Energy Efficiency and Preservation in Our Cultural Heritage: EEPOCH

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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.

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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.

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Most of us like a varied and diverse built environment – not a monotonous one – and this is also what environmental psychologist 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 variation of living and activities like working places, different forms of housing with different ownership categories, meeting places and a variation of services et cetera, and design variations in the built environment is seen as something desirable. The ideal is the city around the year 1900 according to the text. It seems that the bustling inner city with its diversity, complexity and vitality to some extent could serve as a model, even in changes in large-scale districts of suburban.

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 speak with 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 last 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 functioning. 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 there 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. All old and traditional materials and techniques are not healthy, though. The heritage sector[9] has e.g. 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 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 cause need for new development areas leading to large transformations or demolitions. A 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 the cultural heritage.

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 requested of the building, then there is no incentive for preserving it, looking upon it pragmatically. Avoiding loss of built cultural heritage and keeping the desirable diversity and complexity in our built environment, demand 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

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[7] McDonough, William & 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 the national monuments, built heritage and artefacts, archaeology matters and handles the national legislation, furthermore the universities and the museums on national, regional and local levels, and the branch of conservation officers, architects, archaeologists, entrepreneurs and all others interested and volunteers engaged in cultural heritage on national, regional and local level.

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

legitimacy to construction on the whole. [...] All buildings are expected to modify strongly varying local exterior 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.

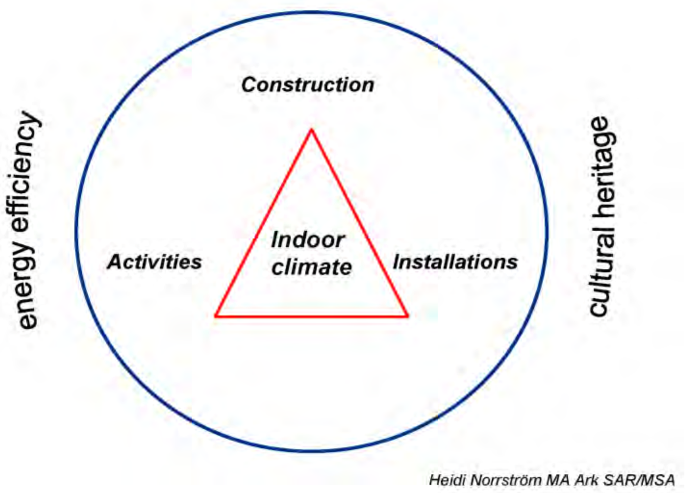

Figure 1 View taken on the buildings reviewed in the EEPOCH project

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 project EEPOCH.

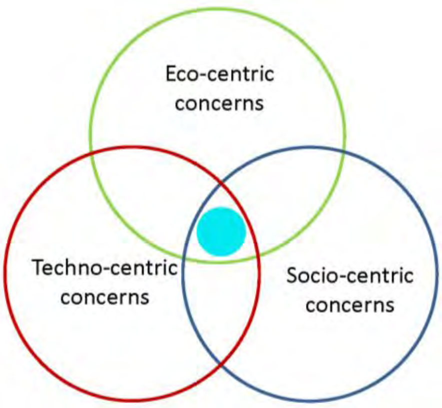

Figure 2 The three pillars according to the Royal Academy's Guiding principles for sustainable development.

The Eco-centric concerns natural resources and ecological capacity, the socio-centric concerns the human capital and social expectations, the techno-centric concerns the 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.'

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[11] Edén, Michael 2007. *Energi och byggnadsutformning*. 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 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, 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 e.g.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 on 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 of incandescent light bulbs will make an impact on the electricity use. But the issue on energy efficient buildings is quite different.

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

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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

[17] Energimyndigheten (2009). *Energiläget 2009 ET 2009:28.* Eskilstuna: Statens Energimyndighet.

% 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 has been 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] earlier 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 dusky history of demolished buildings dating back to the 1960s and 1970s. Housing constructed before 1945 amount to about 33 % [23] of the total 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 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 on 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 to the cultural and historic values in our built heritage. There is an obvious need of 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.

According to the Swedish government's national environmental objective Good Built Environment[26] the cultural, historical and architectural heritage as buildings and built environments with special

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[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 & 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

[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

values should be protected, developed and identified by 2010. Earlier in the 1980s when national financing was available, about 3 000 objects/buildings was 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 sector 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 managing 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 operating about 100 historic buildings at risk, under supervision of skilled craftsmen and conservation officers. Selected objects included castles, windmills, industrial sites, dwellings, warehouses, and theatres among others. '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. The probably last object restored and rebuilt within the Halland Model, in Sweden, was an old fire station which was transformed to 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 added 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, and about 200 ones more indirectly. The Halland Model has been exported e.g. to the Baltic Sea Region, Russia, Poland and Iceland as regional projects for sustainable development and the experiences of the Halland Model has been widely disseminated. The Halland Model is a good example of the tendencies or trends within the heritage sector

[27] The Halland inventory was carried out by antiquarian of built heritage Björn Ahnlund at Heritage Halland and will be available at the County Councils 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.* Göteborg: Chalmers University of Technology.

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 holds examples on managing of energy performance without diminishing the 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 carries 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 in our built cultural heritage prevents actual efficiency potential to be 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 are (1) Fattighuset in the municipality of Halmstad, a brick construction with a general plan and great preserved historic values. Fattighuset are 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 such, and with an added interior insulation. These buildings exemplify some of the most difficult conditions in older buildings to work with and find solutions for regarding the construction when it comes to energy efficiency. Simultaneously the issues on 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 project EEPOCH 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 to investigate and problematize 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 for 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 made from them? There were very few hits altogether and most of them emphasizing just one side e.g. energy use in old buildings without discussing their historic values. Or in other cases restoration problems were emphasized without giving any answers on how to implement energy efficiency measures. And some specifically emphasized sustainability problems, of which some may have relevance and are applicable to heritage issues. In some cases the articles concerned interesting material issues connected to refurbishment. Some of the articles were of 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 is not explored to a greater extent and is still not established. It demonstrates the need and reinforces the decision on investment 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 answers to the questions asked at the beginning of the search are that there are others working in the same area with the combination of energy efficiency and heritage area, but they are 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. By 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 holds a complex set of problems within, and different methods for the various parts was needed, which is the content 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 the 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 is presenting 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 is a summarizing discussion and ideas and plans for continued work are presented. This includes both 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 shows the participating people and the relations of the different research activities and units of analysis. The participating professionals, the workshops and the case are the core of the study. Valuating the energy issues is pure empirical work with numbers and figures but to see 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. Valuating cultural and historical issues demands knowledge as well as experience. Finding objects for valuation 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 are the different subtopics arranged. Some of them were planned from the beginning and some evolved during the workshops. Architectural values, actions and effects of proposed actions, and 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 on the top of the figure were consulted, in the research work with all the eight units. Found facts and results from this study of the objects, forms the basis for the summary and conclusions in the box at right.

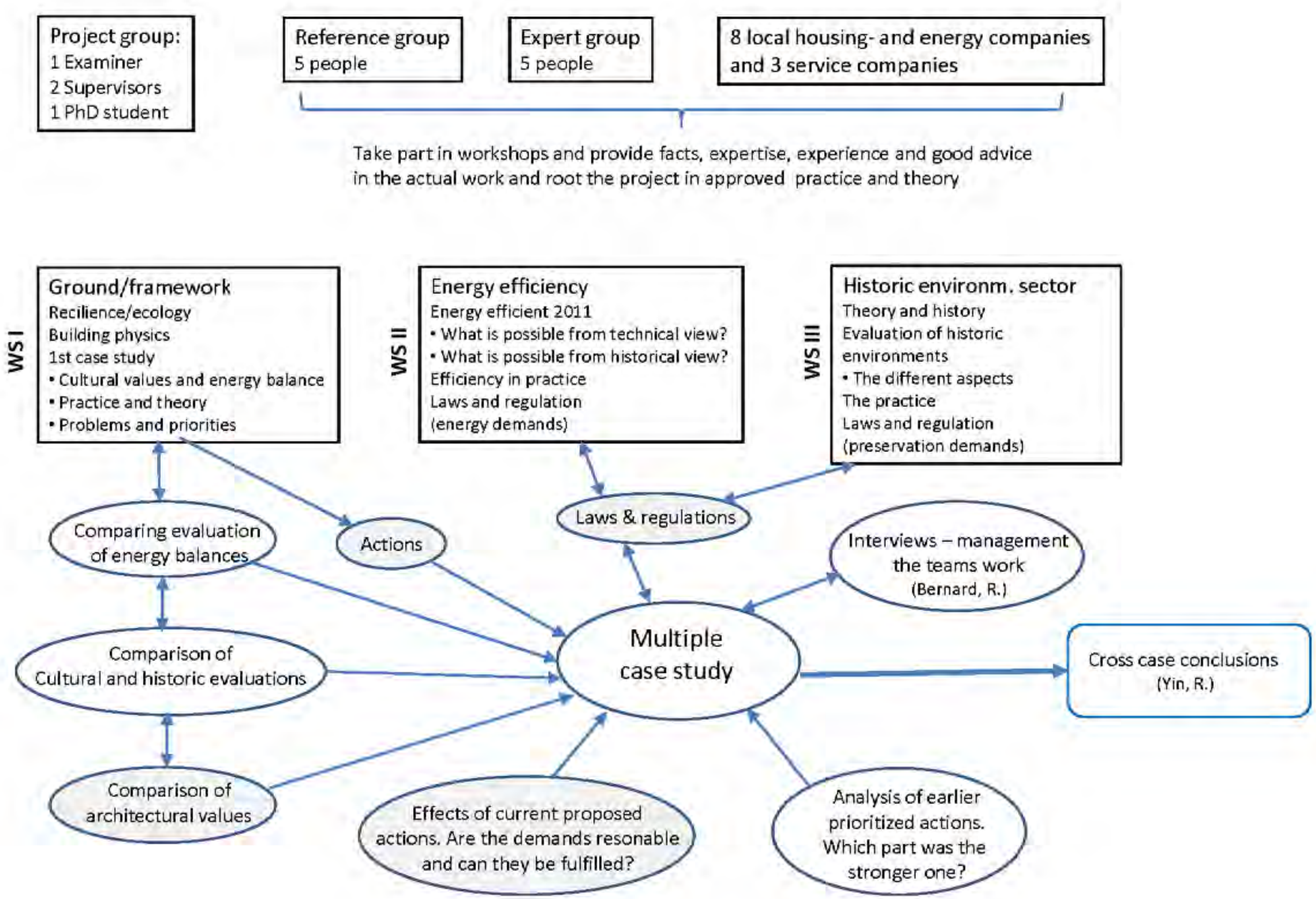

Figure 3. Overall scheme on EEPOCH for communication of the research.

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 notion case study is used to describe the work with the restored buildings, both the actual artefacts and the people working on them. 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 Fattighuset in the municipality of Halmstad, a solid brick construction with an attached wing built in the backyard. It is used for shops, workshops and for offices. The second building is the theatre in the municipality of Laholm, Teatern, a plastered solid brick construction. Tyreshill in Rydöbruk in the municipality of Hylte is the third and smallest object. It is used by one family for both living and a workshop. It has a wooden construction, and a solid such. These buildings exemplify some of the most difficult conditions in older buildings to work with and find solutions for regarding the construction and the issue of energy efficiency. The screening to find them included local archive studies in Halmstad of all hundred objects restored within the regional project the Halland Model.

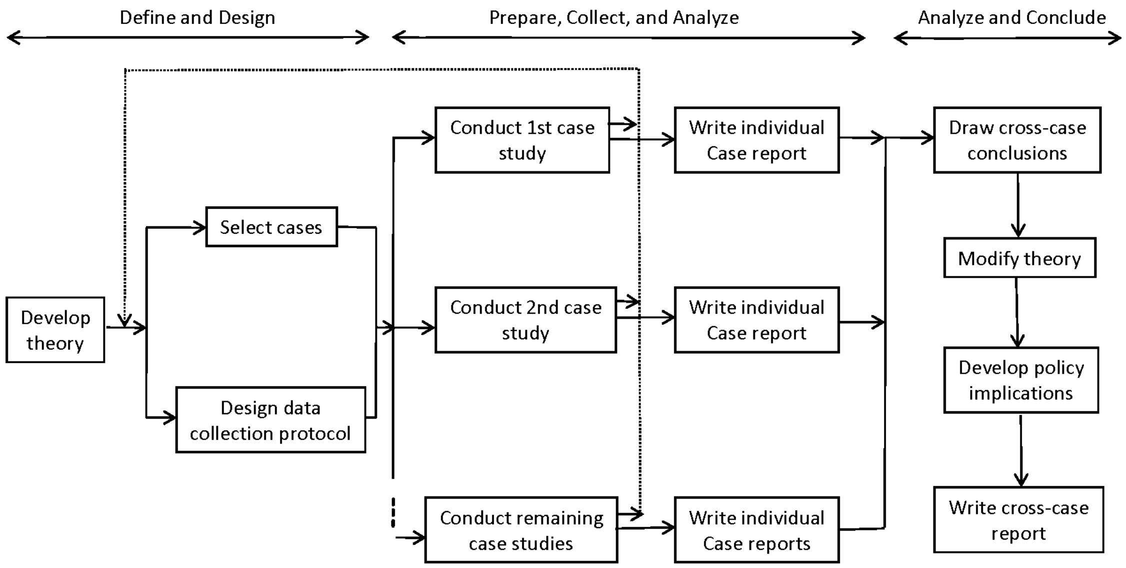

Figure 4 Schedule for the implementation of a case study method with its' different phases, freely sketched from Yin 2009. Case Study Research, Design and Methods, p. 57.

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 of demands emerges from the cases of which some show predicted similar results, - a literal replication, and 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 a possible hypothesis or broader theory.

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

The structures for the case study composition are two. A linear-analytic structure is used for explanatory, descriptive and exploratory purpose which is a standard approach. A theory-building structure is used for explanatory and exploratory purpose[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 analyze	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 cases i.e. restored buildings, is an empirical study in the positivism tradition, pure facts so to speak, and possible to interpret for analysis. This also applies for the assessment of historic and cultural

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

values but the base is the humanities and their historicism. The architectural values or performance are estimated primarily 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 in 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] along the way: '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, to create a case study database, and to maintain 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 the 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. To assess 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 analyzing the objects cultural values emanates from the humanities and historicism and from development of architecture, sociology, society and technology. Authenticity, patina, continuity, symbol value, rarity and other values are considered in the valuation. In a way this can be related to (post)structuralism, due to the evaluating of the qualities and values which is done in a sense of meaning 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 was. 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 analyzed.

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

[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] is stated that we have some common notions for what good architectonic quality is. Usually it means that a building is designed and shaped to adapt to the surroundings, with originality in design, and thoroughly worked through down to 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' achieved energy performance after restoration, and to set it in relation to the achieved degree of preserved cultural and historic values.

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. By this follows that heating can be reduced by minimising loss. This is what the Kyoto pyramid[37] is based on.

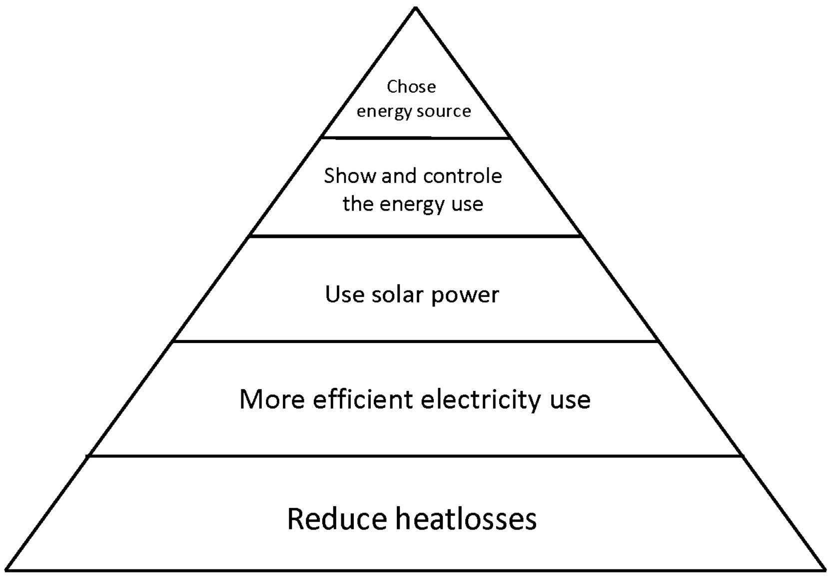

Figure 5. The Kyoto-pyramid emphasizes the reduction of heat losses.

In new constructions the reduction of heat loss through an envelope with low U-values is no problem. In existing constructions a well insulated facade can be as good. An exterior insulation is to prefer as thermal bridges are built in and covered and it keeps the wall warm. This will not do if the facade 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 cannot dry out moisture from

[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 for showing the basic principles for low energy constructions like the passive houses.

precipitation. At cold outdoor temperatures this can cause damage on the exterior facade material when the captured moisture freezes. The thermal bridges at joists or concrete slabs and inner walls, adjoining to the outer walls become exposed areas [38] [39]. These are important basic facts when valuating existing buildings' energy balances and performance, and possible improvement.

The valuation of the objects energy performance was carried out in three ways: With IR 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 showing that the building was maintained very well but could also detect problems indicating actions to be taken and show what could be improved. In *Achieving the Desired Indoor Climate*[40] on energy balance is stated 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. And according to the other 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 that is processed; the simpler the method is the less data. Some of the books were checked for finding the λ–values and to compare if 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 get 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 the general correction and some special thermal resistances were added as stated in the books.

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[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.

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

(Equation 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 standard formula today, from Boverket's mandatory provisions, the thermal bridges χ and Ψ-values, are added and this is the biggest change compared with old formulas. 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 in how much of the solar contribution that really can be of benefit can justify neglecting this effect in simple calculations according to Elmroth[50]. In Boverket's handbook it is also recommended to use degree days or degree hours for simple manually performed calculations which is the choice 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.

First thing to do is always to measure the building's plan and façade from prints. The areas and surfaces for Fattighuset were measured by using the software programme Auto Cad. Measuring the other two objects was carried out with pen and paper using a ruler which was easier. This part is the most time consuming and has to be done whether to use computer in the next step or not. 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 for the old windows to which the values were fetched from the books' different lists. Indoor temperature was measured in 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 air circulation at workplaces recommended[52] is 7 litres per second and person plus 0.35 l/s and m^2 floor area. For other buildings 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 formulas were used. For specific flow one multiplies the room air volume with the air circulation needed, equation no. 3. For specific heat, the specific flow is multiplied with air density and heat

[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

capacity of dry air, equation no. 4. By multiplying the specific heat with degree hours one gets the heat energy demand or in this case the loss, equation no. 5. All figures used for this are in tables B, D and F in the appendix. So are the figures for heat demand for hot tap water, and the internal generated heat.

$$\text{Specific flow} = \frac{V \times \text{air circulation}}{3600}$$ *(Equation no. 3)*

$$\text{Specific heat} = \text{specific flow} \times \rho \times c$$ *(Equation no. 4)*

$$\text{Heat energy loss} = \text{specific heat} \times Q$$ *(Equation no. 5)*

Specific flow has the dimension 1/h
V = room air volume, m^3
Air circulation, m^3/h and m^2
Specific heat, kJ/s and ˚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 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 fit in the building. The other end use is for household or business purpose. The division of the electricity use was roughly calculated by measuring and counting the number of people working or living there and of 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.

ADD A DRAWING!

1

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.

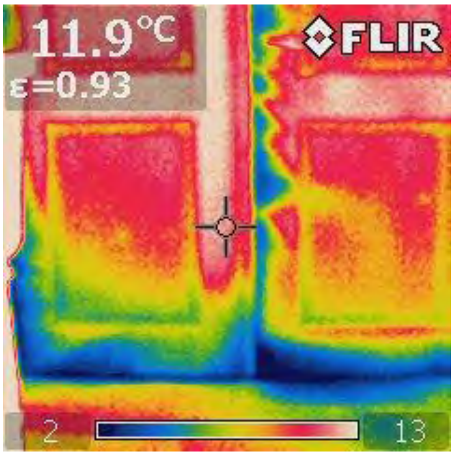
Construction

The main building is a two storey building of 1 ½ brick-stone construction with an attic and 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. 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 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. Of this is hot tap water 12 MWh/year and the calculated heat loss through the ventilation is 47 MWh/year. Key figure for district heating is 176 kWh/m^2 and year. Calculated total demand is 173 MWh/year and the key figure should be 163 kWh/m^2 and year. The difference in figures is likely due to infiltration of air into the building envelope. Using IR, infrared, camera gave some possible answers.

