Project Assessments in Construction and Real Estate - Analysing management of end-user needs and ensuring performance in the building life cycle. CREDIT Report 4

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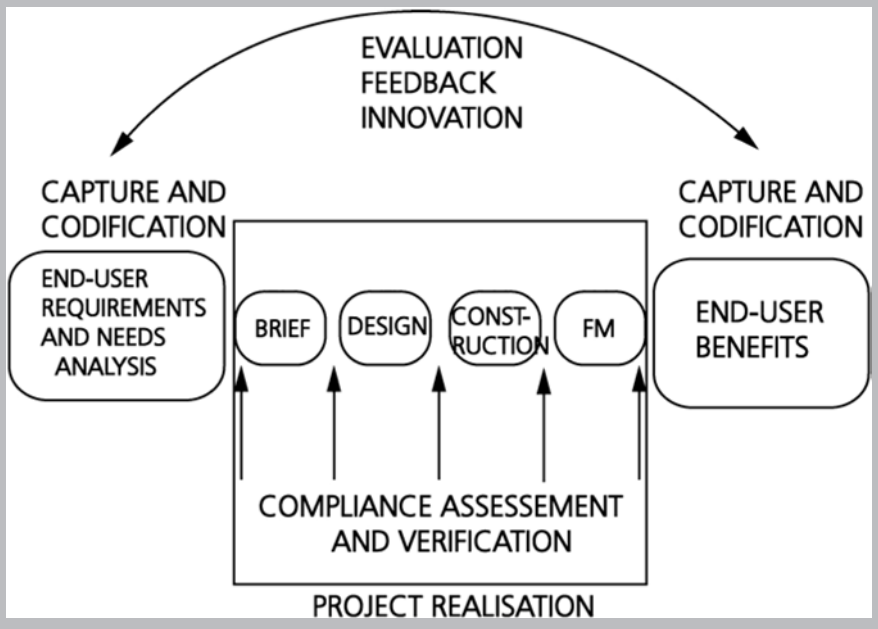

Danish Building Research Institute
AALBORG UNIVERSITY

Project Assessments in Construction and Real Estate

Analysing management of end-user needs and ensuring performance in the building life cycle

CREDIT Report 4

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Contents

Preface

This report summarises the work undertaken in CREDIT and proposals for how to implement CREDIT; it is the second report part of the Nordic/Baltic project *CREDIT: Construction and Real Estate – Developing Indicators for Transparency*. The report presents the finding from WP4 Project assessments and tools.

CREDIT includes the most prominent research institutes within benchmarking and performance indicators in construction and real estate, namely SBi/AAU (Denmark), VTT (Finland), SINTEF (Norway) and Lund University (Sweden). Moreover, three associated partners joined CREDIT for the Norwegian part of the project. The three associated partners are The Icelandic Center for Innovation (Iceland), Tallinn University of Technology (Estonia) and Vilnius Gediminas Technical University (Lithuania).

The project has been managed by a steering committee consisting of the following persons representing the four main partners:
- Kim Haugbølle, SBi/AAU (project owner), Denmark.
- Niels Haldor Bertelsen, SBi/AAU (project coordinator), Denmark.
- Pekka Huovila, VTT, Finland.
- Päivi Hietanen, Senate Properties, Finland.
- Ole Jørgen Karud, SINTEF, Norway.
- Magnus Hvam, SKANSKA, Norway.
- Bengt Hansson, Lund University, Sweden.
- Kristian Widén, Lund University, Sweden.

The steering committee wishes to thank our industrial partners and all the contributors to the CREDIT project. In particular, the steering committee wishes to thank the four Nordic funding agencies that sponsored the project as part of the ERABUILD collaborative research funding scheme: The Danish Enterprise and Construction Authority (Erhvervs- og Byggestyrelsen) in Denmark (funding SBi), TEKES in Finland (funding VTT), The Nordic Innovation Centre (NICe) (funding SINTEF) and FORMAS in Sweden (funding Lund University).

Danish Building Research Institute, Aalborg University
Department of Construction and Health
August 2010

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Summary

In this report a generic model for the capture and assessment of end-user requirements and needs, the CREDIT carpenter model, has been developed. The main determinants of the model is the need for the project organisation (including the facilities management organisation) to ensure a thorough understanding of the end-user requirements and needs as well as an assessment through out the project process. The end-users and the project organisation are often working in two different value chains. This, among other things, means that they may not share a common understanding of the process. Apart from just assessing to what extent the requirements and needs has been achieved it is important to assess the process of accomplishing the desired result. This way it is possible to learn from what has worked well and what has not.

There is some variation in what and how it is being assessed depending on what type of building it is. Assessments on housing are more inclined to focus on softer aspects, for example perception etc. In the other cases there are, generally, a more technical perspective. It may be an affect of how knowledgeable the users are. In regard to housing the users have possible less experience of construction and communicating their needs than in the case of offices etc. There is also a notable difference between approaches and interest on what to assess in the different countries. Sweden has a much more soft approach and an ambition of getting as many as possible to understand what is being assessed and for what reasons while Finland has a much more technical and measurable approach.

The clients, naturally, play a large part in the construction process, also when it come to capturing and transferring the requirements and needs of the end-users. It is mainly the clients that initiate it. Maybe more surprisingly, they do perform a lot of the work themselves as well. Designers play an important role as do known end-users as well. During the project it is mainly the client that initiates the assessments, but the actors of the project process, designers and producers that perform it. Evaluating the degree of fulfilling the requirements and needs as well as assessing the process to enable learning is again mainly a client action both initiating and performing, the rest of the actors do not engage to any larger degree.

The processes from begin of the brief to the end of construction have well developed routines as a part of the project management system. These routines are good enough to successfully fulfil the studied project and the control of the process in order to get *internal efficiency* in the short run perspective. But there is almost no case that shows any assessment tool that support feedback, the knowledge development and the innovation process which is important in the long-run perspective. The missing feedback is marked in the carpenter model. Found in the study there are two examples of tools that together may to some extent overrun this issue. Building Information Models have the potential of acting as an information carrier within a project, storing all types of information needed for assessing a number of different aspects. The main issue is to get the right information and presenting it in a way suitable for the target group. This is done in the case of Falk in Skanska (in Norway). It is a system gathering and presenting a multitude of KPIs, from a number of different systems, in an easy to understand layout.

1 Introduction and objectives

This chapter describes the objectives, organisation and work packages of the CREDIT project as well as the deliverables including the reports published by CREDIT. The chapter is an introduction to the following chapters summarises first the main CREDIT reports and followed by national recommendations of how to implement CREDIT and the conclusion.

1.1 The objectives and the project programme of CREDIT

Sir Winston Churchill once said, “We shape our buildings, afterwards our buildings shape us” (28 October 1943). This quotation underlines how strongly a building can influence its occupier or user. It is not without complications to provide complex public facilities for example for hospitals, schools, universities and libraries able to meet both the internal and external stakeholders’ needs and experience. The aims and demands of different stakeholders within a project may sometimes conflict with other stakeholders’ interest. Understanding the needs and experience of the stakeholders is essential to stay competitive in today’s market. A client who pays attention to the needs of the end-users will be rewarded with a high-performance property. Concurrently, this shift seeks to solve many ills associated with inadequate building conditions that result in poor building function.

The amount of both public and private money that are invested in delivering public and private facilities calls for decisive measures to be adopted. Collaboration with the relevant stakeholders helps building owners to identify performance indicators required for creating high-performance facilities. The project aims to define a model for the implementation of performance requirements that ensures fulfilment of various types of users’ and stakeholders’ needs and demands. The model should also allow for the continuous measurement of the effectiveness of the applied requirements and the model as such, so that it can be improved as more knowledge and experience of it is gained.

Adhering closely to the themes laid down in Erabuild, the aim of CREDIT is to improve transparency of value creation in construction and real estate. Thus, the objectives of CREDIT are:

– To capture end-user needs and experience in order to identify and quantify – where possible – value creation in the constructions and real estate sectors,
– To develop compliance assessment and verification methods,
– To define and develop benchmarking methods and building performance indicators for the construction and real estate,
– To propose recommendations for international benchmarking of key performance indicators of buildings.

Consequently, the deliverables of CREDIT are:

1. The establishment of a network of Nordic and Baltic researchers of benchmarking and performance indicators by frequent interaction in workshops across the Nordic and Baltic countries.
2. A State-of-the-Art report to identify and critically examine a number of existing tools, databases, mandatory reports, approaches and bench-

marking schemes to capture and measure end-user needs, client demands and public requirements to performance and value creation.
3. A strategic management and decision-making tool to guide the definition and development of benchmarking methods and building performance indicators in different business cases.
4. A comprehensive performance assessment and management tool with associated key performance indicators to capture end-user needs and experience and to continuously measure and verify the compliance of performance throughout the life cycle of an actual building project linked to building information models.
5. Recommendations of how sector and national indices of performance indicators can be designed in order to promote international benchmarking of construction and real estate.
6. Dissemination of the lessons learned and tools developed through news articles, press releases and workshops with actors from the construction and real estate sector.

The expected impact of CREDIT on the construction and real estate sector at national and European levels are as follows:
– Improved understanding of end-user needs and client's demands to performance requirements and level of satisfaction.
– New and improved tools to make the costs/value ratio of products and services more transparent throughout their life cycles.
– A more solid and evidence-based background for launching new public policies to improve the competitiveness of construction and real estate business.
– Improved opportunities for more accurate comparisons with neighbouring countries via improved methods.

More information about the background is given in the CREDIT project programme (CREDIT, 2007).

1.2 Main partners in the CREDIT project

The CREDIT project was a cooperative research project including four Nordic research institutes:
– Danish Building Research Institute (SBi), Aalborg University, Denmark – funded by The Danish Enterprise and Construction Authority (DECA) (Erhvervs- og Byggestyrelsen).
– VTT, Technical Research Centre of Finland, Finland – funded by TEKES
– SINTEF Byggforsk, Norway – funded by The Nordic Innovation Centre (NICe)
– Lund University, Construction Management, Sweden – funded by FORMAS.

Another three associated partners joined CREDIT for the Norwegian part of the project:
– The Icelandic Center for Innovation, Iceland.
– Tallinn University of Technology, Estonia.
– Vilnius Gediminas Technical University, Lithuania.

The Danish Building Research Institute (SBi) was project owner and project coordinator of the project as well as legally responsible according to ERABUILD on behalf of the four main partners. SBi, VTT, SINTEF and Lund University were the national coordinators for the project in Denmark, Finland, Norway and Sweden respectively, and moreover SINTEF was responsible for the coordination with the three associated partners.

