrona: Boverket.
[93] Sveriges Riksdag (1998). *Miljöbalken SFS 1998:808.* Available at: http://www.riksdagen.se/webbnav/index.aspx?nid=3911&bet=1998:808.

Sundquist, certified energy expert, gave examples from his work of what difficulties there are and how to solve them. He and his colleagues always do visits on site and a larger, single building takes about 15-30 hours to certify. They use BV2, a calculation programme which is well established and was developed at Chalmers. According to studies made at the University of Lund, though, due to thermal bridges differences in calculated energy use can amount to as much as 20 % regardless of what programme is in use. Another example concerned a business company which lowered its energy use by over 60 %, from 60 MWh/month to 20 MWh/month, simply by engaging an expert who corrected errors in the operation, adjusting and optimising the control and regulating equipment. No change of heating and no added insulation or alteration of windows or other appearances was made – this was one of many good lessons learnt in this workshop.

Workshop III

The third workshop, WS III, had risks and opportunities in the heritage sector and new strategies as a theme. The workshop was held at the Department for Architecture at Chalmers and sixteen people attended. It started by looking at the difficulties involved in assessing cultural, historic and architectonic values which appeared during the work in EEPOCH. A referral on amended mandatory provisions showed that the same low figures on energy use for new constructions will be required for alterations in existing buildings. It is probable that none of the objects in the multiple case study will manage to meet these requirements when planned alterations are carried out. This is worrying since a building's possible preservation is linked to its usefulness and adaptability to new activities and use. In most cases this implies refurbishment. With this background, the need for clearer methods of evaluation becomes evident as cultural values should be balanced against energy requirements. The handbooks in use today have gaps in alignment with current viewpoint, which is increasingly based on user perspective. Manuals and methodology needs to be extended and upgraded. One way of partly doing this could be to add a method for assessment of architectonic qualities and values.

Fredengren and Génetay from the National Heritage Board, NHB, have been working on a new method for assessing cultural and historic values as a mission to review the criteria for national historical monuments, managed by National Property Board, NPB. They had a series of meetings with the NHB's employees to define intrinsic values, user values, scientific values and cultural values. Also at issue was how NHB presents these identity values. One criterion for state ownership must be to give all citizens access to heritage at a public site.

The relationship of heritage to sustainable development — environmental, economic and social — was also discussed. The need for a new model originated with changes in the surrounding world. This was combined with public welfare and national responsibility, when choosing the narrative model. The narrative model had already been presented by Arvastsson during the 1990s and NHB developed it. They tested the new model together with Unnerbäck's model in one object — Ågestaverket — Sweden's first commercial nuclear power plant — and in both cases it was found that the object was part of our heritage and worth preserving. The national value of cultural heritage was assessed against a background of national cultural and historical narratives describing different historical phases, which the objects should belong to. The starting points in geography, gender and class, generation and ethnicity — to tell everyone's story — were necessary for credibility. An independent research group developed the stories to describe Sweden's historical and cultural development. NPB used the model on the stock they were set to manage and 90 % of it was found to be a part of our history, fulfilling the criteria and worthy of inclusion, for cultural and historical reasons, in the national holdings. This raised the question on how the results could be perceived and interpreted and used on a local level. The continued work for NHB includes the issue in a new handbook or framework, defining what can be considered a national interest and what are the priorities, and a revision of the Cultural Heritage Act.

Gustafsson, director of Heritage Halland, has explored the heritage sector both in theory and practice through the Halland Model concept. He started with the story of the sports auditorium which was part of Halmstad's local identity. It showed all possible high rated values according to the assessment models in use today. Yet it was demolished. Why? 'We did not get anywhere with PBA, plans or Unnerbäck's valuation model.'

The most significant change in the last decades is that the national strategies lost their meaning when the European perspective emerged. The national focus is a top-down system while the regional focus is a base-up system, and decentralisation created a regional arena easier to impact than the national one. Sustainable development got its regional strategy with environmental, social and economic dimensions. We left the national guiding principles to build on the specific in every region instead. The history and characteristics manifest in the built environment are a strength and an advantage, and part of the region's strategy on growth. Heritage should not just be protected but should be used, and should even be a driving force in sustainable development. The new horizontal triple helix system is cross-sectoral and system wide. Gustafsson presented the trading zone, which his thesis is based on. It is defined as an active arena for negotiations and exchanges of services or a field of force corresponding to the actors' policies, values and resources.

Traditional protective work within the heritage sector was transformed into proactive work making big inventories to bring to the negotiation table. The inventory is linked to the municipalities and their department for building permits. Restoration of built heritage becomes, through the Halland Model with all participating parties and the turnover it generates, a part of the growth in the region.

Gustafsson also mentioned Sacco's strategic matrix for resource use, development and growth in the cultural sector. When using the matrix for an inventory it shows that the actual production within the cultural sector is scattered across a region. Even though the big institutions like theatres, operas, museums etc. are in the main regional centre, the growth is out in the region. He also mentioned Throsby, who contends that all motivation for economic activities is the concept of value. It is important to identify and take advantage of existing, actual values.

Professor Della Torre referred to a new convention from the year 2000 when restoration got a new focus in Italy. The context was now emphasised and not the single masterpiece. The concept of territorial systems, including social and economic systems, was developed. Restoration should be preventive with authenticity and reversibility for sustainable management of our existing resources. With addition from today heritage could acquire new uses and new possibilities for interpretation could emerge. The concept of conservation was enhanced to include use, e.g. as an asset for tourism in learning regions. The Italian regulation protects 'beni culturali' i.e. work of art but now a building cannot be separated from its landscape. Della Torre called this recognition. When the surrounding world develops but not the heritage, the heritage becomes a museum.

Everything has a cultural and historic value depending on the chosen perspective. The concept of conservation is connected to ideas developed by Bardeschi and Bellini. All evaluations and assessments are relative and time-bound. One cannot isolate a building because it will then lose its different time-layers and authenticity, as John Ruskin and Alois Riegl observed. Buildings should also be able to be used. Architecture must be used to be perceived as architecture.

Most people agree with Feilden's words from 1982, that the mission of conservation is action to prevent decay, but many interpret this to mean that cultural heritage is and must be static and not reflect the dynamics of the surrounding world. Urbani and Paribeni developed a theory of equilibrium and balance during the 1980s, to maintain pure restoration. Heritage was not allowed to become dilapidated nor to be modified to meet new needs. This was a defensive strategy.

With the human ecology as described by Ceruti, the concepts of co-evolution and of widening the limits instead of limiting development are emerging. Ecology and restoration becomes a science and an ethic of diversity. Diversity and identity in a developing co-existence implies change.

The task for the expert is to find new meanings and make relative interpretations of the heritage, and show the dynamic nature of a building's significance, consisting of a variety of values reflecting a variety of interests. These must be utilised to engage people.

Conservation today is characterised by the concept of sustainability and is also expected to be sustainable. This entails increasing complexity. If a building is to survive, adjustments are necessary to meet new needs and also to have a dialogue in the context of co-existence and mutual impact between heritage and society. This demands a long-term strategy of integrated conservation or planned conservation as Della Torre called it. It requires new tools for understanding of conservation as phases of processes, and is an important shift to preventive work.