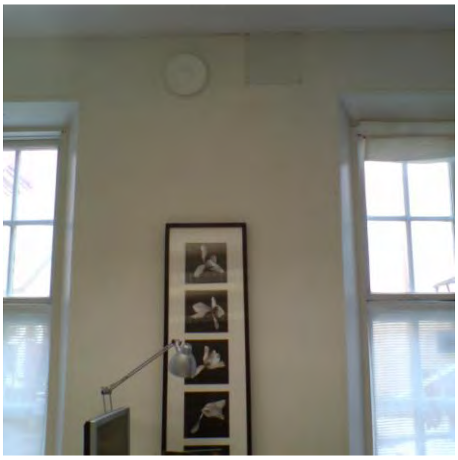
1

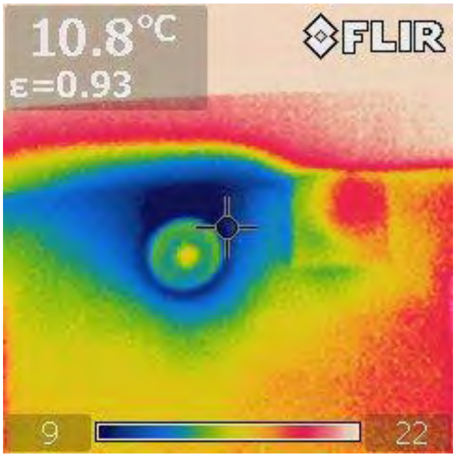


1

Photo 1 and IR photo 1. 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. Photo Heidi Norrström.

Electricity
The figure for total average bought electricity 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 and 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.


2



2

Photo 2 and IR photo 2.The supply air is distributed by fresh air vents in the external brick walls in Fattighuset. Photo 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 backwing has natural ventilation but exhaust air ventilation can be turned on if and when needed. The tenants are experiencing a very bad 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 to +9˚C and simultaneously the temperature outdoor were measured to 0˚C in the winter 2010. The temperature zone that was able for use was 1.5-2 metres away from the wall. The windows are not airtight and are causing draught. In addition there is a feel of cold draught from the cold windows glazing 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 at the attic floor are overly heated and at worst +30˚C according to the tenants. The 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
Key figure for energy consumption is 204 kWh/m^2 and 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 and 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 and year for heating, hot water and electricity for running in the manual calculation and 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 planning 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 lowemission glazing to prevent feel of draught through convection and 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 when this issue is addressed 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 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 for mould the value of this factor f must be at least 0.7 at the most unfavourable point which often is 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. 6)

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 than the 0.7 that is stated as the lower limit. On the ground floor in a room facing the west the following temperatures gives 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

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

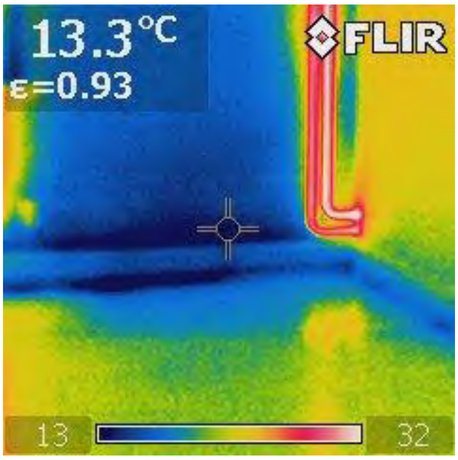
[54] The list of possible measures is to be found in paper no. 2.

[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

both are below 0.7. The outcome of adding a thin layer of lime plaster or nanogel/aerogel or vacuum insulation could be calculated regarding the outer walls' ability of handling heat transmission and moisture.

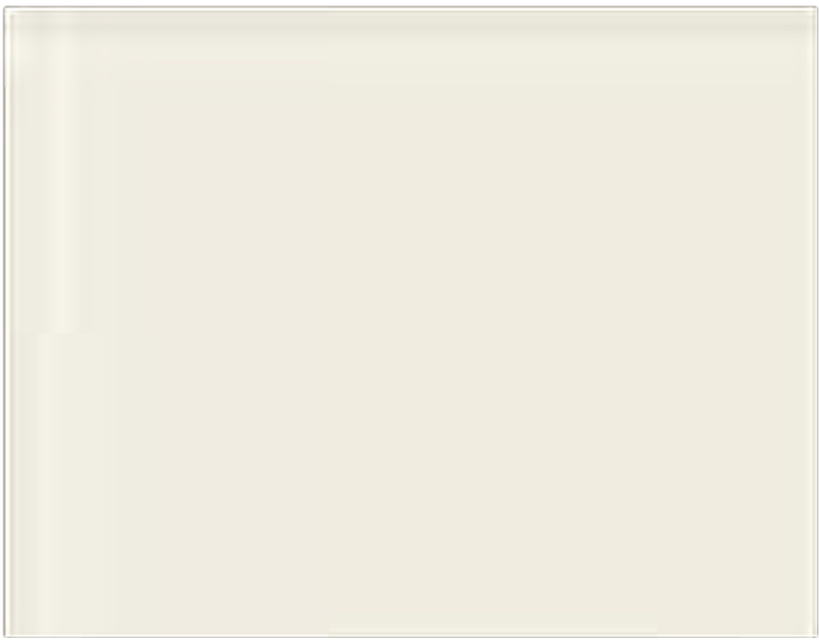


3

IR photo 3. The thermal bridge where the floor is adjoined to 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 a top priority. Fattighuset is also described in paper no. 1, paper no. 2 and in paper no. 3.

ADD A DRAWING!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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 and 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 facades 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 moist problem on the interior walls. Total area heated to +10°C or more, 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 radiator system. The theatre and hotel have had the same meter for many years. The bought amount of natural gas, water and electricity is estimated from an energy declaration made by HEM in Halmstad. The estimation of A_{temp}, in % on the different parts has been used as 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, during 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 and therefore less occupied and because it has no electrical equipment in continuous use as the hotel has. The calculated use of water is 200 m^3/year of which an estimated 33% is heated for hot tap water use.

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

Calculated total demand is 122 MWh/year. Of this is hot tap water 4 MWh/year and the calculated heat loss through the ventilation is 11.3 MWh/year and the key figure should be 138 kWh/m^2 and year. The difference in figures may be caused by the way heat loss through ventilation is calculated, by m^3 and litres, which disadvantage rooms with high ceilings as the theatre is 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 bought electricity 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 purpose. 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 and 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 the chilled draught in wintertime when customers arrive through opening the entrance door. An internal wind catcher with an extra door to open could be built and ease the cold draught. This would not alter the exterior façade but 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 was at the same time measured to +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 used for intermittent operation which is estimated to 600 hours /year.

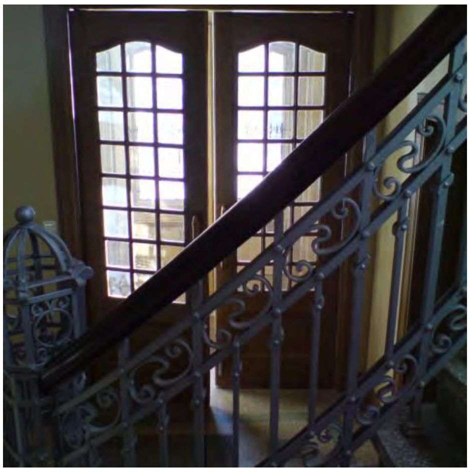
The fact that the ventilation was turned on only when needed was not known when paper no. 2 was written, hence the diverging figures on energy consumption. The first calculated results presented in paper no. 2 presupposed running of the air handling system all 8760 hours of the year.

Evaluation

The estimated key figure for energy consumption is 122 kWh/m^2 and 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 123-185 kWh/ m^2 and 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 and 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 and year are still average compared with the category, type code 826, statistic interval 123-185 kWh/ m^2 and 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.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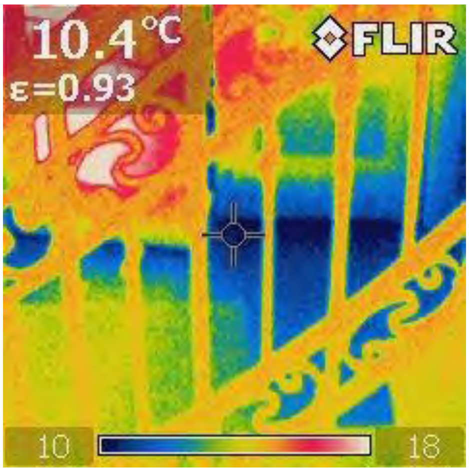

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Photo 3 and IR photo 4. There is a constant draught from the main entrance doors at Teatern which has to be taken care of. Photo Heidi Norrström.

The signs of moist problem 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.6 for checking the risk of condensation at the dew point and mould growth inside a construction gives that there are no risks on the south facade 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 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.


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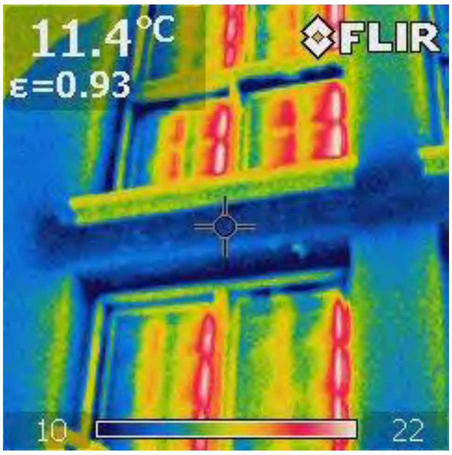

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Photo 4 and IR photo 5. A severe damage at the first floor have appeared and the low surface temperatures is giving f = 0.71 just above the limit of risk for condensation and mould growth in the construction. Photo to the left by Maja Lindman and to 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 severe damage which they have tried to mend but it did not help. 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 only at 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 at 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.

The cement based plaster on the outside surface of the facades 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 the diffusion towards the outer surface of the wall. As the cement has a 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 of 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 '*Humidity measurement in buildings*'[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.

ADD A DRAWING!

3

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[58] Åhström Michael, et al. (2005). *Rätt murat och putsat*. Stockholm: Svensk Byggtjänst. 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 et al (2006) *Humidity measurement in buildings*. Stockholm: Formas

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 facade.

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 got 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 have one ordinary pane and one with low emission on the interior side. The foundation is of granite and was at the restoration filled up with light clinker material and a concrete floor was cast. The first floor has wooden joists. Using IR, infrared, camera gave a positive view on the state of the facades. There are problems in the winter with ice forming on the ground at the northwest facade 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 that is burned so it is difficult to say how much they contribute to the buildings heating. Bought average amount of pellets 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. Key figure for bought heating and hot water is 149 kWh/m^2 and year. Calculated total demand is 38.9 MWh/year and the key figure should be 166 kWh/m^2 and year. The difference in figures could be due to a very good standard of the 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 bought electricity based on the last three years is 10.4 MWh/year. By subtracting the electricity use for the household and business purpose, including electricity for the operation of the kiln, the figure 2 MWh/year is left for running of the building which gives 8 kWh/m^2 and 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 the 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 at the same time measured to +2.3°C. 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 the very good comfort.

Evaluation

Key figure for energy consumption is 157 kWh/m^2 and 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 and 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 and 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 statistic interval.


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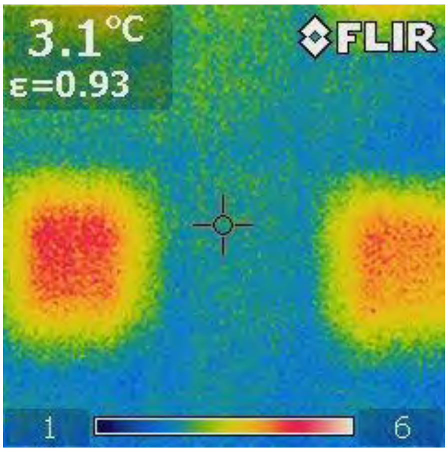

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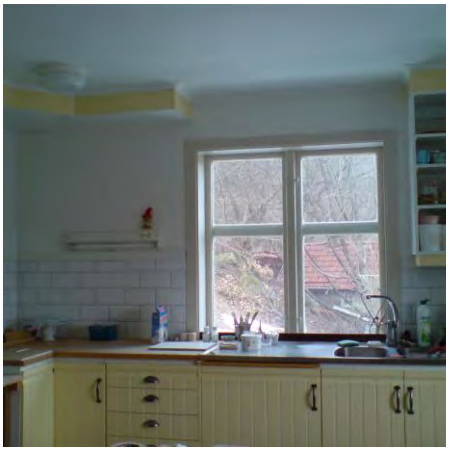
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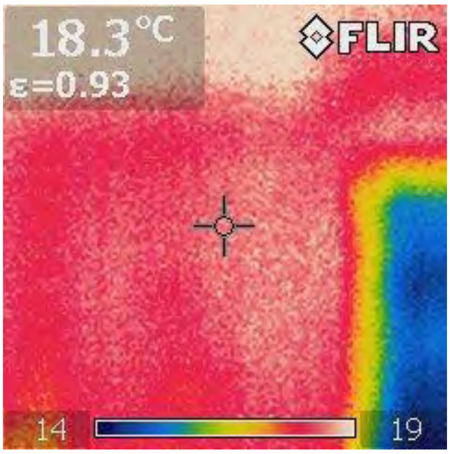

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Photo 5and and 6, IR photo 6 and 7. The northeast façade of Tyreshill show favourable, but energy consuming, conditions in the building's structure. Photo Heidi Norrström.

In this object the IR, infrared, camera gave a positive view on the state of the facades. 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.

 7

Photo 7. To the left in this picture the ice forming on the ground is showed. The hillside is leaking water which at winter freezes. 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 facade was probably the cause of the bad condition 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 a proper drainage. Tyreshill is also described in paper no. 3.

Comparison of the three objects

Calculated	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	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 statistic interval fetched 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 building is also showed 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 keys to low figures. Fattighuset and Tyreshill are equally good, or bad, regarding the heating but differ in electricity use which was expected due to different activities on the premises. If Fattighuset should have 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.

Looking at the measured figures for Fattighuset and Tyreshill they 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 is high according to the statistic 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 year with an addition of 20 % up to 132 kWh/m^2 and 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 statistic interval for this kind of building in type code 826. There are some problems with moisture and draught but if a new restoration was to be carried out it would probably be possible to reach the demanded 110-132 kWh/m^2 and year.

Corresponding figures for Tyreshill are low and very low compared with the statistic 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 statistic interval fetched 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 building is also showed for comparison.

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

Figures for calculating the CO_2 emission from the heating and hot tap water are fetched 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 is to a large extent using renewable energy sources. 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 should have continued growing and then decay and rot in the forest it should have emitted exactly the same amount too. 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 regarding greenhouse gas and the 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.

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 was used to avoid arbitrary/subjective valuation. 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 a valuation 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.

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

[63] Unnerbäck, Axel (2002). *Kulturhistorisk värdering av bebyggelse*. Stockholm: Riksantikvarieämbetet

[64] Robertsson, Stig (2002). *Fem pelare – en vägledning för god byggnadsvård*. Stockholm: Riksantikvarieämbetet

The document values are based on historic 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 require 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 valuation in three steps, linked with two steps for choice of level of preservation and follow-up. The two latter steps are not showed 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, and 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 related to history or historical architects, but nothing on the analysis. From an architectural point of view this was a deficiency found during the work.

IDENTIFICATION BASIC MOTIVE		PROCESSING REINFORCING / OVERALL MOTIVE		VALUATION BALANCED MOTIVATION
1. Document values (historical properties) • construction historical value • building technology historical value • patina • architectural historical value • community /society historical value • social history value • person historical value • technohistorical 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 dominating basic motive) • ADDITIONAL BASIC MOTIVE • REINFORCING / OVERALL MOTIVE

Table 5. Translation of the checklist for valuation 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 an 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.

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

To get an overview and comparison of the three objects, a table was made in which the found cultural and historical values 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 found values.

IDENTIFICATION BASIC MOTIVE							
1. Document values	**FATTIG-HUSET**	**TEATERN**	**TYRES-HILL**	2. Experienced values	**FATTIG-HUSET**	**TEATERN**	**TYRES-HILL**
construction historical value	**X**	**X**	**X**	architectonic value			
building technology historical value	**X**	**X**	**X**	artistic value		**X**	
patina	**X**	**X**	**X**	patina	**X**	**X**	**X**
architectural historical value	**X**	**X**	**X**	value for surrounding environment	**X**	**X**	**X**
community/society historical value	**X**	**X**	**X**	identity value	**X**	**X**	
social history value	**X**	**X**	**X**	continuity value	**X**	**X**	**X**
person historical value				value of tradition	**X**	**X**	
techno historical value		**X**		symbolic value	**X**	**X**	

Table 6 The basic motives divided into document values and experienced values according to NHB's Handbook. Found motives in the three objects are marked with an X.

At a quick glance it seems as if Teatern is somewhat more valuable, or have 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 on 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 analyze 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 the table X 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 level. Everything has a quality, may it be 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 was added. The same was done to the other reinforcing motives. This made it possible to decide which reinforcing motive that 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 historical 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 the table X of basic motives below.

IDENTIFICATION BASIC MOTIVE							
1. Document values	**FATTIG-HUSET**	**TEATERN**	**TYRES-HILL**	2. Experienced values	**FATTIG-HUSET**	**TEATERN**	**TYRES-HILL**
construction historical value	**X** high	**X** high	**X** medium	architectonic value			
building technology historical 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 historical value	**X** medium	**X** medium	**X** medium	value for surrounding environment	**X** high	**X** high	**X** medium
community/society historical value	**X** regional local	**X** local	**X** local	identity value	**X** high	**X** high	
social history value	**X**	**X** local	**X** medium	continuity value	**X** high	**X** high	**X** medium
person historical value				value of tradition	**X** high	**X** high	
techno historical value		**X** medium		symbolic value	**X** high	**X** high	

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

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

FATTIGHUSET, Drottning Kristina 2, in the municipality of Halmstad
The basic motives are the two buildings' high degree of well preserved historical values in both construction and technology and patina both in document value and experienced value, reinforced by the high 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 ability to do so by themselves. Buildings of this type of construction for this specific purpose in the middle of the city and so well preserved are rare both on local and regional levels. The drawings for Fattighuset are by Hans Strömberg, head architect in the city of Gothenburg at the time.

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

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, has been preserved. By this the physical and experienced authenticity is high both in details and in the whole.

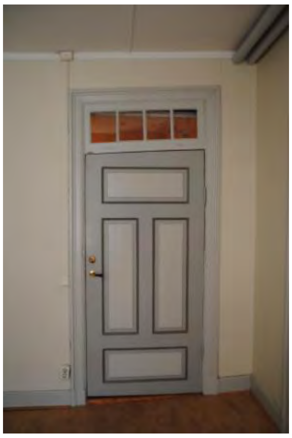 8

Photo 8. A door in Fattighuset that has been adjusted to fit in the doorway. Photo 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 continued throughout their lives, which gives a high value of tradition and continuity. 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.

TEATERN, Laxen 5-8, in the municipality of Laholm
The only object of the three with techno-historical values is Teatern. The scene 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 is supporting the wooden one and can be seen together with the machinery in the attic. 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 facade but with an interior in art nouveau style.

Teatern's south facade facing Hästtorget in Laholm. Photo Eva Gustafsson.

It is a solid brick construction with a plastered facade which was altered when it was refurbished in the 1950s. Exterior cornices and mouldings were demolished to get a smooth facade without decorations, more in style with that time's ideal. In 1995 only the interior was restored to its former grandeur. Nevertheless the theatre has a high quality in construction and building technology values. Gold decorated cornices and balcony balustrade with great patina and artistic value was uncovered when the plasterboards were removed in 1995. The preserved parts own a high authenticity in their patina as do the experienced patina.

Decoration framing the scene at Teatern in Laholm. Photo Maja Lindman.

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 were private, like the theatre was. It is situated in the medieval part at Hästtorget, the place for the cattle and horse market, and is originally an extension of the hotel. The theatre’s value for the 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 and 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, Rydö 3:20, Rydöbruk, in the municipality of Hylte
Tyreshill was raised in 1907 as a private house by Per Olsson, who has the same surname as the owner of the new paper mill at that time. Tyreshill was named after Per Olsson’s daughter Tyra, born 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's facade towards south-east. Photo Eva Gustafsson.

Tyreshill has a great historical value for the community 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 for 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 a 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 historical values are determined by this. The planning is preserved to some part and is still legible, and the two chimneys are original.

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 on the backside 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 the social history and also contributes value to the surrounding environment. In the illustration of the historical emergence of the industrial community, the building has an important and early part and thus a legible continuity value as well as representativeness for the local community's history.

The valuation
Summing up for the balanced motivation in Fattighuset the dominating basic motives are: the rareness and representativeness on regional level of historical value for the society and the social history, together with the patina and high authenticity in construction and technology, and in details. The rareness and representativeness on national level has not been examined. The additional basic motives are the legible identity and symbolic values and in 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 dominating basic motives. The second is the techno-historical value together with the high quality of construction and technology values. The additional basic motives are the representativeness for the social history and the society of Laholm carrying continuity and tradition. The representativeness on a regional level has not been examined. The additional basic motives are legible in the identity and symbolic values thus contributing to the surrounding environment.