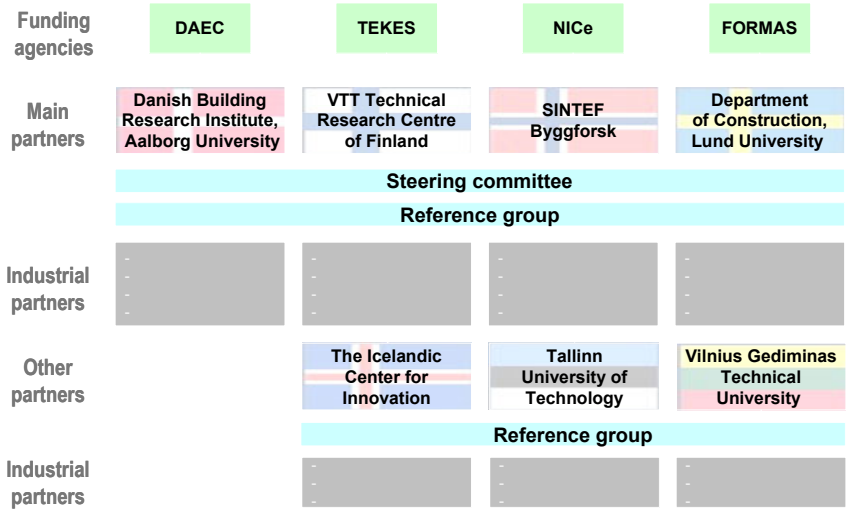
The project was managed by a steering committee chaired by the project owner, the project coordinator was secretary and each of the four main partners had two seats. The steering committee saw to the overall coordination and operation of the project, and was responsible for making the decisions necessary in this regard. The following persons represented the four main partners in the steering committee:

– Kim Haugbølle, SBi (project owner), Denmark.
– Niels Haldor Bertelsen, SBi (project coordinator and DK project manager), Denmark.
– Pekka Huovila, VTT (FI project manager), Finland.
– Päivi Hietanen, Senate Properties, Finland.
– Ole Jørgen Karud, SINTEF (NO, IC, ES and LT project manager), Norway.
– Magnus Hvam, SKANSKA, Norway.
– Bengt Hansson, Lund University (SE project manager), Sweden.
– Kristian Widén, Lund University, Sweden.

In relation to national activities, different partners from the construction and real estate sectors were involved in the case studies and the discussions of the findings. All these national contacts and cooperative partners were referred to as national reference group members. They represented different users of performance data and benchmarking systems in the Nordic and Baltic countries and are therefore the target group for the CREDIT results. Together with policy makers, funding agencies and researchers they constituted the Nordic Baltic Reference Group.

More information about the organisation is given in the CREDIT cooperation agreement (CREDIT, 2008).

Figure 1. The main partners and funding agencies in CREDIT



1.3 CREDIT work packages and meetings

Through seven work packages (WPs), the national research groups studied international experiences and examined a number of existing and new methods, tools and systems for performance assessment and international benchmarking. WP1 and WP7 dealt with the general project management and dissemination of results from CREDIT. WP2, WP3, WP4, WP5 and WP6 represented different steps of the research activities from a general study of the state-of-the-art in WP3 through the performance model in WP2, project

assessment in WP4, national case studies in WP5 and international benchmarking in WP6 and returning with the final conclusions and recommendations to WP2. Coordination of the specific research in WP4, WP5 and WP6 were also handled by WP2, and WP2 therefore had the following three tasks:

1. To formulate the research model and coordinate the research in CREDIT.
2. To classify performance indicators in the CREDIT benchmarking model.
3. To summarise the CREDIT reports including national recommendations.

WP3 studied literature and general national practice as background for the specific research in WP2, WP4, WP5 and WP6, and this resulted in a formulation of more specific tasks and objectives for the four other WPs. WP4 studied different project assessment methods and tools and how the different enterprises worked with indicators, assessment and benchmarking. WP5 studied 28 different case studies in the Nordic and Baltic countries, which were grouped and compared within different building segments. WP6 surveyed sector, national and international benchmarking systems of key performance indicators and experience from front–runners in the construction and real estate sector.

According to the CREDIT project programme (CREDIT, 2007), a number of deliverables (D) were agreed for each of the seven WPs. A final list of the specific deliverables (D) is given in Appendix A, and an overview is given below of each of the seven WPs:

– WP1: CREDIT project management. (Responsible: SBi/DK)
  Deliverables: Steering committee (SC) and SC Meetings (D1), CREDIT project meetings (D2) and Progress reports and accounts (D3).

– WP2: Performance models. (Responsible: SBi/DK)
  Deliverables: Stimulus paper, draft report and final report (D4a) on performance indicator and a draft and final summary report (D4b). D4b is an extra deliverable according to the project programme. CREDIT Report 3 and 6.

– WP3: State-of-the-Art. (Responsible: SINTEF/NO)
  Deliverables: Stimulus paper, draft report and final report (D5) on State-of-the-Art. CREDIT Report 1.

– WP4: Project assessments and tools. (Responsible: Lund University/SE)
  Deliverables: Stimulus paper, draft report and final report (D6) on project assessments and enterprises. CREDIT Report 4.

– WP5: National case studies. (Responsible: VTT/FI)
  Deliverables: Stimulus paper, draft report and final report (D7) on case studies and buildings. CREDIT Report 2.

– WP6: International benchmarking. (Responsible: VTT/FI)
  Deliverables: Stimulus paper, draft report and final report (D8) on sector, national and international benchmarking. CREDIT Report 5.

– WP7: CREDIT dissemination. (Responsible: SBi/DK)
  Deliverables: CREDIT project web (SINTEF eRoom) (D9), reference group and user workshops (D10), press releases (D11), news articles in trade journals (D11) and research articles (D12).

Seven two-day meeting packages (MPs) were held in 2008, 2009 and 2010 in the different countries to strengthen the innovative cooperation between the researchers and the national reference groups comprising the main players in planning, construction, real estate, benchmarking and the responsible authorities. Each meeting package (MP) focused on a specific work

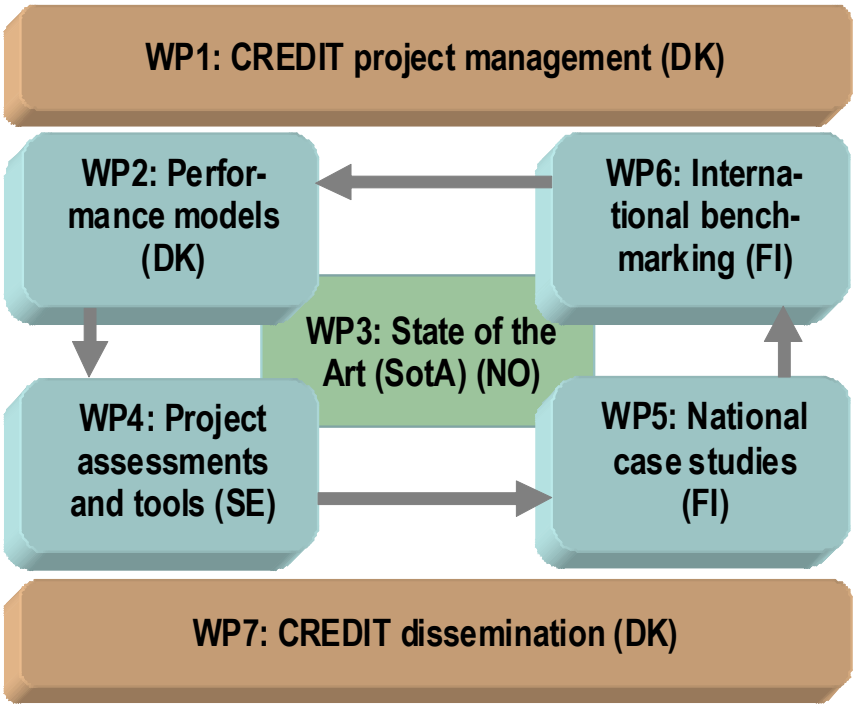
package (WP) and consisted of a one-day project meeting, a half-day user workshop, a reference group meeting and a steering committee meeting.

The seven CREDIT meeting packages alternated between the participating countries:

1 Helsinki, Finland, 24-25 January 2008: Kick off and end-user values.
2 Oslo, Norway, 29-30 May 2008: WP2 Performance models and WP3 State-of-the-Art.
3 Lund, Sweden. 8-9 October 2008: WP4 Project assessment methods and tools.
4 Vilnius, Lithuania, 19-20 January 2009: WP5 National case studies.
5 Reykjavik, Iceland, 8-9 June 2009: WP6 International benchmarking.
6 Tallinn, Estonia, 26-27 October 2009: Discussing the final CREDIT Reports 1, 2, 3, 4, 5 and 6. An extra meeting according to the project programme.
7 Copenhagen, Denmark, 25-26 January 2010: Final reports and closing of CREDIT.

The CREDIT project plan (CREDIT, 2007) outlines the relations between work packages (WPs), meeting packages (MPs) and deliverables (D). Every six months a project status was prepared and a progress report sent to Erabuild at the Danish Enterprise and Construction Authority, and in February 2009 it was extended to a 'CREDIT Progress and Mid-term Report' of 36 pages (CREDIT, 2009). A final version of the project and meeting plan is given in Appendix A.

Figure 2. The seven work packages (WPs) in CREDIT with the responsible countries (DK, FI, NO or SE) in bracket. WP2-WP6 are the main research WPs, and WP1 and WP7 include the project management and dissemination of results of CREDIT respectively.



1.4 CREDIT reports, deliverables and eRoom

The work of each of the main work packages (WP3, WP5, WP2, WP4 and WP6) were documented in five reports - CREDIT Reports 1, 2, 3, 4 and 5 -

and in various scientific articles and news articles. For example Report 1 describes the state-of-the-art as a result of the work of 'WP3 State-of-the-Art'.

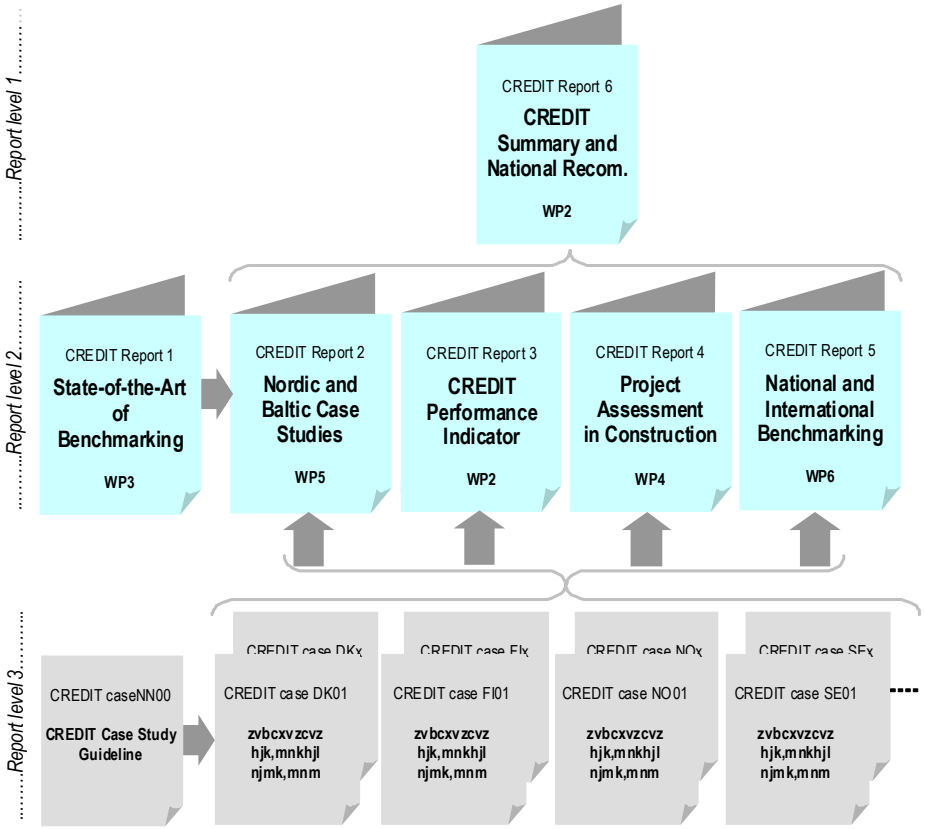
The work of 'WP5 National case studies' resulted in 28 Nordic and Baltic case studies with focus on performance indicators, assessment tools and benchmarking in front-runner building projects, enterprises and benchmarking organisation and reported in CREDIT Report 2. Each case study is described in accordance with a common guideline and together with results from the state-of-the-art report they form the background for the research and proposals for future improvements presented in CREDIT Reports 3, 4 and 5.