Within wide-area projects the notion of conservation is enhanced by the economic aspect. The sites are included in sustainability plans, not only as suitable for tourism since negative effects have been identified in this branch, but from a sustainability perspective. They have another strategy and a model for understanding the impact of immaterial values. In learning regions the whole context is involved and included in a commercialization plan, aiming at regional cooperation for innovative growth where cultural heritage can serve as a catalyst. The shift from pure restoration into integrated conservation work offers economic advantages. The objective is to get the most out of given resources for a local process of development.

The Italian research agenda has slowly moved from one paradigm to another, from restoration to preventive and integrated conservation, and is now about creating development through conservation. Focus is on the sustainable where conservation is an important factor for regional development. This way the heritage sector can have an active role in development and have a seat at the negotiation table.

Professor Rosvall mentioned the knowledge building system as a base for research and for the academy. The academy must represent questioning and knowledge building, and use the sustainability perspective in this.

Cultural heritage can be divided into:

Products - monuments which are tangible and intangible, with artefacts as objects and images as metaphors.

Resources - which are cultural and economic.

Processes - as a dynamic flow of continuously changing assets.

Of these, the last will be the most important for the future. Conservation has transformed in three stages. The early movement considered the conservation of a few selected historic monuments. The next step was to enhance the boundaries and care also for context, and to integrate conservation in community and national planning. Today's view includes the use and the usefulness for contemporary people and their relation or approach to heritage.

Conservation works with respect for the original, with a minimum of intervention and with use of original material. All actions must be reversible and 're-treatable', i.e. they must ensure that it is possible to re-treat the object to its former, original state and original appearance. For this, thorough documentation is needed before, during and after actions. This is also a prerequisite for preventive work with continuous maintenance as opposed to long-term decay followed by restoration. Rosvall showed a diagram on the critical phase of conservation, which has been recreated below.

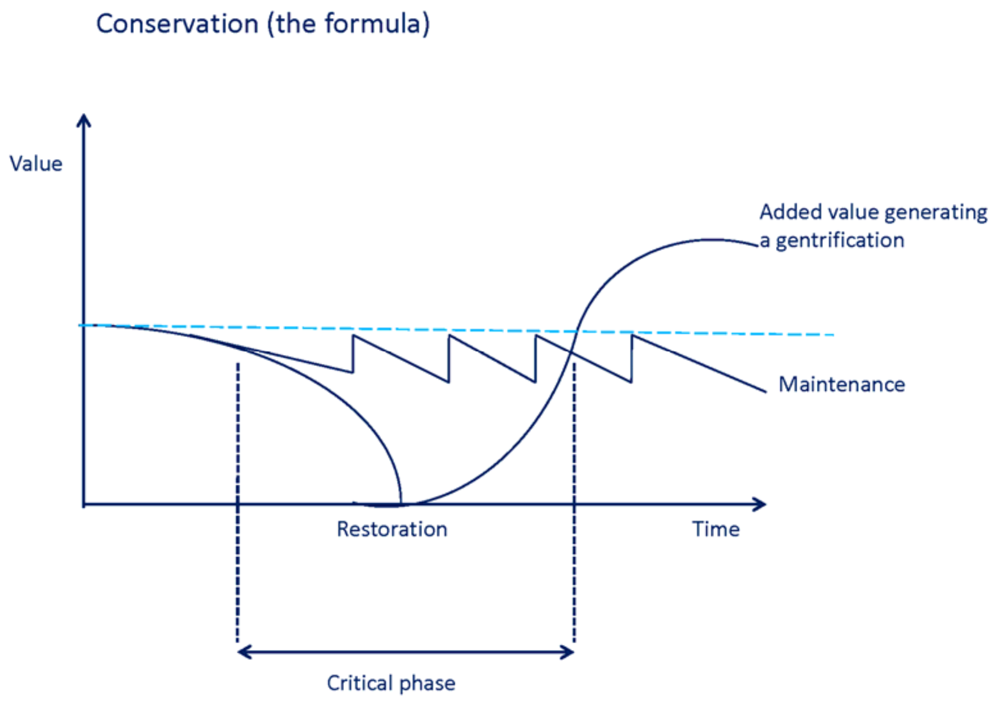

Figure 7 is an attempt to reproduce a diagram showing the critical phase in conservation, and the two different approaches to action. The lighter blue dashed line is the object's original nominal value.

Buildings have a long life and it should be estimated in centuries not decades. In the case of continuous maintenance it is important to know which qualities an object possesses originally so that small changes over this long a time will not be added and distort them.

Rosvall mentioned that there are three phases of conservation. The first one involves the skilled crafts, is traditional, ethnocentric, idiographic and is based on the unique and individual. The second phase involves scientific conservation, is modern, transnational, nomothetic, and based on the universal and general. The third phase belongs to the future and is a multifaceted, analytic, problem oriented holistic view including interdisciplinarity as well as transdisciplinarity. The third phase can be developed cross disciplinary to a new discipline.

Conservation has different structures to work with, as in structures of building construction, structures of society, cultural structures and invisible structures. The process of conservation is based on the assumption that all kinds of material products concerned are bearers of both explicit and hidden messages. The latter includes intangible values or non-measurable values. Rosvall showed a table, very simple at a first glance, but it turned out to reveal a lot about the issue.

	Visual categories	Respondent effects	Character
Material (tangible)	Pictures Paintings Artefacts →	Perception → ↓ Appropriation	Operative
Intangible	Image →	Reception "beholder" →	Intrinsic (becoming internalized in you)

Figure 8. The intangible values are not easily communicated while having an invisible structure and can only occur in the eyes of the beholder. One cannot write a guide for people's insight.

IV CONCLUSIONS DRAWN FROM THE MULTIPLE CASE STUDY

The energy issue has been looked into by describing, exploring and partly explaining the objects' envelope in relation to the indoor climate and installations, and energy supply. The advantages of using three methods for evaluating the objects' energy status was that the differences in calculated and actual energy use indicated problems which could be analysed and verified by using the IR camera. In the round the conclusion must be that this was a good start for an overall view and for giving guidance on further investigations e.g. air humidity and moisture in the buildings' structural material.

A large part of our collective wealth lies in our buildings[94]. Much of the damage in structure of buildings emanates from moisture permeating and being transferred into the materials of the structure, which is seen in Fattighuset and maybe also Teatern. One way to act is to dry out the materials by heating[95] but this is not energy efficient. Using a dehumidifier is more energy efficient and moreover, 'the concept of controlling relative humidity by adjusting the temperature should be used with care, because it may result in considerable moisture migration' [96]. The best option physically and economically is to stop the moisture at the surface or prevent the situation from occurring at all, to avoid damage and promote the further survival of the buildings once invested in. The indoor air humidity must be adequate handled by sufficient systems that are flexible, energy efficient and adjustable to the use of the premises.

As per the environmental impact of energy consumption, the choice of energy source for heating is evident as shown in Teatern.

The overall conclusions as to what makes a healthy indoor climate in existing buildings do not differ much from what is stated for new constructions: air tightness to avoid draughts and discomfort, and control of indoor air humidity and temperatures and air change. Corresponding characteristics are also desirable and applicable for energy efficient buildings.

The lesson learned from assessing cultural and historic values is that the NHB's Handbook by Unnerbäck can be used as a checklist and a tool to help find the relevant values for the building in question in a valuation situation, which is also stated in their Guide[97] by Robertsson. Buildings are architecture, however, and architectonic values must be included.