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

III.V ASSESSMENT OF ARCHITECTONIC VALUES

For valuation of, or to define the architectonic values in the three objects an English publication has been helpful. An unforeseen issue, resulting in this embedded unit of analysis, turned up during the assessment of historic values. As per the National Heritage Board's Handbook, on how to assess cultural and historic values[66], the architectonic values should be assessed which is again emphasised in their guidance for building conservation[67] . The two books consists little of 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[68] *Design Review. How CABE evaluates quality in architecture and urban design*[69] for this

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[66] Unnerbäck, Axel (2002)
[67] Robertsson, Stig (2002)
[68] 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/
[69] CABE, the Commission for Architecture and the Built Environment, (2006) *Design Review. How CABE evaluates quality in architecture and urban design.* London:CABE

assessment. The *Design Review* is a tried and tested method of promoting good design and 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 of which all in some sense will 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 have some relevance to most projects. This study concerns existing buildings but the *Review* also apply 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 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 a similar overview and comparison as with the previous valuation of historic and cultural values.

When evaluating design the *Review* is discussing the context, the object in its context, planning of the site, and the architecture is addressed in asking what makes a good project. In the *Review* is advocated 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 a demand for existing environments. These complex tasks need a work of their own, and this issue is nor topical neither 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 showed in the table X 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 X 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 X 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 while the site is already planned in existing built environment. However the suggested aspects to consider 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 X 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 upon the antique Vitruvius ten books[70] he also holds health and wholesomeness first, and convenience, sustainability and avoiding discomfort[71] very high. As an answer to the question on what makes a good project[72] -

[70] Vitruvius (1989) *Om arkitektur. Tio böcker.* Stockholm: Byggförlaget
[71] Vitruvius (1989) pp. 17, 158.

asked by CABE - fourteen aspects are listed and showed in the table X 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.

Aspects on 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 X Qualities and values that makes a good project according to CABE's Design Review. pp 14-15.

At a quick glance it seems as if Tyreshill has somewhat more of 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 a valuation of the objects. It could be called a basic assessment but a description of the objects is needed.

There are suitable scientific methods to make in depth investigations on 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 is helping the 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 the use. For existing buildings, their attainable future is often determined by the possibility of different use 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 interface human-computer.

[72] CABE (2006) pp 14-15.
[73] International Organization for Standardization(1998) *ISO 9241-11:1998. Guidance on Usability*. Genève: International Organization for Standardization.

Morgan Andersson has made a comprehensive review of the notion in his licentiate thesis[74]. Though usability actually has been investigated in buildings' performance it was focused on the user perspective and how a buildings 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, structures and the organisation of them, as an answer to if they are usable for more than one purpose or in more ways; simply to valuate their specificity, adaptability or universality. A building which is designed for a specific purpose and no other activity and which is not possible to change owns specificity. A building where its functions and properties are possible to change for new activities' demands, owns adaptability. A building where its functions and properties can be maintained, and still be used for various activities, owns universality.[75] With these definitions the aspect flexibility and adaptability in the list above becomes less important while a building who owns 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 the way out to the facade, the site and the whole context. This is a quite 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 already have been defined as it is for existing buildings. In reality it is a constant interaction and the tool to do it is the sketch and model which is part of the architect's practical reality.

FATTIGHUSET in the municipality of Halmstad

Halmstad is the county town in Halland by the river Nissan's outlet 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 and by the old town gate Norre Port to the north, and in the west by a road named Karl XI väg. Remnants of ancient fortification are still legible and found in several places and some have been restored. Within the area there are some 19th and 20th century constructions with three and even five storeys but otherwise the scale height and massing are low. Most part of the town centre is for pedestrians and car access is allowed at four points for those who live there and for 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 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 is from the 19th century and was altered into a fire-station in 1903 and a hose-tower and a coach-house of brick construction was added to the buildings, and the back-wing in the yard became a stable for the

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[74] Andersson, Morgan (2011) *Användning och användbarhet i särskilda boendeformer för äldre.* Göteborg: Institutionen för Arkitektur, Chalmers Tekniska Högskola. pp 8-11.

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

horses. The arched portals are opened up towards the square in the summer time. Half of the square Lilla Torg is occupied for car parking, but the other half is used by the restaurant in the old fire-station for serving their clients in the summer. Opposite of Fattighuset to the west, on the other side of Köpmansgtan is a separate parking lot but there is a wall of trees along the pavement to enclose the street space or street corridor.

There is no traffic passing through since the town centre is free of cars and the only way for cars to access into 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 squares west side is the old telegraph-station from 1926 designed like a fortress of red brick masonry and it is 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 facade of ionic stone-columns and capitals and gable motif. The facades of Fattighuset are of two storeys with a cornice and of handmade red-burned brick masonry and lime mortar, on a foundation of granite. The bricks of second rate quality, give the facades a very vivid expression with many nuances and great beauty. The wooden windows are placed with regularity, and mirror the interior plan's subdivision. An entrance is placed in the middle of the facade facing north. Two other entrances on the east facade give access to the building from the yard. All three can be used for public access but only one is accessible for disabled. The dark green doors and windows reinforce the uniformity of the expression and together with the red tin roof this emphasizes the building volumes. Fattighuset expresses a great and well balanced simplicity. Together with the other buildings it forms a characteristic quality of variety in facades facing north and as such forms a strong identity of the setting around the square Lilla Torg. Fattighuset has become an appreciated part of its setting and has aged gracefully.

The bricks of second rate quality, give the facades a very vivid expression. Photo Heidi Norrström.

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 living daylight from two crossing directions are the ones on the corner that get daylight from west and north. Through the solid brick walls, a niche is created at each window and mediates the daylight beautifully into the rooms. The interior woodwork and details are skilfully formed by craftsmen. The buildings' constructions, structures and the organisation of them, can be maintained, and still be used for various activities, and hereby owns universality.

The materials in Fattighuset are natural, locally manufactured, enduring and possible to maintain. There is mechanical exhaust air ventilation but no heat recovery. It is heated by district heating supplied mainly by renewable fuels and thus sustainable. However the construction and ventilation 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 summer time and with cold air leakage in the winter time. The indoor environment is thus not good for human activities and hence not environmentally sustainable in this regard. The accessibility to 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 the software company's office.

TEATERN in the municipality of Laholm

Laholm is the oldest town in Halland with 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 Lagaholm are remnants of fortification. Lagan is meandering as rivers do when reaching the lowland and sea and it is partly enclosing the medieval town centre to the north and west in a wide meander 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 placed along the narrow streets with gardens in the centre of the small blocks. The shops and other service 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 horse market. The light grey plaster facade has no decorations since cornices and mouldings were removed when it was refurbished in the 1950s. Originally it is an extension to the hotel and was designed to harmonise the hotel's facade. Teatern has three big windows facing south and overlooking Hästtorget and a ridge turret on top of the tinroof and by this distinguishes from the other buildings around the square. In the east part of the square is a fountain and sculpture but rest of it is used for car parking. On the south side are offices, a restaurant and a shop, and the cinema's facade has no windows. The west side is dominated by an old house where the district doctor lived and practiced. Today it is an office. Next to Teatern is the museum of Drawings, the only existing museum in Scandinavia designated to the art of drawing, and it is partly consisting of the old fire station and partly of a newly built extension. Most of the buildings have plastered or brick facades and represents 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, and the theatre is on first floor with a balcony up on a second floor. The entrance door is placed by the side of the shop, yet welcoming with a 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 tells you that you are entering a special place for festivity which is just what you expect.

The stairs leading up to the foyer of the theatre in Laholm. Photo Eva Gustafsson.

The golden decorations in the interior of the theatre raise the expectancy of something spectacular waiting. Well maybe not if you are there to listen to the municipality council who uses the theatre as an auditorium. In the interval of the concert or play, refreshments are served in Barocken with its big window facing the beautiful view of the river Lagan and its sloping north bank. Teatern is a place built for and working for festivity and hence owns specificity. No one is excluded while disabled 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 scene.

The construction has solid brick walls and the materials are natural, locally manufactured, enduring and possible to maintain, but there are some moisture problems with the walls. Insulation has been added at 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, Rydöbruk, in the municipality of Hylte
Rydöbruk is a very small industrial town on the border between the provinces Småland and Halland. It expanded in 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 and wetlands. Valleys with rivers are running 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 the hydropower. The small

town has expanded in an east-west direction along Nissan, the railroad and the old route Nissastigen. The industrial area is in the south on both sides of the river and the main residential area is north of the railroad 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 route Nissastigen by entering up along the slope of Bergs väg. A welcoming porch on the south side is meeting the visitor. To the left are 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 is part of the court yard setting. The different ground levels at the site are part of the experienced architectural value.

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

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 1900s and early 2000s but with the three bigger rooms placed along the entrance facade, facing south, due to the darker, north hillside. The rooms on the gables have a living daylight from two crossing directions.

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

The interior is commodious and the spatial relation can be altered and still have a good spatiality and be used for various activities. Today one family resides there and they also have a ceramic workshop and atelier in the building. Tyreshill with its structure and organisation of it hereby owns adaptability, but nor the site neither the building has accessibility for disabled. Hence it cannot be said to own commodity and it has no inclusive design. There is natural ventilation with small fans for mechanical exhaust air in kitchen and bathrooms. Insulation is 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.

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

III.VI THE INTERVIEWS

Discussions, interviews and conversations have been used for several purposes in this study. In the beginning of the work three conversations with antiquarians of built heritage were recorded in written notes which then were 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 of or judgment on the actual results of the restoration work. The respondents were well aware of these issues and the purpose 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 during a period of about ten years. The Grimeton station is now on UNESCO's World Heritage List. Today there is no financial possibility for this kind of work. One thing mentioned about the Halland Model was that it worked very well for the big projects but minor projects did not fit equally well. The most specific or unusual 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 dominating, 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] for further education and knowledge on preservation of built heritage. In the round the Halland

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

Model was good and important according to the informants and no one had any thoughts about what could have been performed differently.

The second occasion on which conversation and discussion was used as a method, was when an inventory was made on laws and regulations and is reported in paper no. 2. Interviews and conversation were used as a complementing method to reading of law and regulation, mandatory provisions and general recommendations. Questions were asked to and answered by a civil servant and five municipality officials. The questions were written but not readable for the informants. By this it was manageable 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 it 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 wish for more clear and simple 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 analyzing is crucial. Different models were considered for use. According to Nollaig Frost[77], the Labov model could help structuring stories and their elements in the transcriptions and Gees' model for stanzas. This method in qualitative research is considered to be especially useful for findings on organizational dynamics which made it very interesting. Frost also mentions the importance of using reflexive awareness to reveal influence of the authors 'presence and intervention on the informant'. 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 holds 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 of different occupations managed to agree on actions demanded interviews. Through these the roles, methods and organisation would be indicated. The interviews were

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[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.
[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.

analyzed within a discourse where energy counsellors usually are considered insensitive and conservation officers usually are 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 was guiding when analyzing the transcripts. This attempt was inductive to generate a hypothesis. The results were reported in paper no. 3.

The interviews in brief 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 a 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 managing the differences in the professions' 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 performed to obtain the participants' willingness to share responsibilities. This required a transparent organisation which also created a good working climate. A horizontal organisation was a strategy in the work to create good communication within the teams. Altogether this resulted in an efficient and responsible performance which was mirrored in the preservation work. The three informants mentioned that the teams always tried to reach consensus and that the antiquarians' position always was respected. This is showed in the valuation of the three objects chosen for this study but the one where deeper discussions took place during the work was also the one showing up 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 that were possible to perform in an old building, in practice and also due to laws. The discussion had the first surveyed object, Fattighuset, as a starting point. The owners were planning for a refurbishment. It 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 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 current proposal and answers the question if 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 on how they used them in reviewing building permits for alterations in existing buildings in their every day practice.

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[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 introduction.* Lund: Studentlitteratur.

What did these steering documents imply for built heritage regarding 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. Mainly because they were not mandatory and did not apply in 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 wish for more clear and simple legislation. Their reality showed the need for Boverket's decision on new law, regulation and mandatory provisions. The 2nd of May 2011 a new law PBL[83] and regulation PBF[84] came into force and the old ones repealed that date including BVL and BVF. The new law and regulation includes almost all of the content in the old ones.

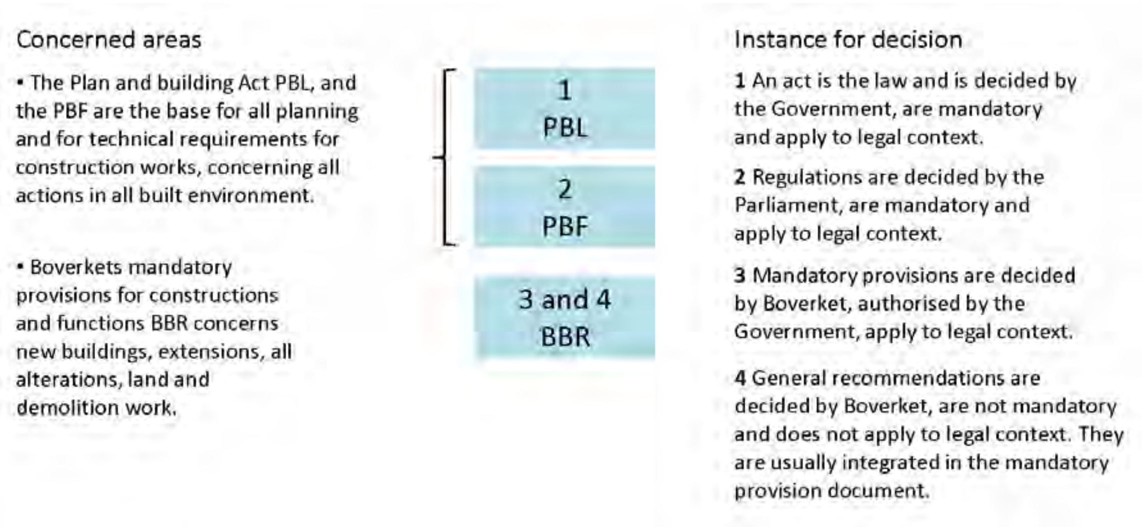

Figure X. Hierarchical scheme on the new basic legal documents concerning energy efficiency and preservation demands in our built environment.

The new scheme on legal documents is showed here in Figure X. The old general recommendations BÄR have now been integrated in the new proposal on mandatory provisions BBR[85] for higher status in legal context. It has been sent to 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 mandatory provisions BBR. 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 demand on cautiousness 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.

[83] Boverket 2011a) *SFS 2010: 900, Plan- och bygglag PBL.* Karlskrona: Boverket
[84] Boverket (2011a) *SFS 2011:338, Plan- och byggförordning PBF.* Karlskrona: Boverket
[85] Boverket (2011b) *BFS 2011:6. Boverkets byggregler BBR*. Karlskrona: Boverket

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 participating in workshops, providing facts, contributing 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 for the opinions of experts in the field. In this way EEPOCH holds both interdisciplinarity and transdisciplinarity within.

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 mirrors 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 of moisture problems that often play a major role for 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. Since the phase of maintenance is the heavier, one must use more of low-grade thermal energy and less of high-grade electrical energy. 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 technology orientation must be more directed at a building as interacting systems where total performance is respected. Someone in the construction process has to bridge over 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

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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 (eds.) *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, Michael (2007). *Energi och byggnadsutformning.* Stockholm: Arkus.

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 pointed out building physical risks associated with energy efficiency. Functional requirements seem to have fallen out of focus today when society's demands - and economy seems intent on - minimizing energy consumption. IEA, International Energy Agency, has calculated an enormous potential for savings. What in general are the biggest risks, and causes most damage in buildings today, are different sources of moisture and our various ways to try to overcome them. We have to adjust constructions and materials for each and every new context. Moist indoor air always has higher humidity than the 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 interior added insulation is a common measure which is a risk while the relative humidity, RH, rises indoors in these cases. The construction will be both very sensitive to air leakage from within and also obtain a colder exterior side. The most important is to have control on joints and thermal bridges, like attachment of floor joists into the facade, when using interior insulation since problems can be built in and then will not be controllable. Calculations on risks 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 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.

Questions occurred during the first workshop on what measures that 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 planned for a refurbishment. It was 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 for disabled - ramps were needed. He also proposed a raise of the backyard area. This implied significant changes of the facades and the question was raised 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 came thus to partially revolve around the production, distribution and sale of energy and energy services. The new services open up for 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 hereby also politics. It seems that from whatever angle the energy issue is looked upon - it owns a very high 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.

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

There are mandatory provisions on what is demanded and how an energy expert should be certified[92]. There are extensive requirements and a large knowledge test must be performed before accreditation. 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 2005, and have recently been updated. In one of Tobin's company they have education and courses for this too, which is an advantage and makes for a 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 conduce to 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 to implement them is actually not compulsory. We do have another law - The Environmental Code[93] - which can be interpreted in such way that energy efficiency measures shall be carried out if there is a possibility 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 give very different outcome, 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 of calculated and measured energy demand the potential of savings

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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

[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] *Miljöbalken SFS 1998:808* Available at:
http://www.riksdagen.se/webbnav/index.aspx?nid=3911&bet=1998:808

become clear. Tobin also talked about strategy and strategic choices and of thinking in systems, which always must be included.

Sundquist, certified energy expert, gave example from his work and 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 good and developed at Chalmers, but differences in calculated energy use due to thermal bridges can amount up to 20 % regardless what programme in use according to studies made at the University of Lund. Another example was about a business company who lowered their energy use by over 60 %, from 60 MWh/month to 20 MWh/month, simply by engaging an expert who corrected errors in the operation and adjusted and optimised the control and regulating equipment. No change of heating and no added insulation or alteration of windows or other appearances – 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 and started with the difficulties to assess cultural, historic and architectonic values which appeared during the work. A referral on amended mandatory provisions showed that same low figures on energy use for new constructions will be demanded for alterations in existing buildings. None of the objects in the multiple case study would probably manage to meet the demands when planned alterations is 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 valuing becomes evident as the cultural values should be balanced with the energy requirements. The handbooks in use today have gaps in alignment with current viewpoint, which more and more is based on the 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, has 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 row of meetings with the NHB's employees to define intrinsic values, user values, scientific values and cultural values. An important issue also was how NHB presents these identity values. One criterion for state ownership must be to give all citizens access to the heritage as a public site.

The heritage's relation to sustainable development; environmental, economic and social, was also discussed. The change in the surrounding world was the origin for the need of a new model. This was combined with public welfare and national responsibility, when choosing the narrative model. The narrative model was presented by Arvastsson already during the 1990s and NHB has 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 stories on cultural and historical phases where the objects should be a part of it. The starting points in geography, gender and class, generation and ethnicity - to tell everyone's story - were necessary for credibility. An independent research group made 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, fulfilled the criteria, and worthy to be included in the holdings of cultural and historical reasons. This raised the question on how the results could be perceived and interpreted and used on local level. The continued work for NHB includes the issue on 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 the last decades is that the national strategies lost its 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 manifested in the built environment is a strength and an advantage, and part of the region's strategy on growth. The heritage should not just be protected but used, and 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.

The traditional protective work within the heritage sector was transformed into a 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 whose meaning it is that all motivation for economic activities is the concept of value. It is important to identify and take advantage of the existing, actual values.

Professor Della Torre related to a new convention from year 2000 when restoration got another focus in Italy. The context were emphasised instead of the single masterpiece and the concept of territorial systems, including social and economic systems, was developed. Restoration should be preventive with authenticity and reversibility for a sustainable management of our existing resources, which with addition from today could get new uses and new possibilities for interpretation. The concept of conservation was enhanced to include the 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 valuations and assessments are relative and time-bound. One cannot isolate a building because it will then lose its different time-layers and authenticity, referring to John Ruskin and Alois Riegl. They must also be able to use. Architecture must be used to be perceived as architecture.

Most people agree on Feilden's words from 1982 that the mission of conservation is the action to prevent decay, but many interprets 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 a pure restoration. Heritage was not allowed to dilapidate and not to be modified to meet new needs. This was a defensive strategy.

With the human ecology as described by Ceruti, the concept of co-evolution is emerging, and to widening of limits instead of limiting development. 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 utilized 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 shall survive, adjustments are necessary to meet new needs and also to have a dialogue with the context for 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 with the economic aspect. The sites are included in sustainability plans, but not only as suitable for tourism since negative effects have been identified in this branch, from 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 the cultural heritage can serve as a catalyst. The shift from pure restoration into integrated conservation work, offers economic advantages. The objective is to get 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 the 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 the questioning knowledge building, and use the sustainability perspective in this.