CREDIT Report 3 describes the CREDIT performance indicator framework as a result of 'WP2 Performance models', and the indicators are relation to national regulations; international standards and research; and:
– Report 4: Project Assessment in Construction and Real Estate.
– Report 5: Internal, National and International Benchmarking.

The results of the five CREDIT reports are summarised in this CREDIT Report 6 together with recommendations on how to implement the results nationally in the Nordic and Baltic countries.

In Figure 3 a graphical illustration is given of the three levels of the hierarchy of CREDIT reports, and after Chapter 8 all CREDIT reports are listed. Through the research all deliverables were filed in the common CREDIT project web in eRoom in SINTEF, Norway, and a complete list can be seen in the minutes of the CREDIT Steering Committee Meeting 8 (CREDIT, 2010).

Figure 3. Graphical illustration of the hierarchy of CREDIT reports.



1.5 Objectives and method

The objective of 'WP4 Project Assessment and Tools' is:

1. to develop a project-related performance management and assessment tool that identifies and capture end-user requirements and to measure and verify the compliance to performance criteria throughout the lifecycle of a building.
2. and to define the concept of value and the related performance indicators for quality of life, productivity, cost, time, amounts and quality

The study has mainly taken a systemic, holistic, approach. Empirical data comes from, in all 28, national case studies. Each case study is presented according to a pre-defined template. In this study it is mainly the information presented in chapter 2 – Buildings assessments in construction and real estate process, but additional relevant material from other chapters have been used to enhance the analyses. The analysis builds on identified theoretical underpinnings.

2. Methods and tools for managing the end users needs in projects

This chapter present the underlying theoretical underpinnings used to analyse the result from the case studies. The first part of it is the results from WP3 – State-of-the-art presented in CREDIT Report 1. The second part describes the development of the model, the carpenter model, used in this report as well as in other parts of the overall CREDIT project.

2.1 State-of-the-art

The literature review, presented in CREDIT report 1 – state of the art, showed that there are a number of different methods for managing end users that could be used for parts, but that there are very few that attempts to cover the whole process. Most methods exist in the early and in the late phases. The methods that attempt to cover the whole process are not very well tested in reality.

Commonalities of the methods and tools:
- Seeks to increase the communication between the stakeholders
- Built on quite complex systems of data gathering and analysis systems
- Improve the understanding of the end users real needs and requirements

Differences of the methods and tools:
- if the process is regarded dynamic or static
- if the focus should be on the individuals experience and need of the building or if the focus should be on an organisational level.

Many of the methods are criticised for not bring any guidance for how to act upon the result/outcome from the method. There is, thereby, a need for improving the usability of the methods and tools from both a micro and a macro point of view to improve the whole building process, before the quality of the built environment can be optimised.

In the state of review of Swedish Real Estate Firms appeared that almost none of the methods and tools discovered in the literature review were in use or the awareness of their existents was very low. The firms in generally measures SCI but some of the firms had difficulties in creating value of the outcome. During workshops it became clear that it was considered difficult to communicate with the end users, to adapt to a constant changing market and to make decisions in an environment with contradictory needs and requirements. In Sweden there are no nationally coordinated benchmarking models on the fulfilment of end-user requirement and value creation today. But there are some national evaluation schemes in use measuring sector change, project effectiveness etc. and some real estate and facilities management companies use post occupancy evaluations and satisfied customer index to measure end-user satisfaction in general and to some extent in relation to how new or refurbishment project fulfil their requirements. Examples of these schemes are Excellent Construction, FIA (Renewal of the Civil Engineering sector) and BQR Best practice program (the construction industries own tool for increasing efficiency and quality).

In the Finish state-of-the-art is stated that the interest of the performance based building has increased internationally. It is essential to create buildings that perform both functional and social well which require that the end-users needs requirements are captured. To improve the quality of the buildings performance are several international and national benchmarking systems created. These systems tend to focus on energy consumption and indoor climate aspects which are parts of the end-users needs but do not bring an inclusive picture. The Danish state-of-the-art concludes as well that the evaluation of building performance is primarily conducted from a technical perspective; the functional, social and aesthetical aspects are very rare. The lack of systems that takes a holistic view of, all the phases in, the construction process was found, in the Danish state-of-the-art, as well.

2.2 The carpenter model explained

2.2.1 The traditional construction process

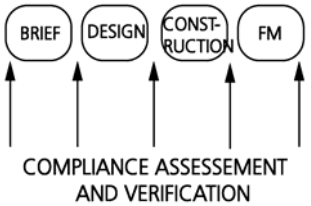
The construction industry is built around a never ending supply of projects. These projects are traditionally arranged according to industry practice in a number of phases in, more or less, a sequential order, often described as a relay race. These phases are typically brief, design, construction and facilities management, see figure 4. Compared to traditional project management literature, see for example PMbok 4th edition (PMBok, 2008), brief, design and construction fits well to the definition of projects, initiate, plan and execute. Facilities management (FM) is in most cases seen as an ongoing process taking over after the project is finished. The rational for incorporating FM into the project framework is that the facilities management often is directly affected of the results of the earlier project phases. To ensure that this link is assessed it is incorporated.

Figure 4. The project processes of a construction project

2.2.2 The professional construction process

According to project management theory, ideally, before the start of a new phase it is ensured that the necessary information to carry out the work of that particular phase is assessed to make sure no information is missing (PMBok, 2008). Similarly, after each of the phases an assessment and verification of the results are carried out to ensure compliance to the goals. As the construction process involves a number of professionals there is a risk for misinterpretation of the information during the process. To prevent misinterpretations compliance assessment and verification activities needs to be performed as well (Othman et al., 2005). In construction terms it may be an assessment of the proposed design, does it seem to correspond to the brief etc. In project literature these handoffs are often referred to as stage gates, milestones, phase gates etc. see figure 5. In reality this assessment is rarely done in any structured way.

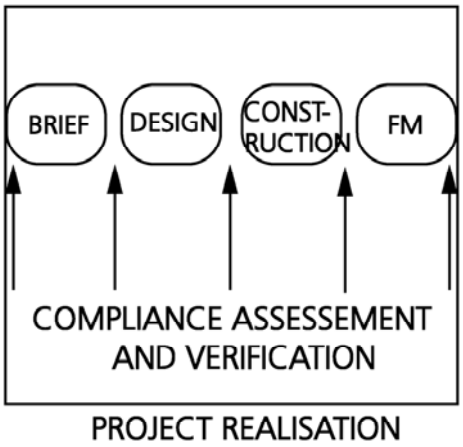
Figure 5. Decision points in a construction and real estate project



2.2.3 Project boundaries

A project is defined as “a temporary endeavour undertaken to create a unique product, service or result” (PMBok, 2008. p. 5). In construction this is carried out by a number of organisations taking part in part or the whole project. To illustrate the limits of the project and also depicture the multitude of organisations involved a square has been drawn around the phases of the project, see figure 6. One important aspect of the project organisation, apart from the client and FM organisation, is that they are a part for a short, compared to the life cycle of the building, and clearly defined time span.

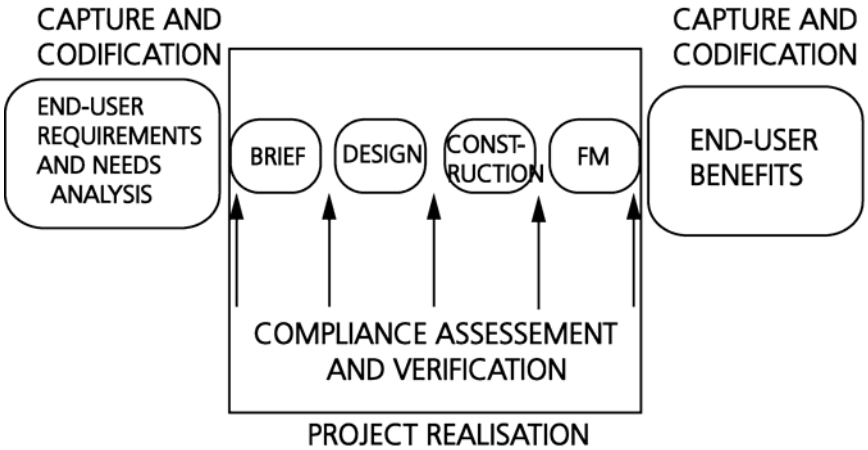
Figure 6. The complete project with the executing organisations



2.2.4 Users and the project

Any project need to have a clear scope on what the project should result in, what value to create. In construction the scope is defined by the requirements or the needs the finished construct are supposed to fulfil. Apart from meeting the time and budgetary limitations, achieving the goals defined in the project scope is what decide whether a project is considered to be successful or not. the end-users should be involved, in one way or another, when identifying and setting the quality of the product, the price and performance (Kashiwagi and Savicky, 2003). Their needs and requirements have to be captured to be able to find solutions that fit the client, end-users and their organisation (Gray and Hughes, 2001) and thus create user benefits. After the needs and requirements are captured they are codified into project language so that the project members can act upon them (PMI, 2008), see figure 7. Value is multidimensional and as a consequence there exist a number of definitions of the concept (Thomas and Mullaly, 2007).