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[94] Hagentoft Carl-Eric (2002). *Vandrande fukt Strålande värme.* Lund: Studentlitteratur. p 13.
[95] Hagentoft (2002) pp. 127-139.
[96] Klenz Larsen, Poul (2007). *Climate Control in Danish Churches*. pp. 167-174. In *Museum Microclimates*. Padfield and Borchersen (eds.). Kopenhagen: National Museum of Denmark.
[97] Robertsson (2002). p 52.

Assessing historic and cultural values is part of the conservation work but the notions of conservation and integrated conservation[98] are wider. To get a better view of the contemporary understanding, a paper on a broad definition of the concept of conservation was studied[99]. The introduction starts with a wide definition, appealing to any creative professions.

'[...] conservation is the comprehensive and general concept used to pinpoint objectives, perspectives, knowledge and practical applications, based on the long term strategies of high quality maintenance, which aim at healthy preservation of material cultural property [...]but also the well being of mankind.' The discipline concerns objects from any period and from all social groups including buildings and landscapes which are related in complex artificial and natural systems. Objects have to be functional in the dynamic situations which characterise our societies, our environments and their contents.

Conservation in the wider and deeper sense described above coincides more with the architectural view than the sheer descriptive hermeneutics do. Assessment of built environment is still, however, an important part of the understanding of history, architecture and the genius loci.

As a whole, considering the time and conditions, the restorations were professionally performed. Looking at them in the round there are some better and some poorer results. It is always much easier to comment on already finished work than it is to perform it, and it may be that it was not possible to foresee the consequences of some of the actions.

From an antiquarian perspective the restoration of Fattighuset was performed excellently, leaving e.g. the gymnasium untouched, preserving a hundred years of patina. However the preservation was carried out at the expense of the indoor climate and energy efficiency, and is in this respect detrimental to the users and tenants. It is an exemplar from one perspective but not from the other and the lesson learned here is that it will not do.

In Fattighuset the airtightness had an important effect on the indoor climate and interior windows and doors could have been added. The airtightness is also linked with the air handling system and another system could have been chosen. The lack of evacuation routes in case of fire is a deficiency and must be looked into. What could have been done also was to insulate the roof and the south wall on the exterior side, and add extra glazing walls of a sliding type on the interior side of the north façade to air tighten the wall where the big glazed doors are. The most important thing in Fattighuset right now is to concentrate on the technical installations.

Teatern in Laholm was restored beautifully and seems to be a good example from both an energy and a preservation perspective. The advantage of added insulation in the attic is evident. The old masoned shafts for the earlier natural ventilation were used for the exhaust air so there are no visible signs of the new technique added in this area. The supply air is distributed by devices for displacement flow integrated in the existing walls. The devices are painted in the same colour as the walls and blend into this special environment. On the balcony small devices are mounted on the floor

[98] The tradition of conservation in Sweden and the emergence of integrated conservation are described in brief in Paper number 1.

[99] Rosvall, Jan & Engelbrektsson, Nanne & Lagerqvist, Bosse and van Gigch, John P. (1995). *International Perspectives on Strategic Planning for Research and Education in Conservation.* Bergamo: Convegno internazionale.

under the seats. These are the only visible energy measure taken. Modern additions like spotlights and loudspeakers are more visible and could be experienced as disturbing from a preservation perspective, but are necessary from the user perspective.

Some issues need to be taken care of. An appropriate solution for air tightness at doors and windows must be designed. The moisture problem must be met and a computer simulation could be performed to get an idea of how the cement based exterior plaster affects the diffusion of moisture in the building's construction. Calculations on what humidity and temperature are required to protect the building may be of value for the future maintenance in the building.

Tyreshill's original state was dilapidated and the owner wanted it demolished, so the conditions for preservation were quite different. The interior had to be reconstructed, enabling possible energy efficiency actions to be carried out, and it turned out well. The preservation part concerned the exterior and the courtyard setting and its value for the community. The object as such must still be considered a good example.

Considering all the effort made in Tyreshill to deal with transmission losses, energy use and indoor climate, it should have had a lower key figure for energy use. If it had been allowed, exterior insulation would have been more energy efficient. The overall result shown in the exterior, however, is good. The only worry concerns the accumulated loss from the floor heating to the ground. When the heating is turned off in the summertime the heat from the ground will move up into the building and when this happens the moisture in the ground will follow the heat into the building. This risk should perhaps be investigated.

The overall conclusion on the objects is that the balancing of the different demands has been better performed in Teatern and Tyreshill than in Fattighuset. The indoor climate is best in Tyreshill but the preconditions were different with many more opportunities to take action. Weighing the three perspectives of energy efficiency, historic values and architecture the performance in Teatern in Laholm must guide the continuation of work within EEPOCH.

The overall architectural evaluation concerns the building/object as a technical system and as a system of space, and its interaction with the context. The use value and function for different activities are seen as important factors while they often determine the object's attainable future.

Compared with the evaluation of historic values and the energy performance, this evaluation is much wider. The objects' history and energy use is in reality part of the architect's assessment whether performed by himself or herself or by a cooperating specialist. Hence the architect's assessment mirrors the typical generalist competence.

'Architects are working with everything from rooms to national planning and the profession is oriented towards covering the whole territory[100].' Handling different demands, functions and designs, technical solutions, site conditions, historic values, administrative and legal conditions and more, characterises the architect's work. This requires an ability to transgress boundaries and understand of the whole. All of this emanates from architecture's contextual mission, which

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[100] Edén, Michael (1987). *Arkitektur med ekologiska förtecken.* Göteborg: Byggnadsplanering, sektionen för Arkitektur, Chalmers tekniska högskola. p. 281.

constantly forces the architect to synthesise. In this way, the generalist competence becomes the profession's speciality. This is the conclusion looking at the restorations from an architect's point of view.

Interviewing people engaged in the restorations was explorative. The interviews have shed light on important factors involved in working with the Halland Model. Horizontal cooperation, flat transparent organisation and good communication created involvement which also resulted in thoroughness and high quality work. Respect and shared responsibility became key factors for a good working climate allowing initiatives and discussions. The Halland Model was developed in a period of recession which differs a great deal from today's social and political context. Yet some of the factors bear a strong resemblance to the ones used today by those in the construction sector engaged in building passive houses. Thoroughness in planning and high quality in work performance at the construction site is required to achieve the necessary airtightness in these houses. This is according to Jansson's thesis[101] on passive houses, where other factors like good communication, involvement, respect and a feeling of importance are also mentioned. The experience from the Halland Model could be of good use for today's construction sector in general.

Monuments with high historic and cultural values on a national level are still protected by Regulation SFS 1988:1229 and on regional level there is the Heritage Conservation Act, KML, SFS 1988:950 which concerns buildings, ancient remains, archaeological finds, ecclesiastical monuments and specific artefacts[102] [103]. Of the about 11 000 objects and sites worth preserving in Halland and listed in 2010 in the latest inventory only 39 are considered as monuments protected by the Heritage Conservation Act, KML.

All other built heritage is protected by the law PBL and regulation PBF and in everyday practice municipal officials use the mandatory provisions BBR when judging applications for building permits for new constructions, alterations and extensions. All three types of legal documents apply to legal context. There are also general recommendations which do not apply to legal context. All are meant to give equal consideration to technical requirements like energy efficiency, and caution about different values in existing buildings.