The 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 this, the latter 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. Next step was to enhance the boundaries and care also for the 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. possible to re-treat the object to its former original state and original appearance. For this a thorough documentation is needed, before, during and after actions. This is also a prerequisite for the preventive work with continuous maintenance as opposed to long-term decay with following restoration. Rosvall showed a diagram on conservation's critical phase, which has been recreated below.

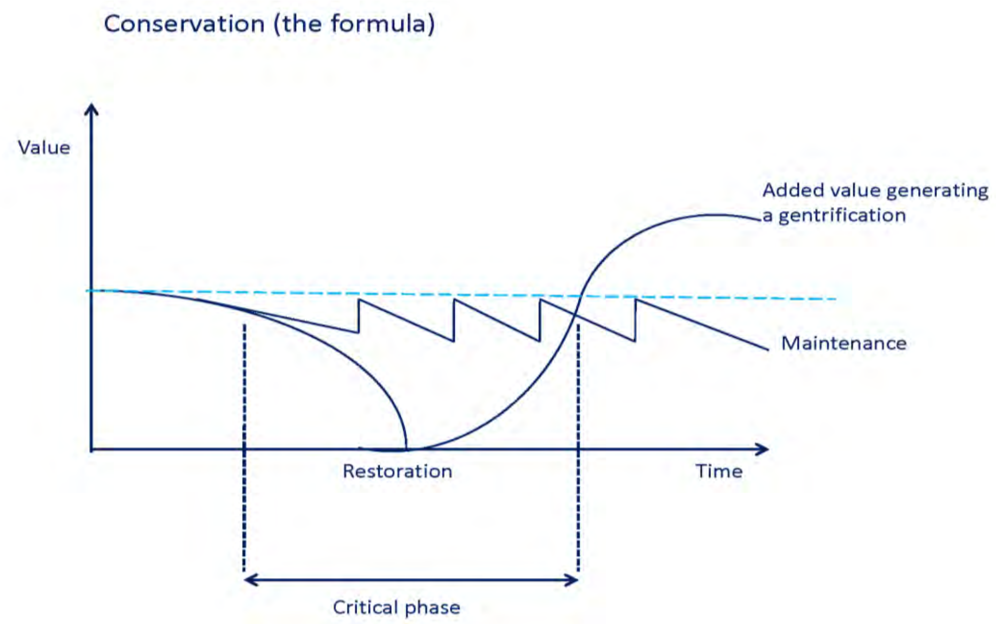

Figure x is an attempt to reproduce a diagram showing the critical phase in conservation as a function of value and time, and the two different ways of action. The lighter blue dashed line is the object's original nominal value.

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 concerns the skilled crafts, is traditional, ethnocentric, idiographic and is based on the unique and individual. The second phase concerns the scientific conservation, is modern, transnational, nomothetic, and is 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 and can be developed cross disciplinary to a new discipline.

Conservation has different structures to work with as in structures of building construction, structure of society, cultural structures and invisible structures. The process of conservation is based on the assumption that all kinds of concerned material products 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 turned out to be very revealing on understanding the issue.

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

Table x 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]. Many damages in buildings' structures emanate from moisture permeating and transferred into the materials of the structure which is also 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 way physically and economically is to stop the moisture at the surface or prevent the situation from occurrence at all, to avoid damage and for 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 conclusion on what makes a healthy indoor climate in existing buildings do not differ much from what is stated for new constructions; air tightness to avoid draught and discomfort and control of indoor air humidity and temperatures and air change. Corresponding characteristics are desirable and applicable also 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 finding 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.

Assessing historic and cultural values is part of the conservation work but the notions conservation and integrated conservation[98] are wider. To get a better view of the contemporary understanding, a

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[94] Hagentoft Carl-Eric (2002) Vandrande fukt Strålande väreme. 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.
[98] The tradition of conservation in Sweden and the emergence of integrated conservation are described in brief in Paper number 1.

paper on a broad definition of the concept 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. Though, assessment of built environment still is an important part of the understanding of history, architecture and of the genius loci.

From an antiquarian perspective the restoration of Fattighuset was excellently performed leaving e.g. the original patina in the gymnasium untouched. There must have been discussions along the way. The ducts for exhaust air have been almost experimentally treated. On the ground floor the system is hidden behind a lowered ceiling in the corridor and on the first floor the system is fully exposed leaving more room height in the corridor. However the preservation was carried out on expense of the indoor climate and energy efficiency, 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.

Teatern in Laholm was restored beautifully and seems to be a good example from both energy and preservation perspective. The advantage of added insulation on the attic is evident. For the exhaust air the old masoned shafts for the earlier natural ventilation was used so there are no visible signs of the new technique added in this part. 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 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.

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 possibilities for 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 an exemplar from both energy and preservation perspective regarding the starting point.

As a whole, considering the time and conditions, the restorations was professionally performed. Looking at them in the round there are some better and some poorer results. It is always much easier

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

to comment on already finished work than to perform it and the consequences of some of the actions maybe was not possible to foresee.

In Fattighuset the airtightness was an important part affecting 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.

Looking at the back wing of Fattighuset it is almost left untouched. If this was the aim, and it probably was, it was extraordinary well done preserving hundred years of patina. What could have been done 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 in Fattighuset right now is to concentrate on the technical installations.

Teatern in Laholm was also a very good restoration job, almost like a rebirth of the theatre but some issues needs 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 construction. Calculations on what humidity and temperature it takes to protect the building can be of value for the future maintenance in the building.

With all efforts made in Tyreshill on behalf of transmission losses, energy use and indoor climate it should have had a lower key figure for the energy use. If it had been allowed, an exterior insulation would have been more energy efficient. However the overall result showed in the exterior is good. The indoor air temperature could be lowered 2 to 3˚C without risking the comfort. 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 doing so the moisture in the ground will follow the heat into the building. This risk should maybe 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 others with much more opportunities to take action. Weighing the three perspectives of energy efficiency, historic values and architecture the performance in Teatern in Laholm must be guiding the continuation of the work within EEPOCH.

The overall architectural valuation concerns the building/object as a technical system and as a system of space, and its interacting 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 valuation of historical values and the energy performance this valuation 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 of transgressing boundaries and understanding of the whole. All of this emanates from architecture's contextual mission, which 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 in carrying out the Halland Model. Horizontal cooperation, flat transparent organization and good communication created involvement which also showed in thoroughness and high quality of work. Respect and shared responsibility became key factors for a good working climate allowing initiatives and discussions. The Halland Model was developed in a context of recession which differs much from today's social and political context. Yet some of the factors strongly reminds of the ones used today by those in the construction sector engaged in building passive houses. To achieve the necessary airtightness in these houses, thoroughness in planning and high quality in work performance at the construction site is demanded. This is according to Jansson's thesis[101] on passive houses, where also other factors like good communication, involvement, respect and feeling of importance are mentioned. The experience from the Halland Model could be of good use for today's construction sector in general.

Monuments with high historical and cultural values on national level are still protected by the Regulation SFS 1988:1229 and on regional level there is the law 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 law Heritage Conservation Act, KML.

All other built heritage is protected by the law PBL and regulation PBF and in every day practice the 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.

The issue on assessment and judgement of energy and preservation demands is and will still be left for interpretation by the municipal officials in service when building permits for alterations comes up or by the planning committee. What they have to use is the law PBL, the regulation PBF and the mandatory provisions BBR which are meant to equally concern technical requirements like energy efficiency, and the cautiousness with different values in existing buildings.

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[100] Edén, Michael (1987) *Arkitektur med ekologiska förtecken.* Göteborg: Byggnadsplanering, sektionen för Arkitektur, Chalmers tekniska högskola. p 281.
[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: RAÄ
[103] Riksantikvarieämbetet (1988) *SFS 1988:950, KML Lagen om kulturminnen m.m. med ändringar t.o.m. SFS 2011:782.* Stockholm: Sveriges Regering, Kulturdepartementet.

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 and key figures 110 or 55 kWh/m^2 A_{temp} and year. And then there is a demand on cautiousness. 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 have specialized in these areas also have different cultures within their professions. This was mirrored in WS I too, the first workshop, but the most important output was that a building must be seen as a whole with interacting systems where the total performance is considered including the users and their activities. The natural following 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 in buildings for rent to have low comfort or high key figures such as 200 kWh/m^2 and year? Are alterations of a facade, with high cultural values and being 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 also printed in paper no 2. From this summarising table it appeared that most of the suggested measures aimed at 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 are almost synonymous; the higher the energy use - the higher the comfort, and the lower the energy use - the lower the comfort. 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.

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 for decreasing the energy use, which also was exemplified. The experience from the third workshop, WS III, was revealing and has had an impact on the work so far and will impact the continuing work in several ways. First and foremost the ongoing shift of paradigm 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 X Participant categories in the three workshops.

The overall conclusion on the workshops is that it was a very good way to take part of all aspects, facts and perspectives and sharing them. One effect of participating is the respect for a subject and a profession when realising the skills needed for performance.

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 contrasting interests in supply of heat; low supply of heat to lower the energy use and costs becomes too low to handle humidity and moist problems causing damage to the construction - the term low is relative to this context.

The measure of added insulation has proven to be most efficient mounted on the exterior side to build in thermal bridges[104] but it definitely alters the facades. Interior added insulation affects details like mouldings and woodwork negative 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 like in Fattighuset if not performed with sensitivity like in Teatern.

In the law, regulation and mandatory provisions there are difficulties in interpreting the demand for cautiousness in relation to the clearly defined demands on accessibility, change of air volume or energy efficiency. This can be a problem in balancing the different demands 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 on the expense of energy efficiency and moreover on the expense of 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 balancing of different demands in assessing applications for building permits can weigh over either to favour the energy demand or to favour the preservation demand.

[104] Hoppe (2009a)

The objects in the multiple case study have been studied from different perspectives. This made a comparison between the objects possible so the answer to the third research question can in this aspect be; 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 was 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 the good experience from the Halland Model is a strong strategic way forward and strengthens the hypothesis.

'There are few writings that bridge the gap between the measurable and qualitative, which provides information on technical performance while discussing aesthetics.'[105] This is an attempt. The aim has not been to nail the truth, but to increase the understanding of the problems and to see the 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 research of this multifaceted field.

(This thesis is a base for a coming contribution to how concrete planning can have an impact on design and diversity of buildings and hence also sites and ultimately cities.(?))

[105] Edén, Michael (2007). *Energi och byggnadsutformning*. Stockholm: Arkus.

V THE PAPERS

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

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The paper was published and presented at the conference.

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

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ABSTRACT: With the implementation of directive 2002/91/EC on energy performance issues have arisen on the complex set of problems that hold between energy efficiency and preservation perspective. The aim of this paper is to describe the state of art in Swedish sustainability regarding energy efficiency and integrated conservation and how these have been carried out in our built heritage represented by the regional co-operation project the Halland Model where case studies are performed. The aim of EEPOCH, Energy Efficiency and Preservation in Our Cultural Heritage; – Through generic research the case studies form a foundation for a theoretical model directed on application for integrated balancing of energy and preservation demands without diminishing intangible values in our built heritage. – The qualitative research part includes interviews for analysis on communication between different occupational cultures to illuminate methods within and between connected professions, especially their interdisciplinary approach.

1 UNDERSTANDING THE HALLAND MODEL – A SHORT SUMMARY

Objects for studies are chosen within a concept called the Halland Model for preservation of historic buildings aiming at regional sustainable development. The County of Halland is situated in the south of Sweden. The regional joint venture, the Halland Model, includes the construction industry, the historic environment sector, the labour market sector, estate owners, local and regional authorities and trade unions. It was started in the 1990s recession to increase the total volume of construction. The very first motto of the scheme was: Save the jobs, save the craftsmanship, save the buildings. It soon developed into a regional cross-sectoral joint-action network aiming at sustainable growth. The aim also was strengthening competitiveness, sustainability including use of renewables and reuse/recycling of materials and development of building conservation.

In Christer Gustafsson's dissertation on the Halland Model (Gustafsson 2009) an application-oriented theoretical platform and a new model, providing adequate approaches to solving boundary-spanning challenges is presented. A generic and entrepreneurial model is developed where the "trading zone" is defined as an active arena for negotiations and exchange of services or a field of force corresponding to the actors' policies, values, facts and resources.

In the Halland Model both preservation and energy efficiency have been taken into account in the conservation work. Over 1100 building construction workers and apprentices were trained in traditional building techniques operating in about 100 historic buildings at risk, under supervision of skilled craftsmen and conservation officers. Selected objects include castles, windmills, industrial sites, dwellings, warehouses, theatres among others.

After the completion of conservation work the improved premises made new functions available inspiring the start of several new businesses. The chosen buildings were seen as resources to be taken advantage of and to develop. Preserved built environments are often seen as attractive for dwelling and if used properly they can be an integral part in trade activities and other businesses and even increase their market value. This is one of many added values which have come out of the concept. 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 and about 200 indirectly. The Halland Model has been exported e.g.to the Baltic Sea Region, Russia, Poland and Iceland as regional project for sustainable development and the experiences of the Halland Model has been disseminated in several conferences in other parts of the world.

When conservation and retrofitting are carried out the running costs must at the same time be reasonable and the energy use efficient. The overarching Halland Model gives good examples on managing of energy performance without diminishing the cultural value and social history in our built heritage. All these facts and the reuse and improvement of existing resources, both material and human resources, implies that the concept is not only building on the three pillars of sustainability i.e. environmental, social and techno-economic, but also manages to enhance the five capitals: human, environmental, social, financial and manufactured capital as described by the Royal Academy of Engineering in London (The Royal Academy of Engineering 2005). The Halland Model concept has a direct as well as an indirect effect in the societal system and thus contributes to it.

2 FORMING OF THE RESEARCH QUESTIONS

A building can be seen as a historical document from social aspects but also purely constructional. The starting of the ”million programme” in 1965 when one million flats were built in one decade was a parting point that changed the epoch of craftsmanship in the construction sector and the industrial era with prefabricated parts mounted on the construction-sites had its' beginning. Sweden has a young building stock. Habitations constructed before 1945 only amounts to about 33 %. Today we have about 4.4 million flats in Sweden of which about 2 million in detached houses (Boverket 2004). It is the handicraft produced building stock i.e. built environment constructed before 1945 that is studied in this research project.

During 1960s and later when the ROT-programme (Reparation-repair, Ombyggnad-reconstruction, Tillbyggnad-extension) was carried out many mistakes were made in the existing built heritage. Our Swedish stock of insulated and plate covered buildings emanates from these years. A later evaluation made by Boverket or The National Board of Housing, Building and Planning in English (Boverket 2003) shows that projects financed by this programme premiered huge reconstructions and added insulation without consideration for cultural and historical values in our built heritage. There is an obvious need of guidance on efficiency in the tertiary sector now with the new law on Energy Declaration and many measures and actions on energy efficiency will be put forward in the years to come.

According to the Swedish governments national environmental objective Good Built Environment (Environmental Objectives Council 2009) the cultural, historical and architectural heritage as buildings and built environments with special values should be protected, developed and identified latest in 2010.

Earlier about 3000 objects/buildings have been identified in Halland and a new inventory points out over 10000 objects. The inventory concerns the housing and service sector as well as industry and others. Similar results will most likely appear in the other regions too. At the same time as the buildings and objects are protected they must be given reasonable running costs. There is a demand for a model/guidance on how energy efficiency can be managed without negative impact on the cultural and historical values in our heritage.

Our officially protected monuments are quite well managed and energy efficiency is of minor interest considering their high historical and cultural values. Preserving the past for the future is not a risk but an obligation. But how about all these buildings at risk not so ancient, not so distinctly characterised still so important for the overall experience of a block, a neighbourhood or a region? They serve as time-documents of a city history and as cultural layers of its development. Are these values protected when the energy experts come to do their job according to the Directive 2002/91/EG on Energy Performance? There is a lot to discuss and investigate and to do within the complex set of problems that holds in between energy efficiency and preservation perspective. From these both perspectives a kind of double core emerges and the main 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 too big cautiousness in our built cultural heritage makes actual efficiency potential not being realised?

Is it possible to explore this dual core, which is the combination of preserved built heritage and energy conservation on the one hand, performed in a way both conservation officers and energy counsellors can accept on the other hand and is this exemplified in the Halland Model?

3 METHODS, ACCOMPLISHMENT AND EXPECTED RESULTS

EEPOCH as a project will explore a dual core, which is the combination of preserved built heritage and energy conservation on the one hand, performed in a way both conservation officers and energy counsellors can accept on the other hand, all exemplified in The Halland Model where objects for case studies are chosen. Within the project generic research on the objects energy performance and preserved values will be carried out for cross-case conclusions. This requires both technical and analytical means and methods.

Evaluating the energy performance can be carried out in linear empirical research grounded in theory of positivism making use of deductive implications as is usual in natural science. However in order to handle the duality of the research question Yin's method for case studies (Yin 2009) in applied social research is more adequate and will be chosen. In this evaluation workshops will be performed together with responsible energy managers in eight local energy and real estate companies owned by the municipalities in the County of Halland. The project will gain from their great experience and knowledge on energy matters and they will in turn get access to the work and results from the project and to the group of experts linked to it. Ten experts from the two sectors technology and the humanities, representing both practice and academy are carefully chosen and they will participate in the workshops. This accomplishment holds both interdisciplinarity and transdisciplinarity within.

Descriptive method for analyzing the objects cultural values emanates from the humanities and the history and from development of architecture, sociology, society and technology. Authenticity, patina, continuity, symbolic value, rarity and other qualities (Unnerbäck 2002) will be considered as well. In a way this can be related to philosophies of (post)structuralism (Lübcke ed. 1988) in evaluating the qualities and values in the sense of meaning and understanding of them. As Schleiermacher defined hermeneutics as the art of avoiding misunderstanding general hermeneutics including interpretation of built form and both written and verbal information will be used in the project. In the assessment an interpretive-historical approach (Groat et al. 2002) is needed when archival data and interviews with involved conservation officers and craftsmen will be analyzed which implies qualitative research. Inspectors of built heritage will be invited to the workshops concerning this part for valuable contribution. These stances and mix of approach and method regard the state of the objects and discernment or judgement on their values.

The second part of EEPOCH will examine the point of common in the involved disciplines within the Halland Model. And the possible synergetic effects of an interdisciplinary perspective in relation to each case for understanding of holistic views on built environment. Finding out how this has been obtained by the teams requires an investigation of roles and organisation on the one hand and methods and actual execution on the other hand and will be carried out in the next phase of the project.

A continued cooperative work, including as many disciplines and practitioners as possible or demanded in each case together with carefully planned and prepared increase of efficiency can lower environmental impact and make our built cultural heritage useful for the future creating attractive environments with low running costs. EEPOCH shall provide the models for managing of energy performance without diminishing cultural values in our built heritage. The expected output with EEPOCH is providing the models for managing through case studies based on the outcome of the Halland Model. The hypothesis is also that the model can be implemented in other projects for demonstration thus contributing to society as a whole. This research project is connected to the National Energy Agency's ”Save and Preserve” programme along with other projects that will form an important component to bring additional quality and contribute to necessary development of knowledge.

4 CASE STUDY NO1, DROTTNING KRISTINA 2, HALMSTAD

4.1 *The Object: Fattighuset, Drottning Kristina 2 in Halmstad*

The first case study is ”Fattighuset” (the Poor-house) or the old fire-station at Lilla Torg (the small market) in the municipality of Halmstad. The real estate's name is Drottning Kristina 2 in the parish of S:t Nicolai. The municipal real estate company Industristaden AB is the owner. The main building was raised in 1859 and 1879. The back wing was built up 1891 and altered in 1901. Total area heated to +10˚C or more amounts to 1062 m^2. The real estate is part of Halmstad old town forming an environment with great values to preserve and protect. An inventory was made from antiquarian and technical perspective and the buildings were measured out and all damages were documented in 1994-1995. All collected original material is being kept at Kulturmiljö Hallands archives at the address Bastionsgatan 3 except for those kept at the town hall.

”Fattighuset” is a corner house at Köpmansgatan and Lilla Torg by the markets southwest part. The buildings have two stories and are of red burnt 1 ½-stone handmade bricks of second-rate on a foundation of granite. Partitions are of wood and slabs. All tiers of beams in floors are wooden. The brickwork is cross-bond mason with lime mortar and an exterior cornice. There are entrances on the north facade towards the market and to the east into the yard. The regular placed four-bayed wooden windows have cross mullions and plate covered window-sills. “Fattighuset” has span-roof and broad-axed Swedish roof-truss with boarding and red-painted plated roof. When the conservation was carried out the earlier garrets were replaced with roof-windows and 175 mm of insulation was added. Two mason chimneys are astride the ridge and the roof towards the market has a hip roof. A lift has been installed. In the attic there is a room for the mechanical ventilation and on ground floor in the oldest part of the building is the boiler room where the exchanger for district heating is placed. The original plan is almost fully preserved. The exterior as well as the interior have many old doors, windows, stairs, floor and roof cornices and more of old date preserved.