Figure 7. The relation between project user requirements and user benefits



The concept is often considered to have a subjective nature as it:

- Is influenced by the contexture of the individual's experiences and the current situation (Thomson et al., 2003)
- Can be the relation between subjective and economic parameters (Andersson et al., 2006)
- Includes both tangible and intangible aspects (Thomas and Mullaly, 2007; Zhai et al., 2009)

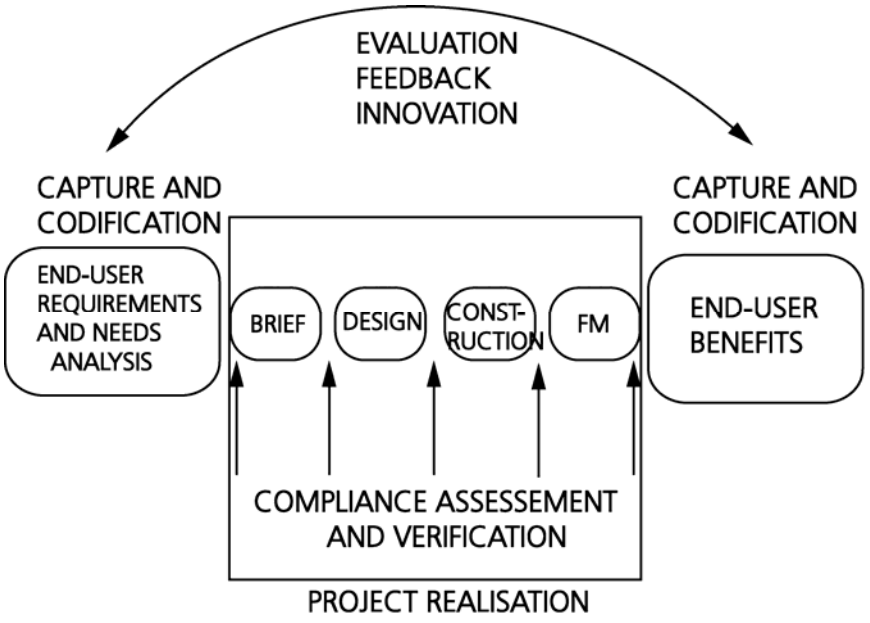
The judgment of value depends on who is making the judgment and for whom the value is created (Love, 2002; Preiser and Vischer, 2005; Lawson, 2006). A project can for example generate value to: customers, enterprise, suppliers/subcontractors and community and be judge from an social, economic and environmental perspective (Zhai et al., 2009).

In construction this is a particular issue to understand as there are a multitude of actors involved and thus, a multitude of 'understandings' of what value is and therefore what to create. The most commonly used perspective is an industrial perspective of economical parameters (for example return on investment) but not everything can be explained in monetary terms.

2.2.5 Continuously learning

In the realisation of the project, the information is fed-forward and processed during every step of the process: briefing, design, construction and facilities management/occupancy phases. To truly understand difficulties in the built environment the end-users should participate/be consulted during briefing (Shen and Chung, 2006; van Ree et al., 2006), design (Preiser, 1983; Love, 2002), construction (Hua et al., 2005) and occupancy (Campbell and Finch, 2004). In the end of the project the end-users benefits should be captured and codified. This is allows for evaluation, learning and improvement of the management of end-users so that value can better be created for them (Luckett and Eggleton, 1991; Rubin, 1995; Sandberg and Faugert, 2007), see figure 8.

Figure 8. The complete carpenter model – depicturing the realisation of a project with its internal phases and assessment and verification as well as the project organisation, the end user requirements and needs – resulting in user benefits and the feedback loop allowing for continuous improvement – and thus better end user value



3 Assessment methods in use

This chapter relates mainly to question 2.2 in the case study reports “The applied assessments and tools in the processes”. The aim was to arrive to an understanding of what tools were used to assess and what is assessed, in relation to the objectives of CREDIT, on a project level. In a few cases information has also been drawn from chapter 3.2 in the case study reports “Applied assessments and tools in the enterprise”. This has been done when the information in that chapter describes assessment or assessment tools on an enterprise level are used on the project level. The results have been clustered in 4 groups depending on what the projects aim to deliver, housing, educational and office buildings, hospitals and shopping centres. The results are sub-divided into three parts building on the carpenter model, end-user requirements and needs analysis, project realisation and user benefits.

3.1 Housing

3.1.1 End-user requirements and needs analysis

The tools to gather information initially to define the end-user requirements has mainly been done on a general level. For example in one case, when the project starts is a survey of how customers want to live on that specific market performed. This survey is followed with a parallel work with product and project development from a customer perspective. The development of the product initiates and ends with different kinds of surveys. Another example of a general approach is relying on the knowledge gained through continuous interaction with their tenants. The employees in one company have knowledge about what different customer groups prefer. For example that the customer wants cheap apartments centrally located. When hiring an architect the employees in the housing company always makes remarks on the drawings. They have knowledge about what the tenants use to complain about and what is rentable. When making new builds they are addressing a brochure about the building and a plan solution for every apartment to future tenants. That same company has two ways of accessing general knowledge of what their customers want. One of them is a questionnaire on their homepage. Anyone can at anytime fill in their wishes for qualities of their future living. The other system is the queue for their dwellings. When signing in the application for registration the company receives information about where different persons like to live. If they prefer a balcony, which floor they like to live in, in what quarter (north, south, east or west) etc. The information gives a picture of different tenants groups but is not yet used. It is though considered as valuable knowledge and they plans to start analyze the information to gain more knowledge and improve their work.

In some specific cases the general approach has been supplemented with interactions with potential customers for example tenants. In these deeper interviews, questionnaires, workshops and reference group meetings have been used. In one of the cases a number of tools and methods were used in order to involve the dwellers in the area and get insight into their wishes, opinions and knowledge about the area. This includes surveys, workshops, and happenings/events. The results of the workshops and happenings were

documented and communicated through exhibitions, a catalogue of ideas, a newspaper and a notice board on the internet.

Survey
Survey of the dwellers (the end users) in the housing area included – a questionnaire done by telephone, a questionnaire distributed to all households and semi structured interviews with different focus groups. This was done in order to:
– To have views from the a representative part of the dwellers in the area
– To get some benchmarks that the result of the building process eventually can be assessed by.
– To get wishes and initiatives that could qualify the planning process
– To get opinions from so many different groups of dwellers as possible.
The survey was done by a third part.

Workshops
3 workshops were held as a part of the strategic planning in the initial phase. These workshops were held in the initial phases of the planning process in order to involve the dwellers (end users) and to get their ideas for improvements and their knowledge of the area incorporated into the brief.
A just as important output of the workshops was to agree about what the objectives or aims of the renovation project should be. The result from the workshops was documented in exhibitions for all the dwellers of the area and later on in an idea catalogue. These ideas were discussed and decided with a vote on meetings in the different departments of the public housing. The children voted as well about the different play ground solutions.

In another case “brain-storming” meetings, workshops and study tours were found fruitful events to start discussions and to formulate the project goals. The goals with the collaborative events were to establish an efficient project team by:
– Receive a common understanding of the end-users needs and requirements
– Reach an agreement of the goals and the “rules” of the game
– Ensure an effective partnering process by performing a common declaration (the moral contract).

3.1.2 Project realisation
During the actual realisation of the project no specific assessment were reported on apart from the traditional project assessments on time, cost and scope.

3.1.3 User benefits
A number of different tools to assess user benefits have been used in the various cases. There has been established metods as Satisfied Customer index (SCI) and Positive Customer Index (PCI) as well as tailored systems. One of the tailored systems focused on four areas:

- The theme quality contained three main topics: architecture, standard and fulfilment of the demand from the ministry. The evaluation was divided into "levels" and started with the outer appearance and the individual apartments and continued with the inner rooms and components.
- The theme building process focused on the more general level with the interplay between the main actors: the ministry, the client, the companies and the local authority.
- The theme economics looked at the costs for construction, operation and life cycle use. Furthermore whether there has been a competition between the companies.

- The theme user satisfaction focused on the users own evaluation of their apartment. They were also asked about use of common areas and social interaction. Furthermore were student movements and the use of the estate evaluated.

In one example where the PCI was used, it was performed by a consultancy through telephone interviews. The main question areas in this PCI were focused on:

- The decision to chose the company's product
- The contact and information at sales
- The optional choices in residence
- How the contact was managed during occupancy
- Experience of quality of living
- The advantage and disadvantage of the living area after moving in

The survey also included questions about safety, finishes, energy and technology, outdoor environment. Besides asking about the experience of the company/product/process general information about the customer (gender, age, family structure, number of cars in the household, size of income, loan ratio, how you found out about the project etc.) was asked for as well.

The results from the PCI are used in two ways: The first is to improve the production and are transmitted to the production-line. The second is to use the result as an inspiration to develop the concept and the product.

In one example of SCI the company measures satisfied customer index, SCI, once a year regardless of action in the company (such as refurbishment, building of a new house, operation and maintenance for example). The purpose is to improve their work and receive a picture of the customer satisfaction. They don't have any goal for how good they want to be, it's a consideration between staff resources – money and cost – appearance.

The company is using an external company to perform the measurement. The measuring is formulated as a questionnaire and sent out in paper form. The respondents can chose between answering on the paper or on the web and the company send out two reminders to the tenants. The questions were

1. Age of respondent
2. How long the respondent have been living in the apartment
3. Number of persons living in the apartment
4. Service
    a. Easy to contact, well treated by the employees, reliable company etc.
5. How they contact the housing company
6. Maintenance
7. The laundry
8. The quality of living
9. Safety
10. New customers/tenants
11. Remaining
    a. Value for money, information, internet, television, the attraction of the apartment/estate etc.

The SCI measurement has lead to improvements and their customers are nowadays feeling safer, like the dwelling better and are more pleased with the availability of the staff in the housing company. Even though this assessment is not used in direct relation to a project, it does give a picture of what works and what does not.

3.2 Educational and office buildings

3.2.1 End-user requirements and needs analysis

In general the assessment methods have been rather direct, aiming at the specific project. For example, in one of the cases new indicator needs were gathered during discussions (interview study) with the representatives of the owner, manager and three tenant organizations of the project. There were also more direct communication with the tenants and those that were going to use the facilities. Joint visions have been used. In one case it was said that the vision was a great help for the end users when taking decisions so that they could focus on the whole perspective and not get lost in details. In the early phases was the main purpose to create a common reference frame and a common language among end users, architects and technicians but also to show the possibilities of a new centre. This was performed with study tours and meetings and workshops. In the early phases was an expert on end user requirement from the real estate company and a consulting architect involved in some of the meetings and workshops. In another one the renewing process started in May year one when first informative occasion to personnel was held and interviews performed. In January year, the space solutions ware presented to personnel and more interviews for groups and individuals were made.

In other cases more strict methods were used. For example assessment methods had to follow certain legislative decisions. In other cases the set of measurable requirements concerning the energy efficiency of the coming building was defined by the client in cooperation with consultants and other stakeholders. The building was to be in energy class 1, which means that the resource consumption was to be (50 + 1100/A) kWh/m² that is 50 % of the requirements in the Danish building regulations. In this particular case the calculations programme is going to be used after every phase throughout the process, from the briefing to the handing over, to assess whether the planned building comply with the required level of energy efficiency. The calculations and evaluations are done by an impartial third part. The assessments and the documentation are used a bit different depending on when in the process the assessments and documentation is done.

- The level of efficiency is defined through the briefing process and is documented in the brief.
- The assessment of the first proposals submitted by the consultants is discussed on a workshop with the client, users and experts besides the consultants presenting their proposal. The best alternative regarding energy efficiency is chosen on the basis of this workshop.
- After the design phase, a third assessment is made. This time the assessment and documentation include alternative solutions that could optimize the energy efficiency of the planned building or the profitability of the solutions.
- As a part of the handing over, it is assessed whether the completed building comply with the agreed level of energy efficiency.
- The actual consumption of energy is registered through the first year of occupancy.