The officials will have clear legal documents to work with regarding energy efficiency in alterations but are still in a grey zone of uncertainty concerning judgements of historical and cultural values and preservation. They will have to consider a set of demands on functionality, ventilation, fire safety, and accessibility, among others; and all clearly defined by width and height, litres per second and m^2, fire protection for 30 minutes or more, gradients of ramps for disabled people and key figures of 110 or 55 kWh/m^2 A_{temp} per year. And then there is a requirement for caution. How will this be defined?

When working within this new combined area of conservation and energy efficiency, awareness of and respect for the different professions and roles included in the process is crucial. These two areas differ very much from each other and are difficult to compare. The researchers and practitioners who

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[101] Jansson, Ulla (2008). *Passive houses in Sweden. Experience from design and construction phase. Report EBD-T-08/9*. Lund: Department of Architecture and Built Environment, Lund University.
[102] Riksantikvarieämbetet (1988). *SFS 1988:1229 Förordningen om statliga byggnadsminnen med ändringar t.o.m. 2011:359.* Stockholm: Riksantikvarieämbetet.
[103] Riksantikvarieämbetet (1988). *SFS 1988:950, KML Lagen om kulturminnen m.m. med ändringar t.o.m. SFS 2011:782.* Stockholm: Sveriges Regering, Kulturdepartementet.

have specialised in these areas also have different cultures within their professions. This was mirrored in WS I, the first workshop, too, but the most important output was that a building must be seen as a whole, with interacting systems, where the total performance — including the users and their activities — is considered. The natural next question was: how can this be achieved? This resulted in other important questions. What professions should be involved? What kind of research and development do we need? Are there too little data on buildings in operation? Have we forgotten about the moisture problem in search for kWh? Is it acceptable to have low comfort or high key figures such as 200 kWh/m^2 A_{temp} per year in buildings for rent? Are alterations of a façade which has high cultural values and is part of a community's history and character on a site, acceptable? These questions have been guiding this work along the way.

A list and table on possible energy measures in an object was also made and pros and cons were estimated. The table was useful for all cases and is also printed in paper no 2. From this summarising table it appeared that most of the suggested measures were aimed at creating better indoor climate and comfort. Increased heat was suggested but it would have the opposite effect from an energy perspective. In an old building where the envelope has not been altered or improved, the energy use and comfort level are almost synonymous; the higher the energy use, the higher the comfort level; and the lower the energy use, the lower the comfort level. Some degree of priority could be ascertained from the list but - what aspect weighed most heavily? Could they be weighed against each other to attain a balance? Clear answers did not come up but a couple of suggestions for further continuation did.

The second workshop, WS II, was all about understanding the energy issue and was indispensable for the analysis of the energy performance in the three objects in the multiple case study. Adjustment and maintenance of existing installations and their devices can have a very big impact when it comes to decreasing the energy use, as was also exemplified. The experience from the third workshop, WS III, was revealing and has had an impact on the work so far. It will impact the continuing work in several ways. First and foremost, this will occur through the ongoing paradigm shift towards a holistic and horizontal perspective with the use value in focus, and the tendency towards a generalist view (according to Gustafsson but also in many ways according to Della Torre and Rosvall).

Participants	Workshop I	Workshop II	Workshop III
Antiquarians/conservationists	5	1	10
Engineers	10	11	-
Architects	3	3	6
Total	18	15	16

Table 13 shows participant categories in the three workshops.

The overall conclusion on the workshops is that they were a very good way to engage with all aspects, facts and perspectives and to share them. The effect of participating and the respect for a topic when realising the skills needed for performance have been evident in the workshops. This is an important assertion which can be made from the ones carried through in this project.

Summarising conclusion

Some questions were formulated for investigation of the complex set of problems in combined energy efficiency and preservation. The answer to the first initial research question is yes. There is a risk that intangible values in our built cultural heritage will be lost in favour of measurable and tangible energy efficiency actions.

Looking at the objects one can see that there are conflicting interests in the supply of heat; low supply of heat to lower the energy use and costs becomes too low to handle humidity and moisture problems causing damage to the construction - the term low is relative to this context.

Adding insulation has proven to be the most efficient measure, when it is mounted on the exterior side to build in thermal bridges[104] but it definitely alters the façades. Interior added insulation affects details like mouldings and woodwork in a negative way and can, in addition, cause moisture problems in the construction, especially at thermal bridges.

Installation of mechanical ventilation or air handling systems alters the interior historic values of a building, as in Fattighuset, if it is not performed with sensitivity, as in Teatern.

In the law, regulation and mandatory provisions, there are difficulties in interpreting the requirement for caution in relation to the clearly defined requirements for accessibility, change of air volume or energy efficiency. This can lead to problems in balancing the different requirements when assessing applications for building permits in alterations and transformations in our built cultural heritage. This is a potential risk. These are the found phenomena leading to the answer yes.

The second research question must also be answered in the affirmative. Looking at the object Fattighuset it is evident that the conservation work has been carried through at the expense of energy efficiency and moreover at the expense of a good indoor climate.

The difficulties with interpreting the demand for cautiousness and defining it clearly in the law, regulation and mandatory provisions are a potential risk here too. The balance of different demands in assessing applications for building permits can tip to favour either the energy demand or the preservation demand.

The objects in the multiple case study have been studied from different perspectives. This enabled a comparison between the objects, so the answer to the third research question, in this sense, is yes: it is possible to explore the duality in the combination of preserved built heritage and energy efficiency. It is harder to compare the different assessed values in each object because of the built-in dissimilarities. Can the historic values be defined by figures? Is the figures' objectivity only apparent? What if energy efficiency were to be defined by its value for the whole in a descriptive way?

Can the combination of preservation and energy efficiency actions be performed in a way that both conservation officers and energy counsellors can accept? This was the fourth question and according to the analysis of interviews and objects presented in paper no. 3, it can. The conclusion of the interviews must be that using good experience from the Halland Model is a strong strategic way forward and strengthens the hypothesis.

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[104] Hoppe (2009a).

'There are few writings that bridge the gap between the measurable and qualitative, which provides information on technical performance while discussing aesthetics.' according to Edén.[105] This is an attempt. The aim of this first phase in EEPOCH has not been to nail the truth, but to increase understanding of the problems. This thesis forms the basis for a coming contribution on to how concrete planning can have an impact on design and diversity of buildings and hence also on sites and, ultimately cities. It is about how to identify opportunities in the interaction between parts and the whole, in the contrast between alteration and preservation; simply to use the architect's generalist competence in researching this multifaceted field.

[105] Edén (2007).

V THE PAPERS

V.I PAPER 1:

Heritage 2010, International Conference on Heritage and Sustainable Development, June 2010, Evora, Portugal

Energy Efficiency and Preservation in our Cultural Heritage in Halland, Sweden

H. Norrström & M. Edén
Department of Architecture, Chalmers University of Technology, Gothenburg, Sweden

The paper was published and presented at the conference.

V.II PAPER 2:

Energy Efficiency in Historic Buildings, International Conference February 2011, Visby, Sweden

Energy Efficiency and Preservation in our Cultural Heritage - EEPOCH

Heidi Norrström Ph.D. stud. and Michael Edén Dr. Prof. Arch.