4.2 *History*

In 1847 Sweden had its' first complete Poor Law saying that every parish and town should take care of those who lacked ability to do so by themselves. The plans for “Fattighuset” in Halmstad are drawn by Hans Strömberg who was head architect in the city of Gothenburg at the time. The first back wing was torn down in 1891 to make place for a new one with cells for the insane and with studies. The object worked as a poor house for 42 years and after the extension on the north façade in 1879 there was room for about 40 needing people and room for offices, staff's living etc. In 1901 this activity moved to new premises. The fire brigade took over. A hose-tower and coach-house was built up with Sven Gratz plans. The main house was reconstructed for offices and the back wing for giving the fire-men a gymnasium. The fire department moved in 1903. The tiled stoves seen in plans from 1901 are gone in plans dated 1934 when a new heating system with water-distributed heat and a boiler was installed. The later alterations are small like garret-windows in the attic 1946 and 1952, altered disposition of rooms, new kitchen and bathrooms. From 1977 when the fire department moved out some local associations and unions moved in and stayed to 1986. After that the buildings were vacant until the conservation work started in 1996. Today “Fattighuset” is hired out to shopkeepers and offices.

4.3 *Cultural values*

”Fattighuset is one of the city's few preserved buildings from the 19th century and as such it is a historic document of this era. It's representing the changes due to the liberal politics' emergence and breakthrough in Sweden during the latter part of the 1800s. The public's role in society grew and taking care of the poor is one good example of this.” (Landsantikvarien 1995)

The buildings are constructed with locally specific materials, worked and handled by skilled craftsmen and are well preserved in materials, original forms and expressive exterior. The very vivid brick-facades have many nuances due to the second rate quality. This character also mirrors the society's view on the pursued activities in the buildings at the late 1800s. The floor plans are almost intact and are of the general character which can hold different activities within and by this possesses a high architectural quality marking good art of building. Further on the buildings as documents and symbols are important parts of the societal development and social history in Halmstad. Fattighuset together with the fire-station and the cinema forms an extremely characteristic quality in facades facing north and as such constitutes an inalienable part of the framework or settings around Lilla Torg. Fattighuset has classification 1 in the city's preservation plan: Building of great cultural and historical values with exterior that cannot be altered.

4.4 *Energy efficiency*

Knowledge on the buildings energy consumption is a condition for running and maintain buildings in an energy efficient way. Measured figures are naturally what to use but these figures don't always match the calculated. These differences could be of value showing that the building is maintained very well but could also indicate that actions could be taken and show what can be improved. Measured figures and manually calculated demand will be accounted for. Halland is in climate zone III according to the Swedish regulations (Boverket 2009b).

Use of district heating is 186 MWh/year. The district heating system in Halmstad amounts to 88 % of renewable energy sources. For Sweden as a whole it was 71 % in 2008. Average electricity use based on the latest four years is 90.4 MWh/year of which 60.7 MWh/year is related to the tenants' activities and leaves 29.7 MWh/year for running the building. This part includes running of two minor machines for air conditioning in the summer. These are installed in the attic floor. Average use of water in the four latest years is 600m^3/year. Key figures for district heating is 176 kWh/m^2, year and for electricity 28 kWh/m^2, year. The table shows comparison of key figures for total energy use in similar buildings.

Fattighuset, Drottning Kristina 2	204 kWh/m^2, year
Energy calculation, type code 826, statistic interval*	144-200 kWh/m^2, year
Other figures in offices**	140-240 kWh/m^2, year
The National Energy Agency's STIL-study, average figure***	202 kWh/m^2, year

*Boverket 2010. ** http://www.byggabodialogen.se/ ***Energimyndigheten 2007.

The buildings have water distributed heating with radiators. The main building has mechanical continuous exhaust ventilation with variable frequency control but no heat recovery. Fresh air is supplied by vents in the brick wall. The back wing has mainly natural ventilation and mechanical exhaust ventilation which can be turned on if demanded.

When preparing for the manual calculations eight different books and guides have been used: Adalberth 2008, Adamson et al. 1986, Anderlind et al. 2006, Boverket 2009a, Boverket 2009b, Elmroth 2009, Petersson 2009 and Wärme 1991. Calculating thermal bridges and the heat accumulating capacity of the brick walls and to determine the outdoor temperature one have to use Ψ-values. These values for massive constructions like brick walls are not to be found in the books or the guides. This could depend on the guides intended use for new constructions and new massive brick constructions are rare in Sweden today. Computer software has not yet been tested. The Ψ-values for massive constructions might be available there. Nor the heat loss through thermal bridge on the negative side neither the positive compensation through the wall's heat accumulating capacity will be referred to in the manually performed calculations. For determining the outdoor temperature (winter) the figure -17˚C is chosen and it is the limit which SMHI, Swedish Meteorological and Hydrological Institute, uses for measuring degree days. A normal year in Halmstad the degree days are 3194. Measuring the indoor temperature in thirteen different places gave the mean value +20.5˚C which gives a difference or Δt=37.5˚C.

Construction	Material	U-value*	Construction	Material	U-value*
Walls	Brick	1.8 W/m^2 ˚C	Doors	Wood/glass	2.7/4.5 W/m^2 ˚C
Window I	Wood 2-panes	3.0 W/m^2 ˚C	Roof I	Wood	0.154 W/m^2 ˚C
Window II	Wood 1-pane	4.5 W/m^2 ˚C	Roof II	Wood	0.287 W/m^2 ˚C
Window III	Wood 1+1-panes	2.7 W/m^2 ˚C	Tier of beams	Wood	0.255 W/m^2 ˚C
Roof-window	Wood/aluminium	1.4 W/m^2 ˚C	Boiler-room floor	Concrete	0.425 W/m^2 ˚C

* U-values tell how much heat that is transmitted from the warm side to the cold side in a construction.

U-value for the brick wall is calculated on actual temperature of the walls' surface and indoor and outdoor temperature on the occasion when IR camera was used. The other U-values are calculated by the book with λ-values for heat conductivity for calculating the heat resistance, R, and with the special transition resistance R_{si} and R_{se}. All other applicable corrections have been made for moisture, for constructive and general corrections and finally some U-values e.g. for windows are taken from the books and guides.

Measured wall surface is 632 m^2, floor surface to the ground 388 m^2, roof surface 534 m^2, window surface 100 m^2 and door surface 33 m^2. By multiplying U-value by surface and by degree days the transmission losses through the envelope amounts to about 136 MWh/year. Using exchanged air volume per hour, the air's density and heat capacitivity, flow and degree days the heat losses through ventilation amounts to about 47 MWh/year. Fresh water coming in to the house usually holds about +8˚C and it takes 1.16 kWh to raise the temperature of 1 m^3 water 1˚C. You have to heat the hot tap water to +60˚C to avoid Legionella bacteria and by multiplying you get a demand for hot tap water about 12 MWh/year. In total 195 MWh/year. Contributing surplus heat from people and electrical equipment amounts to 21.6 MWh/year (3600 kWh+18000 kWh) which gives a calculated bought district heating of 173.4 MWh/year. This is about 13 MWh less than actually bought district heating. Using the IR, infrared, camera gave some possible answers. It was e.g. obvious that lack of draught preventers causes huge heat losses through windows and doors. In addition the problems that tenants and landlord have registered could give an explanation to this difference.

The tenants experience mainly emanates from comfort issues. 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 to +9˚C and simultaneously the temperature outdoor were measured to 0˚C. The windows are not air-tight causing draught in addition to the cold draught from the glass itself meeting the heated indoor air. During the summer the offices at the attic floor is overheated.

From the landlords view the buildings general condition, economy and applicability are the main issues. They mean they have high costs for heating and possibility for letting out on hire is connected to floor plan solutions and indoor comfort. There is also a problem with the foundation and a dehumidifier with continuous measuring and control was installed by Anticimex. Fungus growth in the stone foundation occurred in the beginning of 2001 and was then excavated and a dehumidifier from CorroVenta AB was installed.

5 FRAMEWORK

5.1 *Energy Efficiency a Global Problem and a Tradition in Sweden*

Sweden's total energy use is almost 400 TWh/year (of total supply 600 TWh) and about 36 % is used in the residential and service sector (Energimyndigheten 2009). This sector has an enormous impact on our environment and climate and in an EU-perspective the supply of imported fossil fuels is a problem. The need of import is about 50 % today and will have increased to 70 % in 2030 if actions are not taken (European Commission 2007). This isn't sustainable. Many directives have been formed due to this fact.

In several regional, national and international studies on energy efficiency the potential is estimated to at least 10 % of electricity use (Sveriges kommuner och Landsting 2006) and 20 to 50 % savings of total energy use (European Commission 2007) if installations and constructional measures are considered i.e. heating/cooling, ventilation and insulation. On European basis the tertiary and service sectors are consuming 40 % of the total energy use. For economists a buildings lifecycle is 40 years. During this time span about 85 % of the total energy use (Adalberth 2000) and 50 % of the total costs is within the managing phase. In EU level according to the 2005 IEA summit energy efficiency is considered a key action while it decreases energy demand and its' environmental impact as well as creating new jobs. It's seen as a path to social, financial and environmental sustainability. A slow pace of erecting new constructions in Sweden, about 1-2 % per year, points out the existing constructions and buildings as the big potential. What this implies for the building itself or the inhabitants are rarely mentioned.

When the Oil crises occurred 1973 the issue on energy supply became topical in many countries. The Swedish building regulation from 1967, SBN 67, were valid for building demands in Sweden at that time. The demands were low and equivalent to about 60 mm insulation in walls and 100 mm in roofs or attics and double glazing was required when erecting new buildings (Adamson et al. 1986). Soon an increased energy costs due to the oil crises was mirrored in the regulations. The demand on insulation doubled and the window area was limited to 15 % of the floor area. For bigger buildings heat recovery for ventilation systems was demanded.

The government bill 1977/78:76 Energisparplan för befintlig bebyggelse (Plan for energy saving in the existing building stock) principally implied an objective for 25 % energy savings within ten years. Subsidies for added insulation of facades and having energy counsellors in all municipalities were introduced. All municipalities had to make energy plans and later on by PBA, the Planning and Building Act (Boverket 1987) to include energy management in all development plans. In 1984 a special legislation for houses heated with electricity came up (Byggforskningsrådet 1987). Economic means were put into research and development of renewable energy sources and techniques.

Today our Swedish legislation is based on functions. With BBR 2008 we got a limitation of energy use; from maximum 110 kWh/m^2, year in the south climate to maximum 150 kWh/m^2, year in our north zone and in addition a mean U-value 0.50 W/m^2, K for dwellings. Higher numbers, +20 %, can be accepted if this demand "is not possible to obtain due to cultural and historical motivated limitations" (Boverket 2008).

Through the years a number of bills, regulations, reports and subsidiaries have been delivered and their common sign is lack of holistic view and the one sided consideration of buildings as real capital handled by economic rules and assessments. The energy issues have slowly but consequently been pushed forward, although in uneven steps. During the last ten years with the new focus on environment and climate issues other sides have been enlightened but even then from an economic perspective which the Stern report (Stern 2006) shows, as one example.

In 1999 the Swedish government decided on 15 Environmental Objectives and in 2005 a 16th objective was added (Environmental Objectives Council 2009). Many of them are strictly related to our energy use and its environmental impact. The objectives have been adapted to county level with action-plans in all of Sweden. Sweden has a long tradition of energy balancing, resulting in energy- and environmental counsellors in every municipality in 2008 and over 44 % renewables in the national energy system which is more than in any other EU country. The Swedish government's objective for 2020 is 50 % renewables (Energimyndigheten 2009).

5.2 *The tradition of conservation in Sweden*

In Europe during the 19th century a restoration method based on absolute architectural style had developed as were the trend for new buildings. An opinion against this evolved in the beginning of the 20th century. Crave for genuine and authentic experiences and materials along with national and historical influences characterized the Swedish movement that came to build the base for our stable tradition. The architects Sigurd Curman (1879-1966), Erik Lundberg (1895-1969) and Ove Hidemark (1931) are the main representatives of our 20th century tradition and all three of them were also historians. Other similarities are teaching and publishing theories on restoration and history of architecture. All this have been described by Victor Edman in 1999.

Professor Curman was 1903-1905 studying conservation work in Italy, Germany and France and got in contact with "restauro storico" (Robertsson 2002) emanating from Camillo Boito (1836-1914). For Curman method had to balance rules and freedom of action and furthermore emphasize patina as the ornament keeping the buildings ambience and telling the national history and path of development. Part of this restoration concept was a revival of old materials and methods which were reinvented by skilled craftsmen at the construction sites. Curman and his generation managed to combine the antiquarian and architectural perspectives with creation of a new profession: The restorer as scientist and aesthete. This was mediated to Lundberg.

Erik Lundberg's contribution to the new tradition was his aesthetical approach allowing new artefacts as e.g. designed lighting to elucidate spatial properties and layers in historic environments but principally it was his approach on historical and architectural development and design. He emphasized the historical continuity with all layers, the architecture experienced by senses and history as a living past in a creative process unifying the past, present and future. The Swedish modernism of the 1930s wanted a break with tradition and old and new clearly parted using modern material in restoration. Lundberg was positive but vindicated the importance of tradition and historic perspective. He developed a holistic view including understanding of the buildings gestalt, movement and expression, the skill of the shaping, crafting hands and the primary properties of the materials in use. As a teacher and author Lundberg had a great influence. One of his students was Ove Hidemark.

Hidemark continued the tradition from both Curman and Lundberg with empirical accuracy, emphasizing an objects patina and the historical approach which he developed. His analyzing of strict measuring resulted in a "technical and historical reading" (Hidemark 1978) using the building as the source of knowledge. On European level Cesare Brandi's (1906-1988) theories on restoration "restauro critico" was predominant and formed base for the Venice Charter formulated in 1964 (Robertsson 2002). With its' 16 articles it viewed the building as a historic document where transparency and exposure of its history and restoration dominated. This principle though could sometimes be apprehended as lack of both technical and psychological credibility. Some Swedish architects performed restoration according to this and were criticized. On one level fragments were exposed on behalf of the experience of the whole and modern materials were used on behalf of the buildings identity. In this contemporary context Hidemark developed a respect for the buildings' identity, material, techniques, cultural layers, authenticity and patina resulting in his "Charta Minor", a minimized level of intervention in old buildings using repairable and hence durable materials. Hidemark sees the old building as the abstract concept of time materialized and preservation as mastering the beauty of ageing. Hidemarks thoughts on restoration are material and immaterial. The physical properties are defined by empirical science and the spiritual are to be found in the buildings identity, its' memory.

The Swedish tradition aims at a harmonious combination with the artistic and scientific criteria. Curman, Lundberg and Hidemark have been leading authorities in relation to architectural and historical values as well as excellence in construction, materials and technique, forming unity and balance. All three have opposed rigid doctrinal attitudes. They have had the will to see time as an unbroken tradition with a binding rather than dividing effect. The building itself is the main source of knowledge and must determine the measures taken.

This tradition though must be seen connected to a societal perspective where our stock of buildings radically altered during the 20th century. As in other countries the cities' population increased causing a big housing shortage. Most dwellings were small and lacked sanitary facilities. Investigations on these issues succeeded one another from 1920 and onward. Everyone should have a "God bostad" (Good dwelling) which also gave name to the standards that in course of time was brought forward. Sweden parted from other countries by not promoting social housing or low-cost housing but giving favourable governmental loans to and demanding high standard in all new dwellings (Caldenby ed. 1998).

Sweden had poor housing conditions in the beginning of the 1950s. This originated a row of political decisions and new physical planning. The reconstruction of the cities seemed to be the only answer. New constructions were emphasized before renovation due to the costs. The government had forced the construction industry to develop new economic and rational methods and with the decision to build one million dwellings in ten years pushed them even further thus giving the construction industry a very strong position. Most old towns in the Swedish cities' centres were demolished leaving the towns without identity or historic roots. The strong opinion against the 1950s and 1960s demolition of old cityscapes turned the heritage sector and preservation towards continuous settlements and whole environments. Old built environments were revalued as important and useful. Traditional materials and techniques were seen as healthy and ecological contrary of modern. Hidemark criticized the construction industry for their short term thinking. Step by step a new perspective evolved. New conceptions like cautious reconstruction and cautious city renewal came in use in universities and among architects (Caldenby ed. 1998).

These issues were discussed on European level as well and great manifestations as the congress in Amsterdam took place 1975. Antiquarian preservation was connected to environmental preservation and cultural survival. The Granada Convention passed in the European Council in 1985. The member states committed to take action on legislation, public supervision, planning, education and research aiming on conservation, protection and maintenance of built heritage. Sweden signed on. Within a few years this resulted in new laws. A new view on built heritage and conservation was formed. From a societal viewpoint care for our built heritage must permeate all sectors of society and be seen and handled as an integrated part of the regular planning.

Today we make use of integrated conservation and refer to five important laws and regulations in Sweden of which two will be mentioned here. According to the Planning and Building Act, Chapter 3, section 10, "Alterations to a building shall be made cautiously, with regard to the building's characteristic features and with its constructional, historical, cultural, environmental and artistic values sustained." (Boverket 1987) We also have the Heritage Conservation Act which contains the basic regulations for protection of Sweden's heritage, including buildings, ancient remains, archaeological finds, ecclesiastical monuments and specified artefacts (Riksantikvarieämbetet 1988). The Heritage Conservation Act serves as the core legislation for preserving Sweden's historic environment.

6 RESULTS AND CONCLUSIONS SO FAR

The conservation work in Fattighuset has been performed with great consistency along the line of Swedish tradition. At actual work the uses of traditional or original materials and techniques have been advocated and any incision or alterations were designed reversible. Some of the doors were made with old ones as prototype with great adaptation as a result. New floor cornices have been adjusted to measures from old ones. Radiators have been replaced by new ones in old style. Some small movements in the construction had caused small damages registered in the inventory 1994 and these are apparent at ocular inspection but the moving seems to have stopped. The exterior have many time-layers all adjusted to the original facade showing high authenticity and patina. The gymnasium also owns a great patina and authenticity still having the climbing ropes hanging from the ceiling and gymnasium ribs on the wall. The broad-axed roof-truss with rafters and tie-beams in the attic are exposed and untouched.

The buildings' important part in the environment of the old town and their high architectural values has been preserved. Documentary and symbolic values from societal perspectives and social history are still there for the future. Much of the intangible and tangible cultural values are preserved. Is it on the energy efficiency's expense? The estimate must be that Fattighuset is getting on well in comparison with similar buildings' energy use but it could have been much better. If the computer aided energy balance shows the same results as the manually calculated there are still actions to be taken for improvement of the energy efficiency and indoor climate. Possible measures: Heat recovery in the ventilation system could be installed and mechanical supply air could be added. Much would have been gained by this with the energy use and the tenants' problems partly solved. Air leakage from windows and fresh air vents must be dealt with from both the tenants' and the landlord's point of view. Added insulation of the interior side might cause problem but could be possible if the dew-point of the walls' construction is calculated and the type and thickness of insulation is adjusted to it and carefully chosen. All this must be taken under consideration of an Inspector of Built Heritage, an Energy Counsellor, an Architect and a Construction Engineer together. But right now in this particular case the Halland Model didn't manage to go quite all the way on the energy path.

All together the cultural and historic values have to a very great extent been preserved at the same time as the buildings had an altered use. The technical and comfort issues remaining should be possible to solve with continuously preserved cultural values.

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PAPER 2:

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Energy Efficiency and Preservation in our Cultural Heritage - EEPOCH

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Energy Efficiency and Preservation in our Cultural Heritage - EEPOCH

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SUMMARY

EEPOCH concerns the complex set of problems that hold between energy efficiency and preservation perspectives in our built heritage. With new legislations and demands on energy performance, issues have arisen on how to meet them. A potential for energy efficiency actions has been stated but can this be carried out without endangering the historic values? What is possible from technical and historical views? Can laws and regulations guide us? This will be looked into by means of a multiple case study with a transdisciplinary approach.

Objects for case studies are chosen within the regional co-operation project, the Halland Model. It started in the 1990s recession. The aim was regional growth, and strengthening competitiveness, sustainability and development of building conservation. The restored and preserved buildings, though, have so far not been evaluated regarding their energy performance. Two of them will be presented in this paper.

KEYWORDS

Case study research, Energy efficiency, Built heritage, Building regulations

INTRODUCTION

Summary of the Halland Model

The County of Halland is situated in the south of Sweden. In EEPOCH objects for studies are chosen within the concept Halland Model, a regional joint venture, initially created for preservation of historic buildings and started in the 1990s recession. Over 1100 construction workers and apprentices were trained in traditional building techniques operating in about 100 historic buildings at risk, under supervision of skilled craftsmen and conservation officers. "Save the jobs, save the craftsmanship, save the buildings" was the very 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.