3.2.2 Project realisation

The cases show an interest in assessing how the project realisation is carried out. In one case the necessary data for calculation of the KPI's are collected by the client and the companies during construction. The indicators are mainly calculated after the construction phase and they are used for two purposes. One purpose is an evaluating of the work on the site. Another is to give information about the companies who have executed the building – and

the likelihood that they will do a good job next time. In the individual concrete case the client has to answer some question about factual data in the project and about the execution. In new coming projects the client has to demand KPI results from potential contractors interested in the coming project. In this way the collected data and the calculated KPI's were primarily for the companies and for the client. The resulting Key Performance Indicators are used by the client and the company/the companies to get an impression of quality and effectiveness of the executed work in post analysis. They also give clients a possibility to evaluate qualifications at potential contractors looking for a new job. The basic philosophy is that a building process with a high effectiveness and quality will increase the possibility of getting a building which satisfies the users.

In several of the cases Building Information Models (BIM) were implemented. Although BIM in itself is not an assessment method as such, in principal everything will be stored in the BIM. All the relevant numbers can be found in the same place and made use of. One of the other cases highlights this. One company has developed a program that draws relevant information from all of their different management systems. This means that the managers only have to report their figures ones. The reporting into the system is internal. Different kinds of information are reported with different frequencies:

- Economic progress is reported per month.
- Health, Environment and safety incidents are continuously reported.
- The client fills out a standardised template form when the project is finalized.
- The final project report is used as a guideline for new projects, but is not meant to be used as something to be carbon copied.
- The system uses filters that information can be shown according to context/perspective (enterprise, project management, type of building).
- It is used by management, geographical regions, and country.
- However, information to the project management is provided from the accounting system.
- Benchmarking is done in relation to progress and quantitative measures of technical drawings.
- The client wants to measure the company based on physical aspects of the building actually delivered (for instance air flow through ventilation channels).

3.2.3 End-user benefits

In one country it is compulsory for clients responsible for state and non profit housing projects to ask for KPIs when they are executing new buildings. In practice the demand is part of the contract between the client and the construction company and it is up to the company to make an arrangement with an independent evaluator to make the registrations. The method is based on written and standardised instructions for gathering of data and calculations of KPIs. The costs are calculated as cost per square meter. Services are furthermore calculated as costs per number of people – employees or users. Data are mainly taken from different yearly accounts with information about registered costs and use of heating, water, electricity and costs for maintenance. Renovation of the building is viewed on as building work – and not a part of the operational activities - and is not a part of the registration.

In another case, an internet questionnaire has been sent to users in order to get customer feedback information. Results of the questionnaire give information for corrective actions, in order to control systems and also possibilities to improve Business Park concept for future projects.

Yet in another case a standardized data gathering form is used to collect data on some key indicators. In addition the client has its own energy and cleaning statistics. The client collects both cleaning cost and energy consumption. The motivation for collecting the data in the company is:

- Local assessment of the effect of local measures
- Planning of activities
- Reporting upwards in the system: Property, region, headquarters, Ministry of Government Administration and Reform.
- Basis for Statsbygg analysis and reporting
- Benchmarking against similar buildings
- Improving work processes
- A basis for condition assessment
- Energy consumption has special attention

The system is an integrated part of the company's operation and management of properties. Technical information regarding the buildings, the operation of the buildings and the core business were collected from the municipality.

3.3 Shopping centres

3.3.1 End-user requirements and needs analysis

No information

3.3.2 Project realisation

The same enterprise specific system described in Educational and office buildings were used in one of the cases.

3.3.3 End-user benefits

In these cases studies the assessments were very technical for example in one of the cases the objective of the analysis of results was to verify the active heat loads. The indoor environment studies were focused to the business spaces of shopping centres. The term indoor environment includes thermal conditions, the quality of indoor air, acoustic conditions and lighting conditions. The measurements were mirrored by assumed performance key indicators. Key indicators were defined after the measuring periods.

3.4 Hospitals

3.4.1 End-user requirements and needs analysis

Hospital project are very complex and involves a number of stakeholders. In the case concerning hospitals the first goal for the manager of the end-users was to make people believe in the project, to enthusiasm them and make them understand that their contribution matters. The manager of the end-users had noticed that if the end-users are enthusiastic over the project and "own" it they are talking in terms of "this is what we thought and this is how we did". Otherwise they tend to blame others and have difficulties in accepting minor incorrectness's. "The best method in these early phases is human knowledge and pedagogical skills. I try to be accessible for the end users and talk frequently with them. I am supporting by asking questions about their organisation and work today and in the future. People in hospitals are though, in general, positive towards physical changes" explains the manager

of end user. The project leader explains that the end users have to participate in hospital projects that are an absolute condition.

A well formulated description of the organisation should exist before the architect is involved, though people tend to lock their thoughts when a sketch exists, consider the manager. The description of the organisation is, as well, important when new participants enter the project. If the project has a solid vision through the whole project the result usually becomes successful. To spread the vision to all participants a “24 hours kick- off meeting” were held. A hired consultant was managing the meeting and the participants were architect, consults and representatives from the end user organisation and the real estate company. When the contractor got involved was a similar meeting held. The meetings gather the people and made them start working in the right direction. Other methods used were study tours (nine performed). The manager explains that “before a study tour, it is very important that the end users get a picture of what they want and have a vision. The study tours have to be adapted to where in the process you are, first tour, the goal can be to get a broader view of the organisation. For example, see how others are co-ordinating different functions. Later in the process, it can be fruitful to see details like interior solutions.

3.4.2 Project realisation

During the whole project, the end user project leader has written weekly letters to the end user organisation. The information in the letters was not always understood and sometimes it becomes chaos, experience the end user project leader. The end user project leader was, as well, informing concerned part in a more detailed mail.

A showroom was built up so that the end users could try and evaluate its functionality in a questionnaire. The end user project leader felt it great to have the result of the questionnaire to refer to, when people came with new opinions during the project.

During the project were information meetings held with the end user organisation. They were well visited in the early phases. “When the end users experienced that the project was well managed and they got used to that it have to sound during construction, they stopped coming to the meetings,” explains the end user project leader.

Meetings with the steering committee were as well held during the construction. In the meetings were questions, concerns and changes discussed. In the steering committee were represents from the hospital leading involved. Exchange of knowledge was done in monthly project meetings during the project. During the meetings were end user changed requirements and operation management questions discussed. Though hospitals are very complicated buildings, the designers were involved in meetings during the construction phase as well. This can be seen as a form of knowledge sharing among the participants.

3.4.3 End-user benefits

No information

4 Indicators

This chapter relates mainly to question 2.3 in the case study reports “The applied assessments and tools in the processes”. The aim was to arrive to an understanding of what tools were used to assess and what is assessed, in relation to the objectives of CREDIT, on a project level. In a few cases information has also been drawn from chapter 3.3 in the case study reports “Applied assessments and tools in the enterprise”. This has been done when the information in that chapter describes assessment or assessment tools on an enterprise level are used on the project level. The results have been clustered in 4 groups depending on what the projects aim to deliver, housing, educational and office buildings, hospitals and shopping centres. The results are sub-divided into three parts building on the carpenter model, end-user requirements and needs analysis, project realisation and user benefits.

4.1 Housing

4.1.1 End-user requirements and needs analysis

In general the indicators used were not so muck of technical character. In the user survey the questions in the questionnaire and interviews of focus group meetings was about main themes satisfaction with qualities in the area and the social capital in the area.
The questionnaire included questions about:

– The design of the flat
– The location
– Access to public transportation
– Vicinity to family and friends
– What kind of place is it to live?
– The service from the caretaker's office
– The rent
– The quality of the playground for children
– The reputation of the area
– The shopping possibilities
– The demography of residents in the area
– The outdoor spaces
– The maintenance
– Identity of the area
– Social contact in the area
– Sense of security in the immediate environment and in the other areas.

These questions relate to 2.1 – Location and address, 2.2 - Plot opportunities, 2.3 - Spatial solution and property aesthetics, 2.4 - Surrounding services, 2.5 -Social value, 3.1 – Category of building, quantity, size and area, 3.2 – Safety and security of burglary, 3.3 – Usability and adjustability, 3.9 – Feelings and sensations in the CREDIT Indicator Classification.

In another case the list includes:

– More dwellers at the meetings
– Good publicity in the media
– Few complaints
– Content residents

– All residents are informed about the changes
– Less damages
– The vital connection is realised
– The result of the renovation becomes a reference for other renovation projects.
– More people are visible in the area
– Proud tradesmen
– Proud residents
– Increased possibilities for each resident to have influence on his/her dwelling
– Project will stay within the budget
– The quality of the new facade and out door areas will last

These indicators relate primarily to 2.5 – social values and 3.9 – Feelings and sensations and 6.5 User involvement in the CREDIT Indicator Classification.

4.1.2 Project realisation

No information

4.1.3 End user benefits

In one case the ministry decided that the evaluation should be concentrated on indicators within the following four themes: quality, building process, economics and user satisfaction. The same themes were used for all estates. The inspections are executed in accordance with a general classification of the different parts of a building. They are the indicators. When a deficiency or a building damage is observed it is therefore also marked at the concrete part. The Fund has furthermore established a classification for the seriousness of a deficiency or a building damage. The general classification covers - except from for example indoor equipment - construction parts from the whole building, which are essential for lifetime of the building - especially the climate protection - and comprises

- the foundation and the cellar,
- the structural elements (bearing and stabilizing parts of the building),
- the outer walls,
- the roof,
- the bathroom,
- drainage and sanitary facilities,
- concrete in complicated environment (as concrete in outer balconies) and other building parts (for example outer staircases).

The indicators are the starting point to show whether there are or will be problems with indicators at higher levels in CREDIT classification as indoor environment (as safety and indoor climate) and product performance (as constructions and installations).

In another case the company is monitoring following indicators:

- Satisfied Customer Index
- Resource use (use of energy, material, electricity and water)
- Economical parameters (almost every post in the statement of income).
- Accessibility (In the existing housing accommodation are surveying of accessibility for elderly people performed in collaboration with researchers).

The company is considering almost every parameter of the CREDIT indicator template. The parameters are measured as goals. The market manager considers the list to long to manage to monitor though. The indicators that are not of particular interest are EFQM, Functionality core process, targets and GHG. The risk indicator (if it is the risk of having empty locals) could be

interesting on the habitats. In the dwelling area the queue is so long that this matter is not of particular interest. The manager further considers the social indicators maybe hard to compare with other companies.

4.2 Educational and office buildings

4.2.1 End user requirement and needs analysis

No information

4.2.2 Project realisation

Looking at the information provided for one of the cases the following are used as the preferred indicators when it comes to measures during the building process:

- Category of building parts, quantity size, area
- Category of process, supplier and organisation
- Health, safety and work environment

4.2.3 End user benefits

In relation to measures when the project is finalized the preferred indicators in one case are:

- Safety
- Thermal quality
- Impact on air quality
- Lightning quality
- Acoustic quality
- Resource control and project management
- Health, safety and work environment
- Environmental impact (emissions).