Department of Architecture, Chalmers University of Technology, Gothenburg, Sweden

The Swedish Energy agency's and Gotland University's scientific conference, Energy Efficiency in Historic Buildings, 9-11 February 2011 in Gotland, Sweden

V.III PAPER 3:

ESA 10th Conference in Geneva, September 2011, Switzerland.

ESA 2011 *Cultures of Conservation and Sustainability*

Paper for the 10th Conference of the European Sociological Association in Geneva, September 2011

EEPOCH, A MULTIPLE CASE STUDY INVOLVING ENERGY EFFICIENCY, PRESERVATION, AND MANAGEMENT AND WORKING CLIMATE IN CONSERVATION TEAMS, ESA11-4609

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V.IV POSTER 1:
Orange Quest and AGS Annual Meeting

Reviewed abstract and poster for entry to both the Orange Quest and the AGS Alliance for Global Sustainability, annual meeting held in Gothenburg 23-25 January 2011 at Chalmers University of Technology.

Best poster awards for both events were merged and all abstracts were evaluated according to the Orange Quest criteria, and published in paper edition and on website as well as exhibited at the meeting.

VI SUMMARISING DISCUSSION

Energy efficiency and preservation of cultural heritage consists of a complex set of problems. These two main perspectives have been researched, looking at use value and performance in teams at conservation work, laws and regulations, the history of conservation and architectural values. EEPOCH has been carried out through a multiple case study of methods involving workshops, analyses of different measures and of interviews, and archival and document studies.

The four initial questions answered in this thesis have been illuminated and extended with others, and the overall objective for EEPOCH is still valid. The objects within the multiple case study have been explored to form a solid foundation. To make it even more solid an investigation could be undertaken to explore the occurrence of the same phenomena in other objects; their character and what it consists of; the generality and the special.

Using workshops as a method of participating has been useful, important and not least necessary to get an overview of all different aspects and perspectives. Different suggestions on solutions and how to tackle the problematizing of the research questions have been put forward in connection with the workshops. One proposition to proceed was research by architectural design. Another alternative was in depth interviews with people engaged in the restoration work.

Some found phenomena contribute to formulating and defining problems and others contribute to possible solutions. By illuminating phenomena from different perspectives a clearer picture of the complexity can be discerned. The initial picture should be as wide as possible and then it should be synthesised. Workshops thereby become a necessary method for the continued work, and the architect's generalist competence and ability to synthesise becomes an asset.

Different paths for continuation have been evolving within this licentiate work; choices must be made for shaping the study and closing in on the overall objective, and to test ways of designing the theoretical model. The choice of problem for continued research is associated with the choice of perspective. The main perspective so far has been the combination of the energy, historic and the architectural perspectives. These will be the basis for criteria and positions when formulating a possible weighted assessment as one answer to the chosen problem.

Working from different perspectives is, however, not without problems. Assuming that the scientific community includes diverse cultures, with different norms and values, it can be a problem if representatives of the different cultures do not understand each other's norms and values. This can complicate communication. The meeting of different parties' general cultural reality-images is tangible for the practitioner, and for the researcher the meeting between different scientific ideals presents an additional complication.[106] 'Provided that a discussion on perspective is conducted, preferably also on figures of thought or on paradigms, the problem is researchable.'[107]

[106] Edén (1987). pp. 277, 281.
[107] Edén (1987). p. 252.

Practicing architects are familiar with contradictions between the different interests when examining them. According to Rosvall[108] this is a classic dilemma. On one side are the positivist generalists as technicians or scientists with a nomothetic focus, emphasising the specific interests of e.g. energy efficiency. On the other side are the humanists with romanticism and historicism and the individual — the idiographic — in focus, emphasising conservation concerns. This is also stated by Liedman.[109] It is largely a matter of different cultures among the professionals who work with these questions, and it needs to be investigated. There is positivism or logical empiricism on the one hand and phenomenology and hermeneutics on the other. Maybe Carnap's idea on science as a structural description of reality and its relational system and Schlick's idea that we experiences qualities but have knowledge of structures, as described by von Wright,[110] could be used for analogies to mediate or shed light on the matter.

A short visit in history could sort out the notions and concepts and give an orientation on the background of the different philosophical stances, historically and in theory of science, and briefly how they affect the construction sector and conservation in practice and theory today. This should be one part of the continuation of EEPOCH.

Making an energy balance is a job for an expert and will continue to be, but all different professions cooperating in the construction and heritage sectors must at least be able to perform or understand a simple energy balance for good communication skills and understanding of the process that takes place. An architect must be able to communicate with an engineer as well as with a conservation officer and vice versa. Respect yields respect and we have to know when to call for an expert, and that must work both ways. All professions involved in construction work in existing built environments should understand something of the other professions' conditions, difficulties and skills.

The chosen combined research field has a very high degree of complexity but even when looking at just one field like energy it has a high degree of internal complexity, another thing that was revealed during discussions in workshop I. Energy research is and has to be interdisciplinary and transdisciplinary.

Integrated conservation today has a holistic approach including any scientific or humanistic discipline, and cannot be looked upon as an isolated technical speciality. The results of environmental problems have become globally important, also threatening culture and our cultural heritage, and it is also evident that isolated qualified contributions to conservation, concentrated on a few select monuments, are no longer sufficient[111].

The concept of conservation takes place on three levels hierarchically: on an intervention level, where the real world problems are solved by implementing models; on a modeling level, where the design of models take place; and finally, or first, on a meta modeling level, a level for strategies, where the foundation forms from different sources of knowledge to create the design system.

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[108] Stated in Rosvall's lecture at Workshop III within EEPOCH.

[109] Liedman, Sven-Eric (1998). *Mellan det trivial och det outsägliga. Blad ur humanioras och samhällsvetenskapernas historia.* Göteborg: Bokförlaget Daidalos AB. pp. 12-14.

[110] von Wright Georg Henrik (1993). *Logik, filosofi och språk. Strömningar och gestalter i modern filosofi*. Nora: Bokförlaget Nya Doxa. pp. 144-163.

[111] Rosvall et al (1995).

Evaluative standards are determined from the prevailing system: use values and economic value, emotional values and knowledge values, and also ethics[112]. Applied analogously in EEPOCH this means that the licentiate work has been performed on the metamodeling level and the continuation will take place on the modelling level. This concept or hierarchy could also, with an analogy, be of use when formulating the theoretical model.

The heritage sector in general seems to be more focused, today, on use values which also imply including the energy issue and the economic aspect, and the user perspective, as has been shown in examples in Sweden and Italy. Conservation has taken a seat at the negotiating table and become a vital part of strategic planning for development and growth in the horizontal triple helix actions on a regional level. The NHB's ongoing work, with revision of the Cultural Heritage Act and the need for a new framework for assessment of historic value, is also encouraging. A new and wider valuation system including the architectonic values and economy linked to use value, and the sustainability and resilience, is highly recommended.

When comparing different ways of assessing, valuing and defining energy performance, historic value and architectonic value, the most significant thing is that there are many ways for this to be done in the energy field as well as in the field of architecture, but fewer ways and methods in the historic field or in the heritage sector. For energy and architecture there are several well established methods, making them in a way more accessible and easier to understand since there are many entrances into the topic. The heritage sector would probably benefit from enlarged possibilities for interpretation and from development of various evaluation methods.