In Christer Gustafsson's dissertation (2009) on the Halland Model an application-oriented theoretical platform and a new model, providing adequate approaches to solving boundary-spanning challenges is presented. A generic and entrepreneurial model is developed where the "trading zone" is defined as an active arena for negotiations and exchange of services or a field of force corresponding to the actors' policies, values, facts and resources.

After the completion of conservation work the improved premises made new functions available. They were seen by entrepreneurs as resources to be taken advantage of and develop. This is one of many added values which have come out of the concept.

Both preservation and energy efficiency have been taken into account in the conservation work. The Halland Model holds examples on managing of energy performance without diminishing the cultural value and social history in our built heritage. Thus the Halland Model is appropriate for further research.

Background to EEPOCH

When starting the ”million programme” in Sweden 1965 one million flats were built in one decade. This was a parting point where the epoch of craftsmanship altered into the industrial era with prefabricated parts mounted on the construction-sites. Simultaneously a great part of our built heritage was demolished. Hence Sweden has a young building stock. Habitations constructed before 1945 only amounts to about 33 %. (Boverket 2004). It is the built environment constructed before 1945 that is studied in this research project.

During the 1960s and later in the 1970s oil crisis, when refurbishment were subsidised, many mistakes were made. Our Swedish stock of insulated and plate covered buildings emanates from these years and on. There is a need of guidance on efficiency in the sector. According to the Swedish governments Environmental Objectives Council (2009) the cultural, historical and architectural heritage as buildings and built environments with special values should be protected, developed and identified latest in 2010. In Halland the inventory points out over 10 000 objects, to be compared with the earlier 3 000. Similar results will most likely appear in the other regions.

About 36 % of Sweden's total energy use, and connected environmental impact, lies in the residential and service sector (Energimyndigheten 2009) On European basis the sector is consuming 40 % of the total energy use and in an EU-perspective the need of imported fossil fuels is a problem. The 50 % of today will have increased to 70 % in 2030 if actions are not taken (EC 2007). Many directives have been formed due to this fact. The potential is pointed out in the existing building stock. On EU and national level energy efficiency is considered a key action.

In this context two questions emerged. Will cultural and intangible values in our built heritage be lost in advantage to measurable and tangible energy efficiency actions? Is there a risk that emphasis on cautiousness in our built heritage, makes actual energy efficiency potential not being realised?

– Through generic research in EEPOCH, the case studies will form a foundation for a theoretical model directed on application for integrated balancing of energy and preservation demands, without diminishing tangible and intangible values in our built heritage.

– Through qualitative research in EEPOCH, the methods used within and between connected professions and academics, will be illuminated and especially their transdisciplinary and interdisciplinary approaches.

METHODS

The chosen methodological framework is a multiple-case design with embedded multiple units of analysis according to R. Yin (2009). The theoretical model for balancing of demands will emerge from the cases of which some will show predicted similar results (a literal replication) and some predicted contrasting results for anticipatable reasons (a theoretical replication). Units of analysis are the restored objects, their energy performance and their historic values and the people, organisation and methods in use during the conservation work. The latter part includes interviews and will be carried out this spring. In brief it is about using pattern matching and analytical means to generalize sets of results to broader theories.

Preserved historic values: Data for analysis are collected from archive files, reports, documents and photos, from the evaluation of physical artefact in situ and from people engaged in the conservation work. The Swedish National Heritage Board's handbook, Unnerbäck 2002 is used for assessment in situ. Basic and enhanced motives for preservation have been registered by the investigator and a conservation officer and compared with earlier inventories to enhance the construct validity by using multiple sources of evidence.

Energy performance: The evaluation is carried out in four ways: With IR camera in situ, with computerised (BV2) and manual calculations on their energy balances, and by measuring actual energy consumption. Differences in these figures can show good maintenance but could also detect problems indicating actions to be taken and show what can be improved. When preparing for the manual calculations eight different books and guides have been used: Adalberth (2008), Adamson et al. (1986), Anderlind et al. (2006), Boverket (2009a), Boverket (2009b), Elmroth (2009), Petersson (2009) and Wärme (1991). No calculation model is without flaws but the strength is in using the exact same procedure in every object for an accurate comparison between them, ensuring the reliability of the case study.

For further input and to root the case in approved practice and theory, a reference group, an expert group, and local companies are connected to the project participating in workshops, providing facts, expertise, experience and advice. Findings from the 1st workshop is part of this paper, and the question of what is possible due to laws and regulations occurred when practice and problems were discussed, hence the embedded unit of analysis presented in this paper.

RESULTS

Review of legislation concerning extensions and other alterations in buildings

Our officially protected monuments with high historical and cultural values are quite well managed and protected by the Heritage Conservation Act which includes buildings, ancient remains, archaeological finds, ecclesiastical monuments and specified artefacts (RAÄ 1988).

However all buildings are important for the overall experience of a neighbourhood or a region. They may not be ancient or distinctly characterised still they serve as documents of the history and as cultural layers of development. Are these documents protected? Here follows a review regarding practice of building permits and the demands on energy efficiency and historic values.

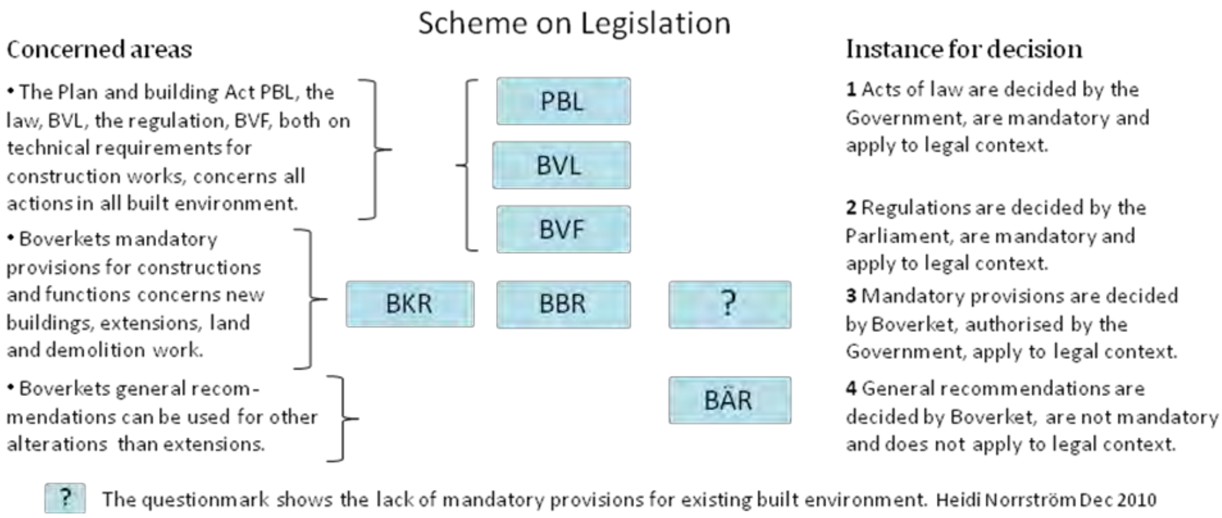

Figure 1. Hierarchical scheme on legislation to respect in actions regarding historic values and energy efficiency in buildings.

Boverket mentioned in this paper is the Swedish National Board of Housing, Building and Planning. Steering documents for managing the historic values in built environment are found in PBL, Ch. 3 and 5, the BVL and BVF, and in BÄR. Corresponding for energy issues are PBL, BVL, BVF and BBR in Ch. 9. The regulation on energy declarations and parts of the Environmental Code, MB, do also have an impact on both aspects but will not be discussed here.

The new PBL coming into force May 2nd 2011 still have the demand on cautiously made alterations in historic buildings but now in Ch. 8, Sec.17 and the prohibition of distortion of historic built environment is now in Sec.13 and on maintenance in Sec.14. The new PBL includes almost all of the content in BVL which repeals May 2nd 2011.

PBL, BVL and BVF concerns all types of construction work. BBR concerns buildings, new ones and extensions (i.e. when the buildings volume increases). BÄR is on other alterations than extensions. This collection of general recommendations is connected to laws and regulations. BÄR is not mandatory but advices on how to act according to the legislation. If the general recommendation is not followed there is still an obligation to show that the demands in the legislation are fulfilled. (BBR p. 18)

Table 1 is the same as table 9:3a Premises with other heating than electric heaters in BBR. (BFS 2008:20).

Climate zone	I	II	III
The buildings specific energy use [kWh per m² A_{temp} and year]	140	120	100
+ addition when the flow of hygienic reasons needs to be more than 0,35 l/s per m² in conditioned spaces. $q_{average}$ is the average specific supply flow during heating season and may only count for up to 1,00 [l/s per m²].	110 ($q_{average}$ -0,35)	90 ($q_{average}$ -0,35)	70 ($q_{average}$ -0,35)
Average heat transfer coefficient, [W/m² K]	0,70	0,70	0,70

The table 1 above (table 9:3a from BBR) is showing the demands for new premises not heated with electricity. Premises with electric heating, in climate zone III, south of Sweden, should manage on 55 kWh per m² A_{temp} and year. The attached general recommendation declares that more electricity and higher need for power can be accepted if special circumstances can be proved e.g. ”…-if the demand on specific energy use isn't possible to fulfill due to cultural and historically motivated limitations. In this condition the values may not be exceeded with more than 20 %.” which in this case means 66 kWh per m² A_{temp} and year.

For dwellings the corresponding demands are 110 and 55 kWh per m² A_{temp} and year, with the same possibility of addition. An alternative demand on a buildings energy use in Sec.9:4, based on U-values, concerns buildings with less than 100 m² A_{temp}.

To ascertain how the legislation is applied a national civil servant and five municipal officials in Halland have been contacted. The same questionnaire-like queries have been put forward to all at meetings (3 conversations) and on the phone (3 calls). Some of the answers are summarized here.

Question: How do you interpret and judge permits by the mandatory provisions and general recommendations in BBR and BÄR? Especially Ch. 9 on energy efficiency, Sec. 9:2 Dwellings, 9:3 Premises and the general recommendation about 20 % deviations at special circumstances? And the general recommendation in section 4, 4.6 on energy efficiency and insulation in BÄR?

One of the answers: “Even if it's an extension, considerations are taken to historically valuable buildings. It isn't always right or easy to insulate properly to achieve the 110 kWh/m², year + 20 % prescribed in BBR.”

All answered similarly. They rather consider cultural values than making unreasonable demands on energy efficiency which are impossible to fulfill. Usually they enlist the help of Heritage Halland and their conservation officers in individual cases to assess the historic values. Sometimes though, they don't agree and the Building committee must e.g. decide on demolition. At extensions less than 50 m² there is no energy demands. Between 50 and 100 m² the U-values in BBR Sec. 9:4 can be used instead of measured figures. But the energy demands are hard to interpret and follow because of all different parameters. In the municipalities there is a wish for more clear and simple legislation.

Extensions in existing built environment

In many old buildings electric heaters are installed to avoid water-pipes and space consuming boilers which affect the interior. According to BBR the demands when using electric heating in extensions is 55 kWh/m^2 A_{temp} and year and 66 kWh/m^2 A_{temp} and year with the 20 % addition.

It can be hard though, to design the appropriate character for a new extension following the energy demands. What does this imply for our existing built environment? Statistic on available key figures shows considerable higher figures for existing constructions built with old techniques.

Table 2 is showing key figures which illustrate the problem.

Fattighuset, Drottning Kristina 2, Halmstad	204 kWh/m^2, year
Laholms Teater, Laxen 5	167 kWh/ m^2, year
Energy calculation, type code 826, statistic interval*	144-200 kWh/m^2, year
Other figures in offices**	140-240 kWh/m^2, year
The National Energy Agency's STIL-study, average figure***	202 kWh/m^2, year

*Boverket 2010. ** http://www.byggabodialogen.se/ ***Energimyndigheten 2007.

Question: The mandatory provisions in BBR should determine the permit for extensions but can it also result in demands on the already existing parts?

According to BVF, a superior regulation, demands can be asked for in existing parts in other alterations but not in existing parts to extensions. The municipal officials were aware of this.

Alterations in existing built environment

In PBL, Ch. 8, Sec. 1, building permit is demanded for new buildings, extensions, adjusting buildings for new purpose and substantial transformation. With Sec. 3 demands are stated on permit for altering facades, install signs etc.

Question: Substantial interior transformations for new activities, altered ventilation system and amendment to the supporting structure are planned for Fattighuset in Halmstad. The alterations will significantly extend the buildings operational life-span. How do you make the assessment on demand for building permits in existing buildings?

Answers: In Halmstad they want a notification for interior alterations if it's not big alterations requiring changes in the comprehensive plan. They demand applying for a permit to install exterior signs or other changes on the facade. If it had been an extension or alterations in the facade they would have demanded applying for permit and it would have been processed according to BBR.

In this case BVF Sec. 3-8 and Sec. 10-15 apply. These Sections include demands on low energy consumption and particularly good energy efficiency with electricity in heating, cooling and ventilation. This shall apply also for those parts "…which, without being subject to the alteration, indirectly is affected by it." Regulation (1995:598)."

BÄR has a connecting general recommendation: "The thermal indoor climate and power demanded for heat stated for new constructions (…) in BBR should be pursued in extensive alterations. If this cannot be obtained, the risk for draught due to insufficient insulation in walls, windows etc. should be met so that no room has higher average U-value than 1 W/m^2, K and no construction part in the envelope a U-value exceeding 2.5 W/m^2, K." (BÄR p. 31) The subsequent text states "The basis for which climate to maintain is to be found in general recommendation on indoor temperature stated by the National Board of Health and Welfare SOSFS 2005:15 (M)."

Answers: This regulation and general recommendation has according to the responding officials' knowledge not been used. An observation in the municipalities is that BÄR is not in use. One explanation expressed: "It isn´t mandatory and hence in practice less meaningful to refer to."

The assessment is that some requirements should be demanded in existing constructions at other alterations than extensions but what requirements are demanded in practice?

Question: When evaluating Fattighuset as an example according to PBL, PBF, BVL and BVF; is it then the general recommendation (cited above) together with SOSFS 2005:15 that should be guiding? Or how should the text, in BVF Sec 8 and 10, be interpreted?

All of them answered that the basis must be the existing building. Lost historic values must be carefully considered and weighed against the energy efficiency gained. One cannot use general rules in old built environments and an assessment must always be done, and there is PBL to attend. BVL and BVF were not mentioned.

Boverket's submission for comments on demands for alterations in buildings

Boverket has paid attention to the problems with other alterations in older buildings by proposing a new revision on BÄR. The present general recommendations have not been in use mainly because they are not mandatory. There would be no point in referring to them in case of legal disputes. The reality shows the need for Boverket's decision on mandatory provisions.

The new proposal includes all buildings, the oldest as well as those built yesterday. That is why it isn't possible to specify level of demand for every single situation. The objective is to clarify that both requirements for cautiously made alterations and technical requirements must be taken under consideration at alterations. The aim is to ease the applying of the legislation.

The intention is to integrate the general recommendations from BÄR into BBR for higher status in legal context. By using table 9:4 from BBR a new suggestion is made. The following is from Boverket's draft/proposal on alterations – mandatory provisions and general recommendations.

Table 3 (same as table 9:92 Envelope in BBR): If the building after alteration does not meet the demands in sections 9:2 or 9:3 it should after alteration have pursued the following U-values. Figures for two cases are added.

Construction part	U-values BBR	Fattighuset 1	Fattighuset 2	Teatern 1	Teatern 2
U roof	0,13	0,15	0,29	0,12	0,14
U wall	0,18	1,80	1,80	1,02	1,43
U floor	0,15	0,26	0,42	0,18	0,18
U windows	1,2	1,4	4,5	1,9	4,5
U entrance door	1,2	2,7	4,5	2,29	4,5

For understanding how high the demands are, the two case studies have been added for a comparison in the table 3 above. The cases show different U-values for different parts and the highest and lowest U-values are shown here as Fattighuset 1 and Fattighuset 2 etc.

Both Fattighuset and the Teatern are solid brick constructions. The facades may not be altered and can't be refurbished with insulation. To add insulation on the interior is always a risk. The construction gets cooler and physically can't cope with moist permeation (Åhström 2005) and the interior holds great historic values. If these U-values cannot be reached to decrease the energy use, a heat pump could be installed but these are using electricity and then again it is the higher energy demand on 55-66 kWh per m^2 A_{temp} that should be met. Boverket's investigation on consequences (p. 16) also mentions cautiousness when carrying out interior alterations.

" The mandatory provisions clarifies that the demands on cautiousness and the prohibition of distortion also are valid for interior alterations. This will presumably lead to better procurement of historic values. The technical requirements are also clarified. If this leads to sided attention to other requirements without corresponding attention to historic values it could lead to negative consequences for the cultural and historic values."

DISCUSSION AND CONCLUSIONS

So what is possible to do on local level, is very much up to the municipal officials in charge. Or is it the laws and regulations lacking clarity? The latter must be the case according to the answers given by the officials. This is also indicated in Boverket's investigation on consequences of the new proposal where findings like the ones described above appear in their text.

In the following a comparison of two cases, and some conclusions, are made.

The first case: Fattighuset, Drottning Kristina 2 in Halmstad

Fattighuset (the poor-house) or the old fire-station is in the municipality of Halmstad. The real estate's name is Drottning Kristina 2 in the parish of S:t Nicolai and has two buildings. The municipal real estate company Industristaden AB is the owner. Fattighuset is a corner house at Lilla Torg, in the old town. The buildings have two stories, an attic and a solid red 1 ½-stone brick construction. Partitions and floors are wooden. Regular placed four-bayed wooden windows have glazing bars and plate covered window-sills. Fattighuset has a red-painted plated span-roof and at the conservation work 175 mm of insulation was added. Mechanical ventilation and a lift were installed. The buildings have district heating.

The main plans for Fattighuset in Halmstad are by head architect in the city of Gothenburg, Hans Strömberg, in 1859 and 1879. It served as a poor house for 42 years. The fire brigade moved in 1903. A hose-tower and coach-house was built up with Sven Gratz plans. The buildings were vacant for some years until the conservation work started in 1996. After the completion Fattighuset was let out to shopkeepers and offices.

The buildings are made of local materials, worked by skilled craftsmen and have well preserved original forms, expressive exterior and preserved furnishing. The almost intact floor plans are of the general character which can hold different activities within, and by this possesses a high architectural quality. Fattighuset has classification 1 in the city's preservation plan: Building of great cultural and historical values with exterior that cannot be altered.

The second case: Teatern, Laxen 5-8 in Laholm

Teatern (the theatre) is a real estate named Laxen 5-8 in the parish and municipality of Laholm. Teatern at Hästtorget is part of Gamleby, the old medieval town. The building is an extension of the hotel, has two stories with an attic and a solid 2 ½-stone brick construction with plastered facade in light greyish and white corners. Partitions and floors are wooden except the auditoriums roof construction which is of steel. At the conservation work 300 mm insulation was added to the inner roof over the auditorium and ventilation with heat recovery installed. The roof is black-painted plate. The wooden windows are of various sizes depending on function but all have glazing bars. The building is heated by a gas boiler.

In 1911 the drawings were delivered from the head architect in Kristianstad, Per Lennart Håkansson. The building was raised in 1913. A liquor store on the ground floor helped financing the work. In the 1950s the auditorium was reconstructed. All golden decorations were covered by plaster slabs and the ceiling lowered. The city council used it for meetings. Teatern had several owners but in 2010 the municipality once again became the owner.

During the conservation work in Teatern in 1995 the 1950s alterations were removed. The original interior was restored with lime plaster and gold to its former state. The original chairs were restored. The big arched windows in the auditorium were reproduced and partly mounted with three window panes. The plastered facade was altered in the 1950s but the question of restoring it has not yet been raised. Still Teatern is one of the most dominant buildings at Hästtorget and has classification 1 in the city´s preservation plan: Building of great cultural and historical values.

Table 4 Comparison of energy use

	Fattighuset, Halmstad	Teatern, Laholm
A) Transmission, envelope	136 MWh/year	119 MWh/year
B) Heat loss ventilation	47 MWh/year	30.4 MWh/year
C) Hot tap water loss	12 MWh/year	3.5 MWh/year
D) Surplus heat, people	3.6 MWh/year	4.1 MWh/year
E) Surplus heat, equipment	18.0 MWh/year	9.2 MWh/year
F) Calculated total need	173.4 MWh/year	140.1 MWh/year
G) Bought heat	186 MWh/year	*100.4 MWh/year
H) Difference / infiltration	12.6 MWh/year	40.2 MWh/year
I) Electricity for running	29.7 MWh/year	*6.9 MWh/year
K) m^2 A_{temp}	1062 m^2	884 m^2
L) Calculated key figure, heat	176 kWh per m^2 A_{temp}	159 kWh per m^2 A_{temp}
M) Calculated key figure, electricity	28 kWh per m^2 A_{temp}	8 kWh per m^2 A_{temp}
N) Calculated key figure, total	204 kWh per m^2 A_{temp}	167 kWh per m^2 A_{temp}

*These are the figures available. In Laholm the hotel and Teatern had the same meter for many years. Figures from an energy declaration made by Anders Salberg at HEM in Halmstad have been used. His estimation for m^2 A_{temp} in % on the different parts has been used as base for modification when dividing the total heat and electricity use. Separate and individual measuring in Teatern started in Nov/Dec 2010 and the actual figures will soon be available.