When finishing building projects in one of the case enterprises, they always make a final internal project report, which describes project facts, building process, results and experiences about:

- Short project description
- Project organisation
- Goal achievement (economy, quality, health/environment/safety, waste)
- Subcontractors and important suppliers
- Changes
- Deviations
- Important observations
- Experience figures from the production
- Building owners evaluation

The impression is that the most important indicators for the clients are related to no accidents and the environment.

In another case Key Performance Indicators (KPIs) which were delivered to the client after execution:

- Actual construction time in relation to planned construction time
- Actual construction time incl. remediation of defects in relation to planned construction time
- Remediation of defects during the first year after handing over

- Number of defects recorded in the handing-over protocol, classified according to degree of severity
- Accident frequency per billion DKK
- Work intensity, man hours per m2
- Labor productivity
- Changes in project price during the construction phase
- Square meter price
- Customer satisfaction with the construction process

KPIs which were delivered after construction to the contractor:

- Actual construction time in relation to planned construction time
- Actual construction time incl. remediation of defects in relation to planned construction time
- Remediation of defects during the first year after handing over
- Number of defects recorded in the handing-over protocol, classified according to degree of severity
- Accident frequency per billion DKK
- Customer satisfaction with the construction process.

The chosen indicators are the result of a thorough investigation into the criteria which can be used to evaluate the work on a building site. They are based on criteria normally used by contractor companies. The indicators address the building as a whole (for example construction time), the process on the site (for example accidents) and the different parts of the building (for example defects).

The indicators used in the assessment of energy efficiency are the energy demand limits defined in three classes of energy demand in the Danish building regulations 2008. The classes are defined by the overall energy demand of the building divided with the heated area of the building. The set of key figures that defines of the energy demand of the building are the indicators in the energy efficiency labelling system EMO. They concern the energy demand for heating the building, hot water, cooling, ventilation and if necessary lighting.

In one case the indicators are calculated and used for assessments during the operation of the concrete building. The most important data are the yearly costs for

- maintenance,
- supplies (water, electricity, heating),
- cleaning,
- common operation,
- services and
- regular expenses as tax.

In yet another case several tools were tried. SeneKPI is a help for management of both new and renovation investments and use and maintenance. It also gives information for resale value estimations. It may be used in comparing different the facilities with each other too and increases interest towards life-cycle based indicators too. Senate Properties is interested in to increase productivity of clients but doesn't use other indicators than working environment. The second approach on indicator frameworks tested in Lappeenranta is VTT ProP® building properties classification. VTT ProP® is a building performance classification which can be used for setting the objectives in order to meet client needs. The Structure of VTT ProP® consists from conformity, performance, life cycle costs and environmental pressure. Third approach on indicator systems is PromisE. It is an environmental assessment system in Finland for office buildings, apartment houses and retail

stores in both existing buildings and new buildings. System also constitutes from an assessment tool over the internet. The forth indicator system tested in the case is LEED (Leadership in Energy and Environmental Design) Main principle in LEED is to provide a sustainability report for a building. End-user feedback was collected as a fifth system because workplaces are foreseeing future changes in organisation and ensured the possibilities, to interactively and positive train of personnel for future changes. This fifth approach of using Post Occupancy Evaluation (POE) revealed following important opinions form personnel after moving to the renovated property

Energy indicators are becoming more and more important in Finland, as in the rest of the Nordic countries. From the 1990s Finland has employed a voluntary agreement scheme to promote energy efficiency. Practical means have been energy audits, analyses and certain energy efficiency investments subsidised by the government. Energy agreements have proved to be effective. The energy efficiency agreements are mainly made for energy intensive industry sectors. Currently in force are the ones for the industries, municipal, oil, goods transport & logistics and public transport. The housing sector property sector has an older energy conservation agreement. The agreements consist of framework agreement and action plans. A company joining the agreement makes the commitment to implementing them. One of the actions used in energy agreements is the energy audit. Energy audits are used to evaluate building energy consumption and identify energy saving measures. Energy audit procedure consists of start-up meeting, basic data collecting, field work, data analysis, reporting and implementation of saving measures.

Several of the case studies have used the indicators below (or similar lists) in assessing the actual buildings.

1. Cost, price and life cycle economy (LCE)
    11 Capital investment, construction and commissioning costs
    12 Building service related to operation and maintenance
    13 Business services related activities in the building
2. Location, site, plot, region and country
    21 Location and address
    22 Plot opportunities
    23 Spatial solution and property aesthetics
    24 Surrounding services
    25 Social values
3. Building performance and indoor environment
    31 Category of building, quantity, size and areas
    32 Safety and security of burglary
    33 Usability and adjustability
    34 Thermal comfort
    35 Air quality and health
    36 Visual climate
    37 Acoustic climate
    38 Aesthetic of building and indoor spaces
4. Building part and product performance
    44 Thermal quality
    45 Impact on air quality
    46 Lightning quality
    47 Acoustic quality
5. Facility performance in operation and use
    51 Category of tenancy and operation and area of space
    52 Applicability of the facility
    54 Services
6. Process performance in design and construction
    64. Quality management

65 User involvement and cooperation
7. Environmental impact
71 Resource use
72 Emissions

4.3 Shopping centres

4.3.1 End-user requirements and Needs analysis

No information

4.3.2 Project realisation

No information

4.3.3 End-user benefits

The assessment is strongly related to the function of the shopping centers. For example in a couple of the cases the measurements included:

– Indoor air temperatures, CO2-concentration, relative humidity
– Air supply and exhaust air temperatures, air flows in terminal devices
– Electricity power monitoring
– Single measurements, carried out during one monitoring day
– Control of air flow rates
– Lighting level, illumination
– Interviews of shop managers

Estimation criteria for measurements

– Indoor air classification, building codes and requirements, National/international recommendations

The main topic in this study was to find correlations between the cooling need, indoor air quality and thermal comfort and electricity consumption – the results showed that further studies are needed to show the possible connection because of the problems in ventilation and cooling system.

Business space specific Key Performance Indicators were said to be:

– Indoor temperature and the stability of temperatures
– Lighting
– Temperature of supply air
– Cooling temperature and cooling power
– Air flow rates
– Electricity consumption, heating energy consumption, water consumption (in general: utilities consumption)
– Air quality, CO2
– Classification of business spaces, e.g. I, II and III according to the use
– Indoor ranking and classification, e.g. Σ(ak1+bk2….+nkn), in which a….n are weighting coefficients and k1….kn = characteristic factors

Facility specific Key Performance Indicators:

– Electricity consumption, heating energy consumption, water consumption (in general: utilities consumption)
– Maintenance costs
– Cleaning costs
– Investment costs
– Taxes, insurances etc

Looking at the information provided for another case the following are used as the main indicators:

- Capital investment, construction and commissioning cost
- Location and address
- Usability and adjustability
- Safety
- Durability
- Thermal quality
- Impact on air quality
- Lightning quality
- Acoustic quality.

When finishing building projects in one of the enterprises, they always make a final internal project report, which describes project facts, building process, results and experiences about:

- Short project description
- Project organisation
- Goal achievement (economy, quality, health/environment/safety, waste)
- Subcontractors and important suppliers
- Changes
- Deviations
- Important observations
- Experience figures from the production
- Building owners evaluation

4.4 Hospitals

No information

5 Relation to enterprise and national benchmarking

This chapter relates mainly to question 2.3 in the case study reports “The applied assessments and tools in the processes”. The aim was to arrive to an understanding of what tools were used to assess and what is assessed, in relation to the objectives of CREDIT, on a project level. In a few cases information has also been drawn from chapter 3.3 in the case study reports “Applied assessments and tools in the enterprise”. This has been done when the information in that chapter describes assessment or assessment tools on an enterprise level are used on the project level. The results have been clustered in 4 groups depending on what the projects aim to deliver, housing, educational and office buildings, hospitals and shopping centres.

5.1 Housing

In general there is no national benchmarking system specifically targeting this segment. There are a few narrow benchmarking schemes focusing on a specific area for example, property value.

There are some what more examples of assessment tools used in relation to the enterprise level, but even there it is difficult to see a common path. It is company specific.

There are some companies that are using for example SCI, but they all use there own set of indicators.

In most cases the assessments carried out have only been project specific. Although in case The experience and knowledge gained form this demonstration project will be used and disseminated to other housing organisations. It is primarily the methods and tools for involving and capturing the users need and the assessment of whether the building project has succeeded with realizing those needs that will be used in other public housing projects.

The experience from the project with user involvement and user innovation and the developed tools are as relevant for enterprises such as process consultants, architects as they are for the housing organisations. The experiences from the project have been disseminated in publications on user driven innovation with architects as the target group.

5.2 Educational and office buildings

The indicators in one of the cases show how it is possible to evaluate the process on the building site after the final delivery. They give the client and the companies an insight and information about the executed work. The results can be used for altering procedures within the contractor and a future client the possibility to evaluate potential contractors for new contracts. Furthermore the KPI's form the basis of a benchmark system. The calculated Key Performance Indicators (KPI's) form the basis for a grade book for the individual company. For the government, politicians and the building industry

the KPI's give the possibility for a general overview of development in the building industry concerning the evaluated topics.

Increased interest in energy consumption has, for example, resulted in that it is mandatory for The Danish University and Property Agency (UBST) to have all the buildings in their portfolio labelled with the national energy label EMO. The UBST's directions for energy efficient building are based on the key indicators as well as the calculation programmes developed and used to in the sector to asses whether new buildings comply with the demands in the buildings regulations and that is used in EMO to assess the calculated energy efficiency of a building. The knowledge gained by monitoring the energy consumption and having the buildings energy demand labelled, makes it possible to know how specific functions of a building such as e.g. laboratories, affect the energy consumption, a knowledge that is used in the briefing process making the decision about what level of energy efficiency the new building has to reach.

In one case the Key Performance Indicators are used for comparing the operation of the actual period with former periods and budgeting the coming periods. Furthermore the resulting KPI's are used as the basis for seminars and workshops where the participating members of the network exchange experiences and get information to reduce costs or increase the quality of the operation. Some of the information go to the press or are used in connection with general statistics concerning costs of the operation of a building. An example is political discussions in connection with budgeting next year's expenses to operation of a single building or a group of buildings. The KPIs are also used in talks with the companies who are doing the actual work and the service providers.

At the moment one of the client organisations has difference indicator systems for different phases of the project. The objective is to harmonize the use of multiple indicator systems.

When facility mangers in another of the client organisations do their benchmarking they compare with other buildings in their portfolio, not with the numbers from the national benchmarking networks. In each geographical region the facility managers meet twice a year. In these meetings the key indicators are used as discussion points.' A challenge with national benchmarking is the "apple and pears" problem. A major problem is that there are substantial differences when it comes to level of maintenance. This organisation believes that their buildings have a relatively equal level of maintenance. If attention is not paid to this matter benchmarking can result in misguiding recommendations. Buildings with too low historical maintenance expenses can become best practice when maintenance level is not taken into account.