Among the cultural and historic values, which are not discussed in NHB's handbook are the intangible values. These values and the difficulty of measuring them were mentioned at the third workshop. Rosvall showed a table, very simple at a first glance, but turned out to reveal a great deal about the issue[113]. The expression 'intangible value' resembles in some aspects an expression taught by Klas Tham in Lund: 'non-measurable needs', referring to needs that are not measurable but which we have to take into account when designing a building[114]. The notion of time is vital for some intangible values but we can measure time. In this sense the two expressions differ from each other. Others, such as the feeling of being rooted and belonging to a place, are difficult to explain in tangible and measurable ways. Tham taught, however, that architecture can be designed and given properties conducive to satisfying our non-measurable needs. Ola Nylander has showed that this is doable in his book *Architecture of the Home*[115] where he conceptualises seven non-measurable qualities within four existing apartment buildings.

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[112] Rosvall et al (1995).

[113] The table is to be found on page 77 under the subheading Workshops.

[114] Tham, Klas 2007. *Människan i arkitekturen. Om människans sinnliga och emotionella behov i den fysiska miljön. Om arkitekturens betydelse.* Konst i offentlig miljö — en framtidsfaktor i Fyrbodal. Katalog # 1. Fyrbodal: Kommunalförbund

[115] Nylander, Ola (2002). *Architecture of the Home.* Chichester: Wiley-Academy.

The objects studied within EEPOCH were restored in the 1990s and the owners are currently planning new refurbishment. A sub project using research by design was suggested in the first workshop, to compare planned actions regarding architectural qualities. Parallel planning should lead to a model for faster definition of problem and balance, in relation to legislative demands, preservation demands etcetera and this is a possible continuation of defining the architectural values and the use of them in our built environment.

As concluded earlier the Halland Model and also the passive house concept seem to have very specific qualities compared with the construction sector in general, as described in a couple of reports[116] [117]where deficiencies and conservative attitudes are stated. Times and circumstances have changed, however, and a growing awareness of the need for innovation also appears, together with solutions, in one of the reports. According to the author these solutions require change and sharpening up of routines and business cultures within the professions and construction sector. Quality seems to be a topic key word. In Edén's book on energy and design[118] the construction process is described in four steps with system requirements and objectives and follow-up of qualities and so forth, and the conclusion drawn is that demands on energy efficiency seem to be a solution for better built constructions in general. His description concurs in many ways with the process within the Halland Model.

Only a few longer interviews were carried out within this thesis. They concerned management, organisation, methods and processes in the actual conservation work. Further interviews could also show which priorities were made and could be a continuation of this work. A model for faster problem definition and choice could be found through analysis of and inference from the material — to be used as basis for balance and decision — and a broader investigation is proposed. Such an investigation could reveal which priorities might be made among the interests, considering their variety, and give guidance on what could actually be carried out later on in practice. This might unfold the project, creating the potential to put forward a proposal on weighted assessments. This is one possible approach when designing a theoretical model for practical application on how to balance energy efficiency and preservation demands. Apart from this, management within the Halland Model seems a good foundation, if not a prerequisite, for the coming implementation of a theoretical model.

How does the legal issue on alterations and transformations impact the balancing of energy and preservation demands? First: the facts in the situation described reinforce the impression that a well-balanced model is needed. Second: all sides and interests must be considered, be engaged and contribute equally. Now what should such a model consist of?

[116] Socialdepartementet och Byggkommissionen (2002). *SOU 2002:115. Skärpning Gubbar! Om konkurrensen, kvaliteten, kostnaderna och kompetensen i byggsektorn.* Stockholm: Socialdepartementet, Regeringen.
[117] Boverket (2009c). *Skärpning på gång i byggsektorn!* Karlskrona: Boverket.
[118] Edén (2007).

What has been discussed in this thesis shows that all different perspectives must be considered. The preservation perspective includes technical experts on the conservation of materials and antiquarians of built heritage with their assessment of cultural and historic values. New ways of undertaking the assessment will evolve. The technical perspective includes experts on constructional problems, installation and energy and so on. Then we have the architectural perspective with its focus on commodity, firmness and delight in the building and its context, structure and physical conditions, and the user aspect of all the different values and functions, and the generalist competence. A way or system of doing overall assessments should be developed. All this together would encapsulate the wholeness of the complex issues. All perspectives belong to the whole and none can be left unheeded.

The next step could be to do an overview of possible priorities, how they could look like in various cases and situations, and if there are more objective or clearer ways of mapping all the aspects. This is important if we are to be able to grasp all a building's inherent capacity to continue contributing to the complex and desirable built environment in an urban context as well in the countryside.

Final comments

Our society can be understood through historical change and our buildings represent our history at certain periods of the development. From this perspective, our built environment concerns and belongs to us all and is there for our needs. The time aspect, participatory aspect and practical aspect mentioned are all parts of a simultaneously stabilising and transformative process. This makes working with our built environment yet more complex. It is important to find approaches and courses of action that simplify the problems without distorting them.

There is imbalance in models and tools. Energy is measurable and assessable. Preservation concerns values not measurable but still assessable, like architecture. This is the first imbalance. Then there is the usable part of architecture, and transformation needs. These do not necessarily emanate from energy issues or preservation. Then there is preservation demanding no alterations or transformations. This is the second imbalance.

When focusing on energy efficiency in the existing building stock, one has to look at it from different perspectives, and perhaps conservation should be considered the major one. Built environment is an important aspect of our heritage worth preserving, but pairing it with energy efficiency implies contradiction. Historic and cultural values are something extant that can be ruined by energy efficiency measures taken with no possible way back. It cannot work the other way around. There is also the discourse on usable values which might have to be given the heaviest weight. After all, we do not maintain buildings to look at them; we have to make use of them. As Della Torre stated[119], architecture must be used to be perceived as architecture. The hypothesis that all perspectives can converge to be met in applied cases has been strengthened. Economic, environmental and social sustainability are natural and uniting approaches in the necessary cooperation.

[119] In a lecture at Workshop III.

An interdisciplinary and transdisciplinary theory building and development of useful methods must entail all aspects discussed. Lessons can be learnt from the development of the trading zone[120] defined as an active arena for negotiations and a field of force corresponding to all actors' policies, values, facts and resources. Can a similar active arena be created for energy and preservation issues in the built environment? And can it gain acceptance and be of use within the construction process at restorations? I think it can, especially if it is there already in the planning phase and has the proper combined tools and models to work with.

[120] The emergence of the trading zone is summarised in Paper no. 3 and is thoroughly explained in Gustafsson (2009).

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Stadshuset, the municipality of Laholm.

Kommunhuset, the municipality of Hylte.

Industristaden AB, Halmstad.

CA Consult, Halmstad.

Architect Håkan Larne, Steninge.

INTERVIEWS AND CONVERSATIONS

Regarding the Halland Model in general:
Björn Ahnlund, antiquarian, Charlotte Skeppstedt, antiquarian, Christer Gustafsson, antiquarian, all working at Heritage Halland.