Teatern has lower energy demand than Fattighuset. This can partly be explained by heavier construction with thicker walls and that it hasn't been occupied as much due to its property as an official auditorium. The bigger surplus heat for equipment in Fattighuset depends on the renting offices'. The bigger difference/infiltration in Teatern will likely change when the actual measured figures comes, see comment attached to the table above. On comparison Teatern, although its lack of patina because of the restoration in the 1990s, has almost as much cultural and historical values as Fattighuset, and yet better energy performance. Both technical solutions and historic values have been in focus. This partly supports the theory that energy and preservation demands can be balanced. The main actions in Teatern were added insulation and ventilation with both exhaust/supply air and a heat exchanger for heat recovery.

Fattighuset has a number of good and some less good qualities depending on perspective. Balancing becomes very difficult when same properties can be understood as very good and very bad simultaneously. Here is one example. The preserved and to a great extent untouched interior (+), causes bad indoor climate for the renters because of cold walls and draught (-). They move out thereby causing the real estate company trouble (-). But during the discussion at the workshop in June 8th 2010 it appeared that some measures counteract and some interact for better holistic in total. As a very short summary the preservation issues in Fattighuset have been prioritized foremost on behalf of the comfort, but also on behalf of the energy issues.

Alterations are planned for Fattighuset as described earlier. This was among other things discussed at the workshop with 18 participants in June 2010 in Halmstad. One of the results thereof was a number of measures for Fattighuset. The measures also apply for other objects.

The table below shows the pros (+) and cons (–). The measures are looked upon from different aspects. The property of being lettable is connected to what the renter want and is prepared to pay for. Some prefer low costs and care less for comfort, some care more for good indoor climate and others care for appearance and ambience etc. The possibility of being let out is dependent on all aspects and has not received a column.

An order for priority can be made from the list. The summary shows that most suggested measures aim at better indoor climate and comfort, by counting the pros (+) and cons (-) in the columns. The energy use and comfort can be understood as synonymous, in a building where the envelope hasn't been altered. Low energy use – low comfort and high energy use –high comfort. One conclusion is that optimization of results includes measures in the envelope. How good energy performance should one demand? The greater the freedom of action for implementing energy measures, the more decreased energy use can be demanded. How much freedom was allowed at the conservation work? Was the state of knowledge different from today? The answers must be that there wasn't much freedom and the state of knowledge is wider today.

MEASURES	FOUR ASPECTS			
Fattighuset	**Preservation**	**Energy/environment**	**Comfort**	**Manag./economy**
Interior 3:rd window pane (the exterior may not be altered)	(-) Original appearance/view changed (+) addition of one extra pane will preserve the original windows untouched	(+) less heat loss (+) less energy use and hence less emissions	(+) better air tightness/less draught (+) no cool convection, bigger floor area along the walls can be used	(-) new investment (+) lower running costs
Original walls restored and preservation of some floors	(+) a very high quality	(-) bigger heat loss (-) more energy use and hence more emissions	(-) lower surface temperature on interior walls gives feeling of draught	(-) new investment (restorer) (-) higher running costs
Interior insulation very thin layers of nanogel / aerogel. (the exterior may not be altered)	(-) painted original walls hide behind a tight layer (as present) (+) painted original walls are preserved behind a tight layer	(+) less heat loss (+) less energy use and hence less emissions	(+) higher surface temperature on interior walls gives less feeling of draught (-) risk for moisture problem in the construction	(-) new investment (+) lowered running costs
Air Star fresh air vents with electric heating/recovery	(+) no bigger exterior change (-) very bad appearance in interior with a "box" at every fresh air vent but (+) leaves the solid construction untouched	(-) more electricity use gives more emissions* (-) more electricity use is wrong system-thinking when renewable district heating is installed * (-) counteracts existing depressurized ventilation	(+) higher temperature on supply air (+) higher temperature on interior walls give less feeling of draught	(-) new investment (-) / (+) higher/lower running costs
Exhaust/supply/heat recovery-ventilation system installed (complementary) and plugging of fresh air vents	(+) no bigger exterior change (-) new holes in the construction for ducts (-) visible ducts alters the interior	(-) more electricity use, see above* (+) higher energy efficiency in existing system (+) use of waste heat	(+) higher temperature on supply air (+) higher temperature on interior walls give less feeling of draught	(-) new investment (-) / (+) higher/lower running costs
Higher flow temperature in the supplied heating system	(+) no material/visible changes	(-) higher energy use gives more emissions (+) district heating gives low emissions	(+) More heat causes less cold convection at windows and increases the comfort	(+)no investment (-) higher running costs
Better lighting, new demand in official sites	(-) more and stronger lighting spots alters the interior	(-) more electricity use gives more emissions	(+) better visuality (+) greater security, safety	(-) new investment (-) / (+) higher/ lower running costs

Table 5 Suggested measures seen from four aspects, showing pros (+) and cons (-).

An open way to look at a building is in its context with all interacting systems where human activities are included. The emphasis for technical orientation must find its' way towards the building as a system where total performance is considered. And we must find another way to assess historic values, with their complexity, in a proper value system. This can lead to the model by faster defining of problems, balancing against regulations and, energy and preservation demands.

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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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ESA 2011 *Cultures of Conservation and Sustainability*

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ABSTRACT

The research project EEPOCH, Energy Efficiency and Preservation in Our Cultural Heritage, concerns the complex set of problems that exist between these two perspectives including usability and team organization in the preservation of built heritage. The teams' performance determines the outcome of the conservation work, and their performance is to a great extent dependent on the leadership and management which are explored in this paper.

There is a great potential for energy efficiency in the existing building stock. At the same time we know that built environment is an important heritage worth preserving, and does not only concern monuments. In the great rush to demonstrate energy efficiency, there is the risk of destroying quality that manifests in other ways. This is considered to be a contradiction. The hypothesis is that all perspectives can converge to be met in applied cases. The aim of EEPOCH is theory building, and development of useful methods for this.

Case studies will form foundation for the methods. Preserved objects for studies are chosen from the Halland Model, a co-operation project and true model for integrated conservation. Its success is described as an outcome of an entrepreneurial model where the trading zone is defined as an active arena for negotiations and a field of force corresponding to the actors' policies, values, facts and resources. It has, though, not thus far been evaluated regarding the energy performance or the working teams' performance and their impact on the outcome of the conservation work. The latter is explored by interviewing the management for the teams.

EEPOCH is carried through by multiple case studies and workshops, analysis of different measures and interviews, and document studies. The work so far indicates that the hypothesis is right and will result in models useful for objects other than monuments.

INTRODUCTION

The work within EEPOCH is about creating a theoretic model aimed at application in practice for balancing energy efficiency and preservation demands in restorations and refurbishments. This is often considered a contradiction. These two areas are so different that they are difficult to compare. The theoreticians and practitioners who specialize in these two areas also have different cultures within their professions.

In our work as practicing architects and conservationists, we have sometimes experienced conflicts between different interests. Now, we examine the specific interests of energy efficiency and conservation concerns. It is a classic dilemma: the positivist generalists as technicians or scientists with the nomothetic focus on the one hand and humanists with their romanticism and historicism and the individual—the idiographic—in focus on the other side. It is largely a matter of different cultures among the professionals who work with these questions but it is also interesting how, and in what way, it proves itself in actual work situations, through conduct in construction meetings.

The latter are likely to be difficult or impossible to get, this long after the actual events, but what has just been described forms a basis that could be paired with the visible results of the restoration work. Has the engineer's strong position in the project resulted in more stringent efficiency measures or has the antiquarian’s strength resulted in more stringent conservation and preservation of objects? If there are such links, a larger study in the autumn is suggested to confirm/validate the results. This is a small pilot study with four informants to determine whether it is possible or desirable to do a larger study in the autumn.

The hypothesis is that there must be a way to deal with any problems. One way might be to develop a weighted score of both cultural values, and the value of energy efficiency measures.

The concept of sustainable development of cultural sites, worked out within the Halland Model, has allowed both conservation concerns and energy efficiency to be addressed in several cases of restored objects. Christer Gustafsson has a doctorate on the subject and described in detail the *trading zone* created in the Halland Model, in his thesis[1]. He has demonstrated the role which the heritage sector and buildings with cultural values can have at the negotiating table in terms of supporting regional sustainable development.

Therefore, the objects in the Halland Model are appropriate when trying to describe the situation, and perhaps also for finding good examples of how balancing the two interests of conservation and energy efficiency can be made, or inspiring thoughts on how this could be done.

This essay is about the team organisation within the Halland Model and how the restorations were performed from the planning to the execution of it, and to reveal if and how it is visualised in the result, the buildings themselves. First and foremost: how were so many professions and concerns reconciled for a common cause? Was it the working methods or the leadership?

[1] Gustafsson 2009

What we want to know is how the management worked with conservators, engineers, architects, site manager, etc., and how, in what way, decisions were taken and implemented. If it has worked well the experience, any methods, processes and strategies may be formulated and be of use in other similar work. Simultaneously, bad experiences can be utilized to learn what to avoid in other similar jobs.

This is a first careful attempt to understand why and how the management made it work. It is not a thorough explanation of how the teams worked when the concept of the Halland Model was carried out. The explanatory part with analyses that could lead to a theory is a project of its own that has to be worked out separately. This essay based on a few interviews is a tentative trial to identify the contents of the management work, a qualitative description or assertion, which may be substantiated in a later quantitative work.

Questions are directed to people managing project teams who worked with objects restored within the Halland Model. What is of interest is the management and working climate created by the management's performance. Were there any special strategies or was any (planned or unplanned) process created to facilitate the work with so many different professions and concerns involved in the restoration projects?

The degree of conservation of historic and cultural values in each case has been evaluated by three professionals, first by an architect and then by two conservationists of the built environment. These evaluations have been compared with archival ones for triangulation of the findings. Both archival data and investigations at visits directly on site have been used for the evaluation as a whole. This is a qualitative description of the management and the teams' work and outcome of the restorations which may be strengthened and substantiated in a larger evaluation with many more respondents.

These questions and their answers are important in order to begin the work of establishing which potential proposed interests should be prioritised and then implementing this in practice. Of special importance is the response when it is suggested that the values in the different interests should be weighted to give the significant values greater weight when balancing the various interests.

When trying to map the management of the working teams, an archive search was made to find key people for interviews. One conservationist of the built environment and two construction engineers and one architect were interviewed, of which three were engaged in the work with most of the objects, and one just with one object. One deeper unstructured interview has been paired with three complementary semi structured interviews. In this Bernard Russel's research method has been giving guidance[2]. All interviews were recorded and transcribed for analysis.

The project EEPOCH is financed by the Swedish Energy Agency and by local companies who are engaged in workshops where solutions evolve.

[2] Russel 2006

DEVELOPMENT OF CONCEPT, STRATEGIES AND METHOD OF THE HALLAND MODEL

The beginning of what later became the Halland Model originated from an inventory of old buildings seen as surplus property in the inland of the County of Halland, in the 1980s. There was a regional support system for this at that time. An action plan for restoration of historically and culturally valuable buildings was made. This was possible thanks to a new approach developing in Sweden and Europe, where old built environment was revalued as important and useful. In Sweden this was manifested in the new Planning and Building Act in 1987[3] and the Heritage Conservation Act in 1988[4]. Care for built heritage became an integral part of the regular planning and the heritage sector was given its role in the traditional vertical hierarchy.

The next step came at the beginning of the 1990s, during the decline of the construction sector, when the concept of the Halland Model was formulated to engage the unemployed construction workers. The innovators were the County Labour Market Board, the County Administrative Board, the County Museum, the industry with the employers' organizations and the Building Workers' union. Now Sweden became a member of the EU whose main idea was to support and develop the regions. The 1990s was also a critical period between industrialism and post-industrial society and the division in sectors with systems of vertical hierarchies were still prevalent. The new regional strategic development needed horizontal collaboration. Creation of the Halland Model was the first attempt in doing this in a social context and working environment that had no experience of working horizontally, and was successful.

A major reason for the success, according to the interviews, was that each organisation had its specific role and responsibilities, which were respected so that the organisations did not interfere with each other's areas. The Labour Market board helped the unemployed as did the union. The industry's task was to survive the recession, keeping the labour force in Halland. Finally, the County Administration Board and the Museum had a cultural perspective, preserving heritage with the highest possible ambitions regarding antiquarian principles.

The County Administration Board, the Labour Market Board and the Museum formed a steering committee. It was the two latter organisations that ran the company, as it was a construction consortium and primarily perceived as such. They took care of the coordination and went around negotiating and creating a horizontal model for planning how the cultural conservation could develop. The Museum created an item bank from old and new inventories, filled with old buildings in need of measures taken for survival. In the overall planning they realised that they had to negotiate with the public as well as the private sector, the owners of the real estate' and surplus buildings. In so doing they also had meetings with the municipalities, tourism industry and culture industry and so on, searching for new and innovative or otherwise appropriate activities to provide new facilities. "As Jane Jacobs cleverly formulated; new ideas occur in old houses." [5] Restoring buildings was now seen as a resource to develop and take advantage of. This was an entrepreneurial and economic view with user value in focus.

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[3] Boverket 1987

[4] Riksantikvarieämbetet 1988

[5] This is a citation from one of the interviews.

A selection method was developed for establishing what kind of buildings were to be restored. This was based on what the market needed and what, when and how it could be done, depending on what professions within the construction industry had high levels of unemployment. And all this was horizontal work and crossed sector boundaries in an arrangement in which the different systems could cooperate for economic growth and regional development. They were forming a trading zone. In this process those who had built up their identity and their livelihood as specialists suddenly found themselves in a generalist's role. A larger picture evolved including not just labour market policies and preserved heritage but also social and environmental dimensions as well as an economic one.

This approach became an important part of the regional strategic development. The old vertical hierarchies with separate sectors had to make way for horizontal regional cooperation in the new networking society, which is the model in use today. Horizontal thinking was permeating the whole concept of the Halland Model and also transferred into the teams at the construction sites.

The Halland Model was based on restorations and was first and foremost seen as the construction consortium in the County of Halland. The developed method—the generic model—was, however, transferred into other contexts, e.g. the version of the model with democratic focus that was exported to Poland and to other countries from 1996 and onwards.

CONCLUSIONS ON MANAGEMENT OF THE TEAMS

Leadership expresses human values and visions in the context of the basic approaches in our society—consciously or unconsciously. This also shows in the approach taken to leading and organizing work.

Formal leadership is about inducing individuals to work together to achieve common goals. It also means initiating and maintaining a continuous group process and being a catalyst for individual and team development so that objectives can be achieved in mutual interaction. A step further ahead is dynamic or functional or transformational leadership.[6] This kind of leadership has different names in the literature but the notions are based on a democratic type. This type has been proven to be the most effective and results in good quality work, in comparison with authoritarian leadership which leads to faster results but disgruntled employees, and with the laissez-faire leadership which performs by far the most poorly and also results disgruntled employees.[7]

Dynamic leadership is functional, flexible, seizes initiatives, distributes the leadership and is often process oriented. The leader's role is both task-oriented and person-oriented, in various degrees depending on the situation. Leadership in the transformational sense is about setting goals and strategies and at the same time being able to convey these to their co-workers so that everyone feels involved, engaged and responsible.

A major strategy for managing the different teams working on the chosen objects within the Halland Model was to choose a democratic type of leadership and to create exclusive inclusiveness. A key action taken by the managers was making sure to let everybody in the projects, on all levels, be involved.

[6] Larsson et al 2006
[7] Maltén 1998

The different professions' cultures include the usage of many technical terms. In most cases they also include schooling in a tradition where silent or tacit knowledge based on experience is an important part of the knowledge transfer. This is especially obvious within the sector of craftsmanship and is not easy to bridge when different professions have to communicate in a workplace, and misunderstanding sometimes occurs. This was also the case within the Halland Model but it could be kept at a moderate level by keeping the groups task-oriented, and because of the restraining effect of the overarching objective and the given duration of each project.

The objective—save the jobs, save the craftsmanship, save the buildings—could be understood by all participating professionals. It gave the groups identity and facilitated affinities, as early as the orientation phase. The typical second phase of conflict and control was handled by creating a relaxed atmosphere with respect, care, inviting initiatives and allowing discussions. It was time consuming but it did not matter. Quality was a priority. This strengthened the group identity in the phase of affinity and lengthened the effective cooperation phase.[8] After work was accomplished, evaluations were made to take the experience into account and improve on it. This is a sign of a learning organisation.

For example, when educating the apprentices in old construction techniques e.g., a part of it was introducing them to the vision or main idea (for inclusiveness). In this way they all got an understanding of the importance of their part of it, the importance of their actual work at the construction site for the overall achievement. This can be called *inclusive management, obtaining the participants' consent to share responsibilities*, and it requires a transparent organization. This was one way to create a good working climate within the groups for an effective outcome.

A construction site always includes dangerous elements, and piecework can be stressful so traditionally a hierarchy and standards are needed to prevent and avoid accidents in the workplace. A high degree of comfort and security and safety was established at the construction sites in order to create good working conditions. Great care was also taken when choosing the apprentices' supervisors. They were selected from among the best craftsmen and in this way the necessary respect came with the package, so to say. Each of them was responsible for no more than three apprentices at a time, which made it possible to provide all the time needed. At the first restorations and on construction sites the real estate owners had their own organisation with project managers, and professional site managers were consulted but a system for this was developed along the way and a consultancy was eventually engaged for both tasks.

A team is also a team play and generally a flat organization was the aim for the groups. The size of the teams has significance for communication. When all individuals need to communicate at the same time, which is one of the prerequisites for a small, flat organisation, there must not be too many lines of communication. According to Larsen[9] a group or team of seven or fewer individuals is preferable. This can be shown with this formula for communication lines in a group. The letter n stands for the number of group members.

[8] Maltén 1998.
[9] Larsen 2003

$$\frac{(n-1)\,n}{2} = \text{number of communication lines}$$

Figure 1: Formula reproduced from Larsen 2003 p. 135.

When organizing the teams' work it seems that all factors in figure 2 that it was possible to affect was considered and designed for an efficient, satisfactory and responsible performance and outcome. The only uncertain factor was the employees' personalities. Incentive for the unemployed workers was of course to have a job and not risk being cut off from their unemployment benefit which is always a risk if you haven't had a job for a long time. And there was also the pride and satisfaction in doing something special that was appreciated by many, which was further reinforced by the positive image of the Halland Model in the media.

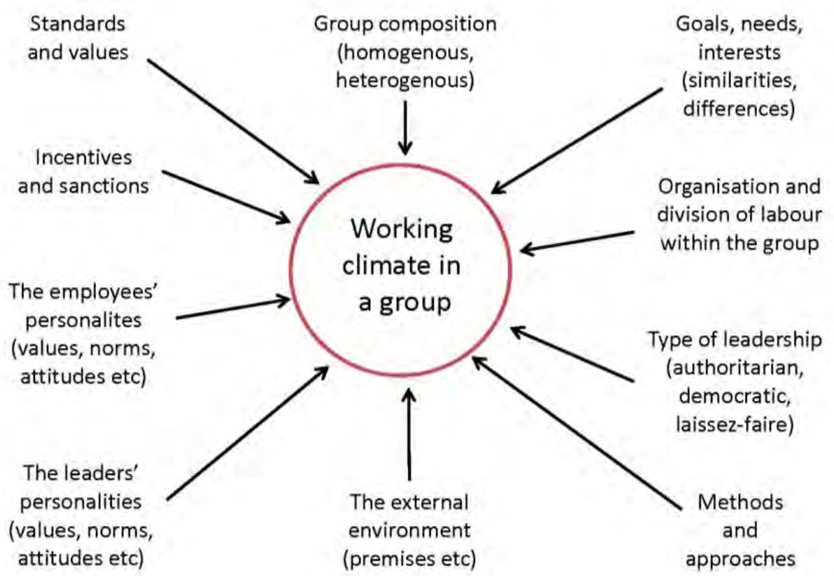

Figure 2: Factors affecting the group climate, freely reproduced from Maltén 1998 p.121

On the question of what could have been better performed within the Halland Model, three informants mentioned accessibility for disabled people in the buildings. Two also mentioned environmental issues and three mentioned that today they would have paid more attention to and performed better on the energy issue. Their overall assessment, though, is that the working teams' performance and the outcome were good and that they are proud of their work. The overall conclusion at this stage, however, must be that all this together affected the visual and actual outcome of the restorations. It is the restorations of Fattighuset, Drottning Kristina 2, Halmstad and Teatern in Laholm, Laxen 5 and Tyreshill in Rydöbruk, Hylte that are explored.