5.3 Shopping centres

Two of the cases' contribution to the CREDIT project involves 1. Indoor air and energy efficiency-related measurements carried out during the autumn season 2008 and winter/spring season 2009 in two shopping malls. The companies have their own facility management and energy management system, but it is not detailed enough at the moment to find out some deviations, malfunctions or operation errors on-line. The main interest of the participant is to find relevant indicator to manage and control technical performance of real estates and also share the costs by proper way between the customer shops. The level and type of existing building automation system

varies depending on the target. The third goal was to analyze what kind of changes or additional installations (sensors etc) is needed to improve the facility management, including reporting. There are no general information dealing with shopping malls available – also the generally accepted performance level classification and indoor conditions ranking is missing, but various retail chains and shopping mall owners have their own procedures and concepts, but in most of the cases these concepts are not public. The building codes and indoor air classification determine the general requirements, but e.g. the overall commissioning (Cx) procedures are not in use at the moment.

5.4 Hospitals

No information

6 Objectives and innovation for future improvements

This chapter relates mainly to question 2.4 in the case study reports “The applied assessments and tools in the processes”. The aim was to arrive to an understanding of what tools were used to assess and what is assessed, in relation to the objectives of CREDIT, on a project level. In a few cases information has also been drawn from chapter 3.4 in the case study reports “Applied assessments and tools in the enterprise”. This has been done when the information in that chapter describes assessment or assessment tools on an enterprise level are used on the project level. The results has been clustered in x groups depending on what the projects aim to deliver, housing, educational and office buildings, hospitals and shopping centres. The results are sub-divided into three parts building on the carpenter model, end-user requirements and needs analysis, project realisation and user benefits.

6.1 Housing

The experiences from one case study indicate that when you focus on the end-users requirements and work with a joint ambition positive effects can be achieved. The result is good concerning the product, the time-schedule and the economy. These are heavy arguments to develop different kind of collaborative and learning organisations and teams.

The methods and tools for involving and capturing the end users opinions and needs is one of the experiences that is gathered and disseminated to be used in other housing organisations that is part of AlmenNet (Innovation network for public housing organisations in Denmark) as a part of the network's guidelines 'Beboerdemokratisk process 02' (Participatory democracy for the residents). The experiences are also gathered in a publication – 'A model for value creation in the building industry that was one of the planned results of the project. This model and the guideline will be tested and developed further through the use of other housing projects. The objective with AlmenNet is this to further learning processes in public housing, and to develop methods and processes that will improve the user's satisfaction with their dwelling and housing area. The innovation strategy of U2 as well as AlmenNet is user driven innovation. It is the members themselves and their partners that initiate, develop and test new methods or processes and share their experiences with other members of the association. Future changes might be anticipated due to political changes; however no information on this can be disclosed at present time. The client, Boligselskabet, is satisfied with the way the inspections are executed and uses the results in the operation of the estate. The main vision is to strengthen the implementation of the experiences by a stronger use of them in connection with the planning and design of new estates.

The main finding, for the future, when it comes to the projects concerned with housing is to ensure that the lessons learned are fed back into the system and used in coming projects.

6.2 Educational and office buildings

There are several indications that there will be a need in the future to ensure not to put too much burden on the different parties in the construction process. There are for example suggestions that in order not o simplify the work with collecting data and free the companies for the work, letting the client be responsible for the collection and registration of the data. Similarly there have been actions to improve indicator performance by getting the occupiers views. As said in another case “The vision is to use fewer resources to collect data and more resources on analyzing them”. One possible way forward, which has been put forward in one of the cases, is to make use of the data collected for and stored in the BIM database. An important aspect is to get the systems to communicate seamlessly. The idea is not to create a data warehouse, but a system that collects data as needed from subsystems. There are also examples were company specific systems can be used for collecting project specific data automatically, although not being used at its full potential at his point.

One area that shows an increased attention, and that is likely keep on increasing, is to measure energy consumption, environmental impact etc. There are programs being developed. In one, the objective with the Directions for energy efficient building is to establish an experience with different solutions for energy efficient building and gain knowledge about whether the level of ambition is reachable and if it increases the costs. Within the same program, due to changes in the level of ambition, it has been judged to be to detailed. The assessment tool Be06 is the same in the new energy strategy as it was in the directions for energy efficient buildings. The assessment method is also the same with calculations of the energy demand of the planned building made after every phase in the building process from the brief to the handing over done by an impartial third part. The assessment tool Be06 is the same in the new energy strategy as it was in the directions for energy efficient buildings. The assessment method is also the same with calculations of the energy demand of the planned building made after every phase in the building process from the brief to the handing over done by an impartial third part.

From another case it has been found that future use and changes has to be assessed as these will affect the energy consumption as well as the environmental impact. This case also showed the necessity of measuring over some consecutive years as to get reliable values.

In renovation it is a little bit different but, it is not complicated to evaluate the influence on energy, electricity and water consumptions. Besides, the renovation also realised indoor environment changes, particularly in indoor air quality. The higher target level in indoor environment may also cause alterations because of extra ventilation periods. The issues described earlier could be studied in e.g. an energy audit or in an inspection for energy performance certification and it could be clarified how energy efficient the building really is and is there some potential for energy efficiency or indoor environment improvements. The understanding of energy consumption behaviour is very important in long run, and may help to detect faults in building systems before large damage exists.

It is expected that the clients in the future will demand more detailed and frequent information when it comes to safety and environmental aspects.

6.3 Shopping centres

To determine the key performance indicators in the level of single spaces is not any unambiguous task in the shopping centres. The needs of the shops are different – the performance of the systems must be mirrored against the required values. When it all comes around we have to recognise that the key issue of the owner is optimizing the cooling and share the costs in proper way in this particular case study. Based on the results a procedure can be created for monitoring and increasing the shops activity control for their utility consumption. In the future, also the reflections to key performance indicators (KPI`s) and the validity of these KPI`s will be discussed.

The results showed that first some adjustments should be done in case of ventilation system and cooling convectors. The systems should be brought to operate by correct way and in proper level. Probably same type of problems occurs in other shopping centres. It also means some new concepts when designing building automation systems and installations and facility management systems. Also the “owner’s requirements” should be set more detailed than at the moment. In shopping centres the building commissioning (Cx) procedure should show its usability if it would be used.

6.4 Hospitals

A systematically exchange of knowledge is on the wishing list. The knowledge exists in the head of the people, explains the manager of end users. The end user project leader think it would be interesting with an evaluation system as well “what is it people really say when they say that something is not good?”

The end user project leader experience that the structure of the role and responsibilities of different participant were sometimes fussy. As well to have a continuous contact with one person in the real estate company, many people come and went during the project. The end user project leader believes that a full understanding of the consequences of savings and changes were often lacking.

The project leader considers that too many end users often are involved in projects; “When too many people are involved it becomes hard for them to make decision about what the real needs are. They need support continuously during the project. To have an end user as the link between the end users organisation and the project organisation is positive. If a professional inform them they often got an attitude like; “the builder” is making a mess. The end users tend to accept the message/circumstance better if an end user delivers the message.”

Important words to succeed with end user participation are: engaged participants and good communication. It is also important to have a well structured project organisation, the project do not work without it, explains the project leader. Decision paths and rights have to be clear and followed. Informal decision making paths should not exist.

The project leader believes more in goals than in visions though goals have to be obtained. And further that the professionals have to be better to explain the construction process for and better to support the end users.

7 Discussion and conclusion

This chapter relates the result from the case studies to the Carpenter model. Firstly the result from the case studies will be discussed in relation to the three main assessment phases of the project process, the assessment;

- of end-user needs and requirements
- during project execution
- of the fulfilment of end-user needs and requirements

After that there will be a discussion on the benefits of the different assessment phases in light of the assessment of the overall process ensuring a learning process that enables continuous improvement and innovation. In this section will also the connection to business specific assessment tools and national benchmarking systems.

7.1 Assessment of end-user needs and requirements

The literature review showed that there are a number of different methods for managing end users that could be used for parts, but that there are very few that attempts to cover the whole process. Most methods exist in the early and in the late phases. One commonality of the tools is that almost all seek to increase the communication between the stakeholders in the project by meetings and interviews. Many of the methods are built on quite complex systems of data gathering and analysis systems that require knowledge and practice to manage. Another difficulty that many of the methods are trying to, in different ways, understand end users real needs and requirements of a building. It becomes obvious when reading about all this methods that there are difficulties in understanding issues of subjective nature. In the CREDIT project indicators for measuring and benchmark is the primary focus. In the early phases not many methods seeks to measure the outcome of the phase. The measuring between the brief and design performance often concern the process or product few concern the design quality aspects such as satisfaction, innovation or aesthetic appearance.

In the cases reported within the CREDIT framework there has not been any use of the methods found in literature to assess the end-user needs and requirements. The information gathering tools commonly used in the identified methods have been used though. Interviews, questionnaires and workshops have all been used in many of the cases presented. The tools have been used in both the cases were the users been known in advance and where they have not.

There are some differences in the application of the tools between different types of end products. There have also been different approaches within the same type of end products In housing projects where the users are known and included the tools used have included more face to face communication with a high degree of pedagogic elements included. See for example the Danish Case Study DK03, where the users even have been included in developing certain parts of the project more actively. In the cases where the users at the start of the project have been unknown the approach have been to combine general information on user needs and requirements, often gained through surveys, and in-house knowledge gained from day-to-day

contact with existing users combined with results of evaluations among the existing users for example through SCIs.

In environments where the users are of a more professional nature, for example in offices, hospitals and schools, similar approaches on engaging them when they are known. There seem to be a stronger belief though that the professional users should be better in defining their needs and requirements. Whether or not this is the case can not really be seen from the cases.

Indicators used were mainly related to 2.1 – Location and address, 2.2 - Plot opportunities, 2.3 - Spatial solution and property aesthetics, 2.4 - Surrounding services, 2.5 -Social value, 3.1 – Category of building, quantity, size and area, 3.2 – Safety and security of burglary, 3.3 – Usability and adjustability, 3.9 – Feelings and sensations in the CREDIT Indicator Classification in the cases related to housing. In several the educational and office buildings cases close to the complete CREDIT indicator list, or similar ones, were used.

7.2 Assessment during the project execution

In the project execution phase the situation is quite the opposite compared to the early phases. Here there is a lack of methods on how to involve end user but several on how to measure different aspects. The most important in the execution phase is that stakeholders affected of the construction are held informed about the project and that every member is aware of the end users so that every change is done with the end users in mind.

From a general perspective it is interesting to note that there is no information presented in the cases regarding housing on assessment apart from the traditional project assessments on time, cost and scope. In the cases reporting from facilities with professional activities there are reported on more interest in assessment. In one case the necessary data for calculation of the KPI's are collected by the client and the companies during construction. The indicators are mainly calculated after the construction phase.

In several of the cases Building Information Models (BIM) were implemented. Although BIM in itself is not an assessment method as such, in principal everything will be stored in the BIM. All the relevant numbers can be found in the same place and made use of. One of the other cases highlights this. In another case it was reported on a program that draws relevant information from all of their different management systems. This means that the managers only have to report their figures ones. The reporting into the system is internal. Different kinds of information are reported with different frequencies. A combination of BIM and a program drawing relevant data transforming them in to KPIs would dramatically ease the burden of the project administration. That in turn would probably increase the acceptance for submitting KPIs.