Regarding the demand on cautiousness in existing buildings, and the law, regulation, mandatory provisions and general recommendations:
Otto Ryding, Boverket, Charlotta Hansson, municipality of Laholm, Karl-Henrik Widén, municipality of Halmstad, Agne Benjaminsson, municipality of Halmstad, Monica Rudquist, municipality of Falkenberg, Pontus Swahn, municipality of Hylte.

Regarding the management within the Halland Model:
Christer Gustafsson, antiquarian, Heritage Halland, Bo Ek, engineer, CA Consult, Lars Harrysson, engineer, own business, Håkan Larne, architect, own business.

APPENDIX

TABLE A and B: The First Object, Fattighuset, Drottning Kristina 2, in the municipality of Halmstad.

TABLE C and D: The Second Object, Teatern, Laxen 5, in the municipality of Laholm.

TABLE E and F: The Third Object, Tyreshill, Rydö 3:20, Rydöbruk in the municipality of Rydöbruk.

Fattighuset, areas, brick walls incl. m^2	Main house	Back wing		Fattighuset, areas, brick walls excl. m^2 Main house A_{temp}	Back wing A_{temp}	
Plan 0	0,0	81,9		0,0	0,0	
Plan 1	360,3	81,9		329,8	71,8	
Plan 2	360,3	76,6		329,8	63,1	
Plan 3	272,4	0,0		267,2	0,0	
Sum	993,1	240,5	1233,6 m^2	926,8	134,9	1061,7 m^2

Fattighuset façades

Main house	Façade surface m^2	Windows m^2	U-value $W/m^2\,°C$	Transm. W/°C	Doors m^2	U-value $W/m^2\,°C$	Transm. W/°C	Rem:g Façade surface m^2	U-value $W/m^2\,°C$	Transm. W/°C
Façade south	113,3	0,0			0,0			113,3	1,8	204,0
Façade east	156,6	26,2	3,0	78,5	9,2	2,7 and 4,5	32,6	121,3	1,8	218,3
Façade north	73,0	10,1	3,0	30,2	2,9	2,7 and 4,5	10,8	60,0	1,8	108,1
Façade west	170,4	40,3	3,0	120,8	0,0			130,2	1,8	234,3
Façade northwest	17,1	4,0	3,0	12,1	0,0			13,1	1,8	23,5
Sum	530,5	80,5		241,5	12,1		43,4	437,9		788,1
Ground floor 1	309,2	0,0			0,0			309,2	0,3	78,8
Ground floor 2	20,6	0,0			0,0			20,6	0,4	8,8
Roof	447,6	3,5	1,4	4,9	0,0			444,0	0,2	68,4
Sum	777,3	3,5		4,9	0,0			773,8		156,0

Back wing	Façade surface m^2	Windows m^2	U-value $W/m^2\,°C$	Transm. W/°C	Doors m^2	U-value $W/m^2\,°C$	Transm. W/°C	Rem:g Façade surface m^2	U-value $W/m^2\,°C$	Transm. W/°C
Façade south	130,2	0,0			0,0			130,2	1,8	234,4
Façade east	4,5	0,0			0,0			4,5	1,8	8,1
Façade north	82,9	16,3	2,7 and 4,5	53,8	21,4	2,7 and 4,5	67,7	45,2	1,8	81,3
Façade west	4,5	0,0			0,0			4,5	1,8	8,1
Façade northwest	22,4	2,7	3,0	8,2	0,0			19,7	1,8	35,4
Sum	244,5	19,1		62,0	21,4		67,7	204,0		367,3
Ground floor	58,5	0,0			0,0			58,5	0,3	14,9
Roof	90,4	0,0			0,0			90,4	0,3	25,9
Sum	148,9	0,0			0,0			148,9		40,8

Table A shows measured areas and surfaces and the U-values used for calculation of heat loss / transmission through the envelope in Fattighuset, Halmstad.

Fattighuset, Halmstad					
Transmission losses envelope					
	Main house	Back wing			
	Σ (U x A)	Σ (U x A)	tot U x A	tot U x A x Δt	tot U x A x Q
Windows	241,5	62,0		Δt 37,5˚C	Q 76,65 k˚Ch
Doors	43,4	67,7			
Brick walls	788,1	367,3			
Ground floor 1	78,8	14,9			
Ground floor 2	8,8	0,0			
Skylight	4,9	0,0			
Roof	68,4	25,9			
Sum	1234,0	537,7	1771,7	66,4 kW	135811 kWh

Heat loss ventilation	Main house 0,35 l/s, m^2 and 7,0 l/s, person		Back wing 0,35 l/s, m^2 natural ventilation		
Exhaust air volume	2690 m^3		520 m^3		
A_{temp}	926 m^2		135 m^2		
Air density ρ	1,2 kg/m^3		1,2 kg/m^3		
Heatcap, dry air c	1,0 kJ/kg˚C		1,0 kJ/kg˚C		
Degreehours Q	76,65 k˚Ch		76,65 k˚Ch		
Flow	0,46		0,05		
Heat	0,5568 kJ/s˚C		0,0566 kJ/s˚C		
Sum		42678 kWh		4338 kWh	47016 kWh in total

Hot tap water and heat loss			
Tempered water 600 m^3 in	8˚C	tempered water in	8˚C
of which 33 % is heated to	60˚C	tempered water out	23˚C
1,16 kWh/˚C and m^3	Δt 52˚C		Δt 15˚C
Sum heat for tap water	12052 kWh	***Sum heatloss***	10440 kWh

Internal generation of heat			
From people	3600 kWh	***Sum heat energy losses 194 770 kWh***	***194,8 MWh***
From equipment	18000 kWh	***Sum internal heat generation 21 600 kWh***	***21,6 MWh***
Sum	21600 kWh	***Sum bought heat energy 173 170 kWh***	***173,2 MWh***

Table B shows input data, calculated aggregate heat loss minus internal generated heat, giving the total heat demand in Fattighuset, Halmstad.

Teatern, areas, brick walls incl. m²		***Teatern, areas, brick walls excl. m²***		
			A_{temp}	
Plan 0	393,0	345,0	0,0	
Plan 1	393,0	345,0	345,00	
Plan 2	595,0	540,0	540,00	
Attic floor insulated	290,8	265,0	0,0	
Attic floor	304,0	275,0	0,0	
Sum	1975,8	1770,0	885,0	m^2

Teatern fasçades	Façade surface m^2	Windows m^2	U-value W/m^2 °C	Transm. W/°C	Doors m^2	U-value W/m^2 °C	Transm. W/°C	Rem:g Façade suface m^2	U-value W/m^2 °C	Transm. W/°C
Façade south 1a	149,5	32,0	3,0 and 1,9	81,4	7,7	3,0 and 2,3	20,2	109,8	1,0	112,0
Façade south 1b	98,1	11,8	3,0	35,5	5,7	2,3 and 4,5	19,0	80,6	1,4	115,3
Façade south 2	16,8	0,0			0,0			16,8	1,4	24,0
Façade west 1	172,5	24,9	3,0	74,6	3,5	2,3 and 4,5	11,4	144,1	1,4	206,1
Façade west 2	124,0	19,4	3,0	58,3	0,0			104,6	1,4	149,5
Façade north 1	109,8	14,9	3,0	44,6	3,4	2,3 and 4,5	11,1	91,6	1,4	131,0
Façade north 2	100,7	20,8	3,0	62,5	10,1	2,3 and 3,0 and 4,5	28,8	69,7	1,4	99,7
Façade east 1	26,9	2,9	3,0	8,6	0,0			24,0	1,4	34,3
Façade east 2	28,1	7,5	3,0	22,4	0,0			20,6	1,4	29,4
Sum	826,3	134,1		387,9	30,4		90,5	661,8		901,3
Ground floor	345,0	0,0			0,0			345,0	0,2	63,5
Attic floor insulated	265,0	0,0			0,0			265,0	0,1	30,4
Attic floor	275,0	0,0			0,0			275,0	0,1	39,3
Sum	885,0	0,0			0,0			885,0		133,2

Table C shows measured areas and surfaces and the U-values used for calculation of heat loss / transmission through the envelope in Teatern, Laholm.