CONCLUSION ON THE RESULTS OF THE RESTORATIONS

TEATERN

Teatern in Laholm, Laxen 5, was built in 1913 and refurbished in the 1950s, and in 1995 it was restored within the Halland Model. It is a solid 2 ½-stone brick construction with a plastered facade. Partitions and floors are wooden except for the auditorium's inner roof construction of steel. In Teatern the original interior of the foyer, auditorium and the official restroom for refreshments and use between acts were restored to their former state with lime plaster and gold. The plastered facade was altered in the 1950s but was not restored during the conservation work in 1995. Still, Teatern is one of the most dominant buildings at Hästtorget in Gamleby and has classification 1 in the city´s preservation plan: building of great cultural and historic value.

At the conservation work, 300 mm insulation was added to the inner vaulted steel roof over the auditorium, and ventilation with both exhaust/supply air and a heat exchanger for heat recovery was installed. The vaulted windows in the auditorium were reproduced and partly mounted with three window panes. These were the main energy efficiency actions in Teatern. The measured energy consumption for heat and electricity is 108 MWh/year and per area A_{temp} heated to +10 °C or more[10], and A_{temp} is 884 m^2. The key figure for energy consumption is 122 kWh/m^2 and per year. This is considered low for an old building in this category, type code 826, according to the comparative key figure given, statistic interval 123-185 kWh/m^2 and per year, when calculating the building's energy performance at Boverket's web site.[11]

The authenticity in the buildings' appearance is high although it lacks some of the patina of 1913 mostly due to the 1950s refurbishment. The energy efficiency measures have been nicely adapted to the building and are not experienced as disturbing.

FATTIGHUSET

The main building in Fattighuset in Halmstad, Drottning Kristina 2, was built in different stages in 1859 and 1879 and the back wing was built up in 1891 and altered in 1901. They have a solid red 1 ½-stone brick construction. Partitions and floors are wooden. The buildings are made of local materials, worked by skilled craftsmen, and have well preserved original forms, expressive exteriors and preserved furnishing. The interiors have many old doors, windows, stairs, floor and roof cornices and more old features. The almost intact floor plans are of the general character which can hold different activities within, and by this possesses a high architectural quality. The buildings, and especially the back wing, have great authenticity and patina. Fattighuset has classification 1 in the city's preservation plan: building of great cultural and historic value with exterior that cannot be altered.

In the attic there is a room for the new mechanical continuous exhaust ventilation and fresh air is supplied by vents in the brick wall. The tenants experience poor comfort levels. 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. On the ground floor in the oldest part of the building is the boiler room where the exchanger for district heating is placed. There is also a problem with the

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[10] This is the defininition for A_{temp}.

[11] http://www.boverket.se/Bygga--forvalta/Energideklaration/Mer-information/Berakning-av-energiprestanda/

foundation. Fungus growth in the stone foundation occurred in the beginning of 2001 and was then excavated and a dehumidifier with continuous measuring and control was installed. When the conservation was carried out the earlier roof garrets were replaced with roof windows and 175 mm of insulation was added to the roof. During the summer the offices on the attic floor are overheated despite this.

The conservation work started in 1996 and after the completion Fattighuset was let out to shopkeepers and offices. The measured energy consumption for heat and electricity is 216 MWh/year. Total area heated to +10°C or more, A_{temp}, amounts to 1062 m^2. The key figure for energy consumption is 204 kWh/m^2 and 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 and per year, when calculating the buildings' energy performance at Boverket's web site.

The results from the conservation work are considered good, with well preserved authenticity and patina but in short the preservation issues in Fattighuset have been prioritized foremost at the expense of the comfort and energy issues.

TYRESHILL

Tyreshill, Rydö 3:20, in the municipality of Hylte is a solid timber building raised in 1907 as a private house for three families. In 1949 it was rebuilt for five families. It is one of the oldest houses in the industrial community Rydö Bruk according to the conservation plan, and has a typical red wooden panel facade with white corners. It was in bad condition in the 1990s and the owner at that time wanted it demolished, but the building committee did not allow it. It was renovated in 1997-1998 and the exterior facade is for the most part intact despite the poor condition. It was totally refurbished and parts of the construction on the ground floor had to be reproduced. Many construction details and aspects of the interior woodwork had to be produced by working from old models. During the restoration the attic was insulated with 200 mm mineral wool and 45 mm was added to the interior side of the walls. Low emission glass was selected for the inner panes of the windows. Two wood stoves were installed, one on each floor, using the original chimneys, along with a boiler for wood pellets with storage in a shed on the property with a culvert into the house. The building has floor heating and natural ventilation. Today one family lives on the first floor and they have a workshop and a pottery on the ground floor.

The measured energy consumption for heat and electricity is 37 MWh/year and area heated for +10°C or more, A_{temp}, is 235 m^2. The key figure for energy consumption is 157 kWh/m^2 and per year. 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 and per year, when calculating the building's energy performance at Boverket's web site.

The result of the restoration is a very comfortable house, warm with no draughts. It has a modern kitchen, bathrooms and space for laundry and all the facilities needed in a household of today. The two houses' appearance is original but lacks all patina. Their cultural value is considered moderate but Tyreshill has high value in its context as part of the young community's history. Usability, comfort and energy issue were prioritized at the expense of the original authenticity and patina, due to its poor condition.

A high level of ambition as regards preserving values was the result and is mirrored in one of the cases studied, Teatern in Laholm; the energy efficiency measures taken were performed with respect for cultural value and the energy use is low. In the second case, Tyreshill, a moderate level of preservation of values was obtained but the original state of the building was bad. Comfort and usability are great but with energy use a little too high considering the energy efficiency measures taken. In one case, Fattighuset in Halmstad, it seems that the preservation of cultural value has been given much greater weight than issues of energy efficiency and good indoor climate, with low usability and difficulties in letting it out as a result. This can be interpreted as a result of, or evidence for, the overall acceptance of high ambition in relation to the antiquarian principles within the Halland Model. The four informants mentioned that the teams always tried to reach consensus and the antiquarians' position was always respected. The best balanced example of the three cases, with regard to both energy efficiency and preserved historic and cultural values, is Teatern in Laholm, even though it was the only case where actual discussions, on the edge to conflict, arose, about the ventilation system. Two of the informants mentioned this discussion. Maybe one cannot draw conclusions from this but it seems that pushing our interests, regardless of which side of the matter we stand on, makes it possible to reach further ahead with both a high degree of preservation and low energy use. So we should not be afraid to take part in a discussion, on occasion.

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POSTER 1:

AGS annual meeting

Abstract for a poster to the AGS meeting was accepted and printed in paper edition and on website. The poster was produced and presented at the exhibition during the AGS, Alliance for Global Sustainability, annual meeting in January 2011, Göteborg, Sweden.

Save & Preserve

SWEDISH ENERGY AGENCY'S RESEARCH PROGRAMME FOR ENERGY EFFICIENCY IN HISTORIC VALUABLE BUILDINGS

ENERGY EFFICIENCY AND PRESERVATION IN OUR CULTURAL HERITAGE

ENERGY EFFICIENCY AND PRESERVATION IN OUR CULTURAL HERITAGE, EEPOCH IS ONE OF THE LATEST PROJECTS WITHIN THE PROGRAMME. THE AIM IS TO FIND MODELS FOR INTEGRATED BALANCING OF ENERGY AND PRESERVATION DEMANDS.

EEPOCH contributes to necessary development of knowledge in the complex set of problems that holds between energy efficiency and preservation perspective. An expertgroup representing both the energy and the heritage sectors is connected to the project. Together with real estate and energy companies in Halland they participates in workshops and seminars where solutions evolve.

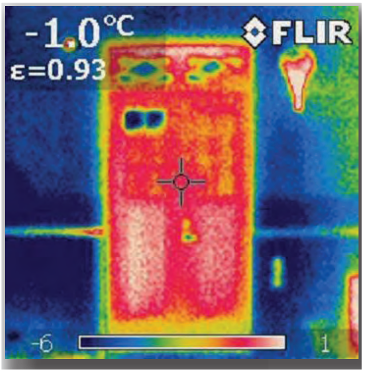
Preserved objects for case studies are chosen within the co-operation project Halland Model performed in the County of Halland in the 1990s recession. The aim at that time was regional growth, strengthening competitiveness, sustainability and development of building conservation.

The studies will form a foundation for a theoretical model directed on application for integrated balance of energy and preservation demands and a best practice.

For economists a buildings lifecycle is about 40 years. During this time the lion's share of the accumulated costs lies within managing energy use which also has a big environmental impact. Hence energy efficiency is considered a key action when finding a path to social, financial and environmental sustainability. The potential is pointed out in the existing building stock. What this implies for the building itself is rarely mentioned.

Two questions arise:

- Will intangible values in our built heritage be lost in favour of measurable and tangible energy efficiency actions?
- Is there a risk that too big cautiousness in our built heritage makes actual efficiency potential not being realised?



Preserving the past in an energy efficient way creates diversified and attractive environments for the future but this needs a model for balancing the energy and preservation demands.

Objectives for the first two years:

- summarise the work on measuring and calculations, actions, evaluation and key figures and analysis on method, process and model
- define needs for development of calculations and simulation tools and for processing analysis and communication between professions and the use of demonstration projects for implementation
- define needs for continued research within the field and of continued development of professional competences to join the different demands

Supervisor is Michael Edén, professor in Design for Sustainable Urban Development at Chalmers University of Tecnology and part of Chalmers Energy Center, CEC. PhD student is Heidi Norrström, architect SAR/MSA.

The expert group represents:
GMV Center for Environment and Sustainability, Politecnico di Milano, BEST, Anneling Tobin Consult AB, Gotland University, Heritage Halland, the Swedish Energy Agency, the Region of Halland and Energirådet Halland.

Participating real estate and energy companies in Halland:
Södra Hallands Kraft, Laholms kommun, Laholmshem, HEM - Halmstads Energi och Miljö, Falkenbergs Bostads AB, Varberg Energi AB, Eksta Bostads AB and Industristaden AB.

Swedish Energy Agency

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VI SUMMARISING DISCUSSION

Energy efficiency and preservation of cultural heritage consists of a complex set of problems, and these two main perspectives have been researched including use value and performance in teams at conservation work, laws and regulations, history of conservation and architectural values. There are almost too many parameters to consider and investigate. EEPOCH has been carried out by a multiple case study and 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 several others and the overall objective for EEPOCH is still valid. The objects within the multiple case study has been explored forming a solid foundation. To make it even more so; an investigation could be carried out about the occurrence of the same phenomena in other objects; their character and what it consists of; the generality and the special.

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

Different paths for the continuation have been evolving within this licentiate work and choices must be made for tapering the study and to close in on the overall objective, and to test ways of designing the theoretical model. The choice of problem for the continued research is associated with the choice of perspective. The main perspective so far has been the combination of the energy, the 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.

To work 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 with the different parties' general cultural reality-images is tangible for the practitioner, and for the researcher is also added the meeting between different scientific ideals.[1] 'Provided that a discussion on perspective is conducted, preferably also on figures of thought or on paradigms, the problem is researchable[2].'

In our work as practicing architects, we sometimes experienced contradictions between the different interests when examining them. According to Prof. Rosvall's lecture at Workshop III within EEPOCH this is a classic dilemma: the positivist generalists as technicians or scientists with the nomothetic focus on the one hand emphasizing the specific interests of e.g. energy efficiency. On the other side we have the humanists with romanticism and historicism and the individual-the idiographic-in focus,

[1] Edén (1987) pp 277, 281.
[2] Edén (1987) p 252.

emphasizing conservation concerns[3]. It is largely a matter of different cultures among the professionals who work with these questions and needs to be investigated.

There is the positivism or logic empiricism on the one hand and phenomenology and hermeneutics on the other side. Maybe Carnap's idea on science as a structural description of reality and its relational system and Schlick's meaning that we experiences qualities but have knowledge of structures could be used for analogies to mediate or shed light on the matter[4].

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 could 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 communicating 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 environment should understand somewhat of the other professions' conditions, difficulties and skills.

The chosen combined research field owns a very high degree of complexity but even when looking at just one field like energy it owns a high degree of complexity within, which also 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 threatening also culture and our cultural heritage and it is also evident that isolated qualified contributions to conservation, concentrated on a few selected monuments, are no longer sufficient[5].

The concept of conservation hierarchically takes place on three levels: intervention level, where the real world problems are solved by implementing models, on modeling level, where the design of models take place, and finally, or first, meta modeling level, a level for strategies, where the foundation forms from different sources of knowledge to create the design system. Evaluative standards are determined from the prevailing system: use values and economic value, emotional values and knowledge values, and also ethics[6]. 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 modeling level. This concept or hierarchy could also, with an analogy, be of use when formulating the theoretical model.

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[6] Rosvall et al (1995)

The heritage sector in general seems to be more focused on use values today which also imply including the energy issue and the economic aspect, and the user perspective, as has been showed in examples in Sweden and Italy. Conservation has taken a seat at the negotiating table and become a vital part of the strategic planning for development and growth in the horizontal triple helix actions on 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 is that there are many various ways for this in the energy field as well as in the field of architecture but less 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 valuation methods.

Some of the cultural and historic values, which are not discussed in NHB's handbook, are the intangible values. These values and the difficulties of measuring them were mentioned at the third workshop. Rosvall showed a table, very simple at a first glance, but turned out to be very revealing on understanding the issue[7].

The expression intangible value is in some aspects resembling of 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. The notion time is vital for some intangible values but we can measure time. In this sense the two expressions differ from each other. In others like in the feeling of being rooted and belonging to a place it is equally difficult to explain in tangible and measurable ways. However Tham taught that architecture can be designed and given properties to conduce to satisfying of our non-measurable needs. Ola Nylander has showed that this is doable in his book *Architecture of the home*[8] where he conceptualizes seven non-measurable qualities within four existing apartment buildings.

The objects studied within EEPOCH were restored in the 1990s and the owners are currently planning for new refurbishment, which wasn't foreseen. A sub project using research by design was suggested in the first workshop, to compare planned actions regarding architectural qualities. Parallel planning could 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

[7] The table is to be found at page xx under the subheading Workshops.
[8] Nylander, Ola (2002) *Architecture of the home.* Chichester: Wiley-Academy.

reports[9] [10]where deficiencies and conservative attitudes are stated. However times and circumstances do have changed and a growing awareness of the need of innovation also appears together with solutions in one of the reports. And solutions that requires change and sharpening in the routines and the business cultures within the professions and the construction sector. Quality seems to be a topic key word. In Edén's book on energy and design[11] the construction process is described in four steps with system requirements and objectives and follow-up of qualities and so forth and a conclusion is made that demands on energy efficiency seems to be a solution for better built constructions in general. His description has many concurrences 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 and were presented in paper no. 3. 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 and inference of the material - to be used as basis for balance and decision, and a broader investigation is proposed. Such an investigation could reveal which priorities of the interests that is possible to suggest, considering the variety of interests, and give guidance on what actually could be carried out later on in practice. This might unfold the project, giving a possibility to put forward a proposal on weighted assessments. This is one possible way when designing a theoretical model for practical application on how to balance energy efficiency and preservation demands. Apart from this the 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 equally considered, be engaged and contribute. Now what should such a model consist of?

From what have been discussed in this thesis, it shows that all different perspectives must be considered. The preservation perspective with its technical experts on conservation of materials and its antiquarians of built heritage with their assessment of cultural and historic values. New ways of doing the assessment will evolve. The technical perspective includes experts on constructional problems, installation experts and energy experts and so on. Then we have the architectural perspective with the 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 could be developed. All this together would do/give the wholeness of the complex issues. All perspectives belong to the whole and none can be left unheeded.

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. There have been many benefits of using workshops as

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[9] Socialdepartementet och Byggkommissionen (2002). *SOU 2002:115. Skärpning Gubbar! Om konkurrensen, kvaliteten, kostnaderna och kompetensen i byggsektorn.* Stockholm: Socialdepartementet, Regeringen.
[10] Boverket (2009c) *Skärpning på gång i byggsektorn!* Karlskrona: Boverket.
[11] Edén, Michael (2007). *Energi och byggnadsutformning.* Stockholm: Arkus.

a method and of participating. It has been useful, important and not least necessary to get an overview on 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 to the workshops. One proposition to proceed was research by architectural design. Another alternative was in depth interviews with people engaged in the restoration work. The method of using workshops will be part of the continuing work.

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 seize a building's all inherent possibilities of continued contribution to the complex and desirable built environment in urban context as well on the country side.

Final comments

Our society can be understood through the historical change and our buildings represent our history at certain times of the development. In this perspective, our built environment concerns and belongs to us all and it is there for our needs. These time aspects and participatory aspect and practical aspect are all part of a simultaneously stabilizing and transformative process. This makes it yet more complex when working with our built environment. 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 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 maybe conservation must be considered the major one. Built environment is an important heritage worth preserving, but pairing it with energy efficiency implies contradiction. Historic and cultural values are something existing that can be ruined by energy efficiency measures taken and with no possible return. It cannot work the other way around. There is also the discourse on usable values which might has 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; Architecture must be used to be perceived as architecture. The hypothesis has been strengthened that all perspectives can converge to be met in applied cases. The economical, environmental and social sustainability are natural and uniting approaches in the cooperation needed.

An interdisciplinary and transdisciplinary theory building, and development of useful methods must consist of all parts discussed. Lessons can be learnt from the development of the trading zone[12] 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 the energy and preservation issues in built environment? And can it gain acceptance and be of use within the construction

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

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 by.

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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. m²	Main house	Back wing		***Fattighuset, areas, brick walls excl. m²*** 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 facades

Main house	Facade 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 Facade surface m^2	U-value W/m^2 °C	Transm. W/°C
Facade south	113,3	0,0			0,0			113,3	1,8	204,0
Facade east	156,6	26,2	3,0	78,5	9,2	2,7 and 4,5	32,6	121,3	1,8	218,3
Facade north	73,0	10,1	3,0	30,2	2,9	2,7 and 4,5	10,8	60,0	1,8	108,1
Facade west	170,4	40,3	3,0	120,8	0,0			130,2	1,8	234,3
Facade 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
Groundfloor 1	309,2	0,0			0,0			309,2	0,3	78,8
Groundfloor 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	Facade 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 Facade surface m^2	U-value W/m^2 °C	Transm. W/°C
Facade south	130,2	0,0			0,0			130,2	1,8	234,4
Facade east	4,5	0,0			0,0			4,5	1,8	8,1
Facade 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
Facade west	4,5	0,0			0,0			4,5	1,8	8,1
Facade 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
Groundfloor	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 Σ (U x A)	Back wing 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			
Groundfloor 1	78,8	14,9			
Groundfloor 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	
Spec. 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 fascades	Facade 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 Facade suface m^2	U-value $W/m^2\,°C$	Transm. W/°C
Facade 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
Facade 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
Facade south 2	16,8	0,0			0,0			16,8	1,4	24,0
Facade 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
Facade west 2	124,0	19,4	3,0	58,3	0,0			104,6	1,4	149,5
Facade 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
Facade 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
Facade east 1	26,9	2,9	3,0	8,6	0,0			24,0	1,4	34,3
Facade 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

Groundfloor	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			
Groundfloor	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	
Spec. 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 facades

Main house	Facade surface m²	Windows m²	U-value W/m² °C	Transm. W/°C	Doors m²	U-value W/m² °C	Transm. W/°C	Rem:g Facade surface m²	U-value W/m² °C	Transm. W/°C
Facade northwest	95,0	9,8	2,0	19,7	2,1	2,7 and 4,5	6,9	83,1	0,3	25,6
Facade southwest	86,1	8,1	2,0	16,2	0,0			78,0	0,3	23,9
Facade southeast	93,0	9,2	2,0	18,5	2,1	2,7 and 4,5	6,9	81,7	0,3	25,4
Facade 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
Groundfloor	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	Facade surface m²	Windows m²	U-value W/m² °C	Transm. W/°C	Doors m²	U-value W/m² °C	Transm. W/°C	Rem:g Facade surface m²	U-value W/m² °C	Transm. W/°C
Facade northwest	13,2	0,0			6,6	2,7	17,8	6,6	0,3	2,0
Facade southwest	24,6	0,4	2,0	0,7	0,0			24,2	0,3	7,2
Facade southeast	14,0	0,7	2,0	1,4	0,0			13,3	0,3	4,0
Facade 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
Groundfloor	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	Shed				
	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	73,8	3,2		Δt 37,5˚C	Q 84,88 k˚Ch	
Doors	20,8	22,1				
Walls	97,8	19,9				
Groundfloor	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	
Spec. 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