Teatern, Laholm			
Transmission losses envelope			
	tot U x A	tot U x A x Δt	tot U x A x Q
Windows	387,9	Δt 35,5˚C	Q 79,29 k˚Ch
Doors	90,5		
Brickwalls	901,3		
Ground floor	63,5		
Attic floor, insulated	30,4		
Attic floor	39,3		
Sum	1512,9	53,7 kW	119982 kWh

Heat loss ventilation	Teatern incl. Barocken	The shop	
	7,0 l/s, person,	0,35 l/s, m^2	
	mech. vent. heat recov.	mechanical exhaust air ventilation	
Exhaust air volume	1509 m^3	1135 m^3	
A_{temp}	272 m^2	307 m^2	
Air density ρ	1,2 kg/m^3	1,2 kg/m^3	
Heatcap, dry air c	1,0 kJ/kg˚C	1,0 kJ/kg˚C	
Degreehours Q	79,29 k˚Ch	79,29 k˚Ch	
Flow	0,42	0,11	
Heat	0,50 kJ/s˚C	0,13 kJ/s˚C	
Sum	1117 kWh	10181 kWh	11298 kWh in total

Hot tap water and heat loss			
Tempered Water 200 m^3 in	8˚C	tempered water in	8˚C
of which 33 % is heated to	60˚C	tempered water out	23˚C
1,16 kWh/˚C and m^3	Δt 52˚C		Δt 15˚C
Sum heat for tap water	4017 kWh	***Sum heatloss***	3480 kWh

Internal generation of heat			
From people	4110 kWh	***Sum heat energy losses 135 297 kWh***	***135,3 MWh***
From equipment	9164 kWh	***Sum internal heat generation 13 274 kWh***	***13,3 MWh***
Sum	13274 kWh	***Sum bought heat energy 122 023 kWh***	***122,0 MWh***

Table D shows input data, calculated aggregate heat loss minus internal generated heat, giving the total heat demand in Teatern, Laholm.

Tyreshill, areas, walls incl. m²				***Tyreshill, areas, walls excl. m²***		
	Main house	Shed		Main house A_{temp}	Shed A_{temp}	
Plan 1	110,8	42,5		98,4	38,3	
Plan 2	110,8	0,0		98,4	0,0	
Attic floor insulated	110,8	0,0		0,0	0,0	
Sum	332,3	42,5	374,8 m²	196,8	38,3	235,1 m²

Tyreshill façades

Main house	Façade surface	Windows	U-value	Transm.	Doors	U-value	Transm.	Rem:g Façade	U-value	Transm.
	m²	m²	W/m² °C	W/°C	m²	W/m² °C	W/°C	surface m²	W/m² °C	W/°C
Façade northwest	95,0	9,8	2,0	19,7	2,1	2,7 and 4,5	6,9	83,1	0,3	25,6
Façade southwest	86,1	8,1	2,0	16,2	0,0			78,0	0,3	23,9
Façade southeast	93,0	9,2	2,0	18,5	2,1	2,7 and 4,5	6,9	81,7	0,3	25,4
Façade northeast	85,8	9,7	2,0	19,4	2,1	2,7 and 4,5	6,9	74,0	0,3	22,9
Sum	359,9	36,9		73,8	6,3		20,8	316,7		97,8
Ground floor	98,4	0,0			0,0				0,2	15,1
Attic floor insulated	98,4	0,0			0,0				0,2	15,1
Sum	196,8	0,0			0,0					30,1

Shed	Façade surface	Windows	U-value	Transm.	Doors	U-value	Transm.	Rem:g Façade	U-value	Transm.
	m²	m²	W/m² °C	W/°C	m²	W/m² °C	W/°C	surface m²	W/m² °C	W/°C
Façade northwest	13,2	0,0			6,6	2,7	17,8	6,6	0,3	2,0
Façade southwest	24,6	0,4	2,0	0,7	0,0			24,2	0,3	7,2
Façade southeast	14,0	0,7	2,0	1,4	0,0			13,3	0,3	4,0
Façade northeast	24,6	0,5	2,0	1,1	1,6	2,7	4,3	22,5	0,3	6,7
Sum	76,4	1,6		3,2	8,2		22,1	66,6		19,9
Ground floor	38,3	0,0			0,0			38,3	0,4	16,3
Roof	38,3	0,0			0,0			38,3	0,2	6,7
Sum	76,6	0,0			0,0			76,6		22,9

Table E shows measured areas and surfaces and the U-values used for calculation of heat loss / transmission through the envelope in Tyreshill, Rydöbruk, Hylte.

Tyreshill, Rydöbruk, Hylte

Transmission losses envelope

	Main house Σ (U x A)	Shed Σ (U x A)	tot U x A	tot U x A x Δt	tot U x A x Q
Windows	73,8	3,2		Δt 37,5˚C	Q 84,88 k˚Ch
Doors	20,8	22,1			
Walls	97,8	19,9			
Ground floor	15,1	16,3			
Attic floor insul. and Roof	15,1	6,7			
Sum	222,5	68,2	290,7	10,9 kW	24671 kWh

Heat loss ventilation	Main house 0,35 l/s, m^2 natural ventilation	Shed 0,35 l/s, m^2 natural ventilation	
Exhaust air volume	472 m^3	73 m^3	
A_{temp}	197 m^2	38 m^2	
Air density ρ	1,2 kg/m^3	1,2 kg/m^3	
Heatcap, dry air c	1,0 kJ/kg˚C	1,0 kJ/kg˚C	
Degreehours Q	84,88 k˚Ch	84,88 k˚Ch	
Flow	0,16	0,02	
Heat	0,19 kJ/s˚C	0,03 kJ/s˚C	
Sum	16290 kWh	2540 kWh	18830 kWh in total

Hot tap water and heat loss			
Tempered water 200 m^3 in	8˚C	tempered water in	8˚C
of which 33 % is heated to	60˚C	tempered water out	23˚C
1,16 kWh/˚C and m^3	Δt 52˚C		Δt 15˚C
Sum heat for tap water	4017 kWh	***Sum heatloss***	3480 kWh

Internal generation of heat			
From people	2627 kWh	***Sum heat energy losses 47 518 kWh***	***47,5 MWh***
From equipment	5971 kWh	***Sum internal heat generation 8 598 kWh***	***8,6 MWh***
Sum	8598 kWh	***Sum bought heat energy 38 920 kWh***	***38,9 MWh***

Table F shows input data, calculated aggregate heat loss minus internal generated heat, giving the total heat demand in Tyreshill, Rydöbruk, Hylte.