In one case reports on project progress was reported back to the end users. There were though, some problems with getting the end users to take it in.

Indicators were mainly those traditionally measured:

- Category of building parts, quantity size, area
- Category of process, supplier and organisation
- Health, safety and work environment

7.3 Assessment of the fulfilment of end-user needs and requirements

In occupancy/FM the balance between methods for involving end users and measure is better than in other phases. In general there are a number of different assessment methods have been used. In the cases reporting in regard to housing established methods as Satisfied Customer index (SCI) and Positive Customer Index (PCI) as well as tailored systems. In some cases it was carried out in-house while in others external consultancies were used. These methods do not focus on assessing a specific though, but the overall assessment on how users found the delivered products or services in general.

In the cases from educational and office buildings the assessments were in some cases used for specific projects. In those cases standardised questionnaires were used to get customer feedback on delivered products and services with the aim of finding out where corrective actions were needed and areas for improvement in the future.

One case reported on a system for submitting KPIs mandatory for clients responsible for state and non profit housing. These KPIs are supposed to be used in the future when assessing proposals.

In the cases reporting on shopping centres the assessments were on a technical level for example on thermal conditions, the quality of indoor air, acoustic conditions and lighting conditions.

Indicators related to the housing cases are rather divers. In the case related to educational and office buildings and shopping centres again are close to the Credit list. There may be a slightly stronger focus on the technical aspects than on the softer issues.

7.4 Benefitting from assessment on a project level

Assessing the need of en users and the level of fulfilment of those needs are essential aspects of construction and real estate projects. There are many pit falls to overcome for example different understandings of value among the actors, different professional languages etc. In the cases reported there are various approaches to deal with this, if nothing else traditional project management assessments such as time, cost and scope. In order to improve the level of fulfilment as well as the assessment methods it is important to ensure that the professional actors learn continuously and use that increased knowledge to improve. A systematically exchange of knowledge is asked for. The knowledge exists in the head of the people, explains the manager of end users. To achieve this it is of utter most importance that there are structured methods of feeding back the knowledge gained, both on fulfilling end user needs and the assessment methods used, into the process. In none of the cases reported any such structured approach has been explicitly described.

In the views of how the respondents want it to work in the future a number of issues have been put forward on how to achieve this, in whole or in parts. There is common understanding of that there will be a need in the future to ensure not to put too much burden on the different parties in the construction process. As said in one case “The vision is to use fewer resources to collect data and more resources on analyzing them”. One possible way forward, which has been put forward in one of the cases, is to make use of the data

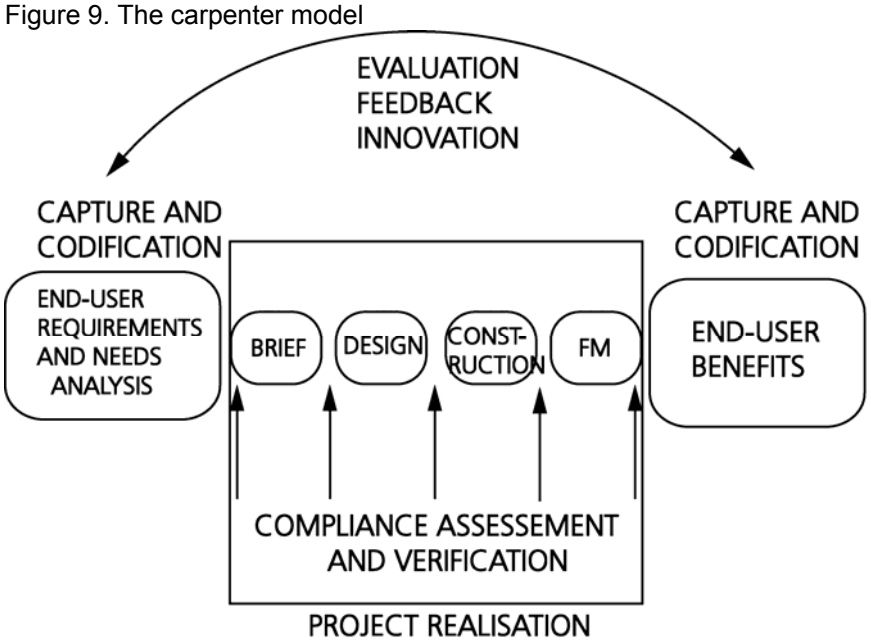
collected for and stored in the BIM database. An important aspect is to get the systems to communicate seamlessly, One area that shows an increased attention, and that is likely keep on increasing, is to measure energy consumption, environmental impact etc.

The main finding, for the future, when it comes to the projects concerned with housing is to ensure that the lessons learned are fed back into the system and used in coming projects.

7.5 Conclusions

A generic model for the capture and assessment of end-user requirements and needs, the carpenter model, has been developed, see figure 9. The main determinants of the model is the need for the project organisation (including the facilities management organisation) to ensure a thorough understanding of the end-user requirements and needs as well as an assessment through out the project process.

Figure 9. The carpenter model



There is a few other general issues that also are important to deal with. The end-users and the project organisation are often working in two different value chains. This, among other things, means that they may not share a common understanding of the process. And this needs to be dealt with accordingly. The other issue is the need to continuously improve performance. Apart from just assessing to what extent the requirements and needs has been achieved it is important to assess the process of accomplishing the desired result. This way it is possible to learn from what has worked well and what has not.

As stated in report 1, state-of the art, the literature review showed that there are a number of different methods for managing end users that could be used for parts, but that there are very few that attempts to cover the whole process. Most methods exist in the early and in the late phases. The methods that attempt to cover the whole process are not very well tested in reality.

Commonalities of the methods and tools:

- Seeks to increase the communication between the stakeholders
- Built on quite complex systems of data gathering and analysis systems

- Improve the understanding of the end users real needs and requirements

Differences of the methods and tools:
- if the process is regarded dynamic or static
- if the focus should be on the individuals experience and need of the building or if the focus should be on an organisational level.

7.5.1 Contextual dependencies

There is some variation in what i and how it is being assessed depending on what type of building it is. Assessments on housing are more inclined to focus on softer aspects, for example perception etc. In the other cases there are, generally, a more technical perspective. It may be an affect of how knowledgeable the users are. In regard to housing the users have possible less experience of construction and communicating their needs than in the case of offices etc.

There is also a notable difference between approaches and interest on what to assess in the different countries. Sweden has a much more soft approach and an ambition of getting as many as possible to understand what is being assessed and for what reasons while Finland has a much more technical and measurable approach.

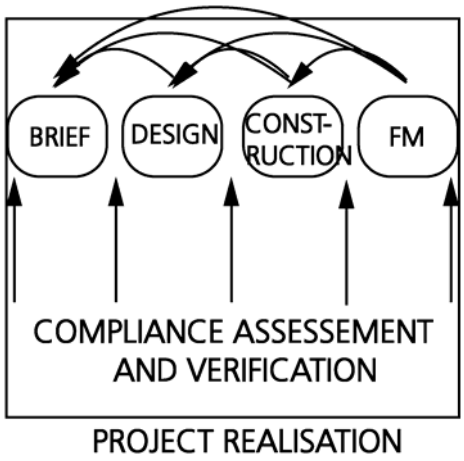
7.5.2 The role of the actors

The clients, naturally, play a large pert in the construction process, also when it come to capturing and transferring the requirements and needs of the end-users. It is mainly the clients that initiate it. Maybe more surprisingly, they do perform a lot of the work themselves as well. Designers play an important role as do known end-users as well.

During the project it is mainly the client that initiates the assessments, but the actors of the project process, designers and producers that perform it. Evaluating the degree of fulfilling the requirements and needs as well as assessing the process to enable learning is again mainly a client action both initiating and performing, the rest of the actors do not engage to any larger degree.

The processes from begin of the brief to the end of construction have well developed routines as a part of the project management system.
These routines are good enough to successfully fulfil the studied project and the control of the process in order to get *internal efficiency* in the short run perspective. But there is almost no case that shows any assessment tool that support feedback, the knowledge development and the innovation process which is important in the long-run perspective. The missing feedback is marked in the carpenter model, figure 10.

Figure 10. The missing feedbacks of the construction process.



In the study there are two examples of tools that together may to some extent overrun this issue. Building Information Models have the potential of acting as an information carrier within a project, storing all types of information needed for assessing a number of different aspects. The main issue is to get the right information and presenting it in a way suitable for the target group. This is done in the case of Falk in Skanska (in Norway). It is a system gathering and presenting a multitude of KPIs, from a number of different systems, in an easy to understand layout.

7.5.3 The concept of value

Value is multidimensional and as a consequence there exist a number of definitions of the concept. The concept is often considered to have a subjective nature as it. The judgment of value depends on who is making the judgment and for whom the value is created. A project can for example generate value to: customers, enterprise, suppliers/subcontractors and community and be judge from a social, economic and environmental perspective. Most often is, though, a single-minded perspective of value used when trying to understanding the value of an organization. The most commonly used perspective is an industrial perspective of economical parameters (for example return on investment) but not everything can be explained in monetary terms. In this study five different perspectives on value have dominated:

- Economic value, for example tax value, market value project cost etc.
- Social value – although not clearly defined what it is.
- Measurable values (quantitative) – values that can be measured objectively – often this had a relationship to indoor climate, environmental impact etc.
- Client value
- Customer value

Both the two later ones seem to be something that is taken for granted that is something that should be achieved, but not clearly defined what it is. In many of the case studies they were not even mentioned.

When discussing value it is very important to understand that, as value is multi dimensional and may be interpreted differently, value means different things to different people and organisations.

CREDIT reports and references

CREDIT reports and CREDIT case study reports are published by Danish Building Research Institute (SBi), Aalborg University, Copenhagen, and all reports are available free of charge in http://www.sbi.dk/byggeprocessen/evaluering/credit-construction-and-real-estate-developing-indicators-for-transparency-1/?searchterm=None.

Extracts from the reports may be reproduced but only with reference to source as this example: Hansson, B. et al. (2010). Project Assessments in Construction and Real Estate. Analysing management of end-user needs and ensuring performance in the building life cycle. CREDIT Report (SBi 2010:17). Hørsholm: Danish Building Research Institute, Aalborg University.

CREDIT reports

- CREDIT Report 1 (2010). *State-of-the-Art of Benchmarking in Construction and Real Estate. Developing indicators for Transparency*. Karud, O. J.; Edvardsen, D. F; Bertelsen N. H.; Haugbølle, K.; Huovila, P; and Hansson, B. SBi 2010:14.
- CREDIT Report 2 (2010). *Nordic and Baltic Case Studies and Assessments in Enterprises*. Porkka, J.; Huovila, P.; Bertelsen, N. H.; Hansson, B.; Haugbølle, K.; Hietanen, P.; Karud, O. J.; and Widén, K. SBi 2010:15.
- CREDIT Report 3 (2010). *CREDIT Performance Indicator Framework. A proposal based on studies of building cases, regulations, standard and research in seven Nordic and Baltic countries*. Bertelsen N. H.; Frandsen, A. K.; Kjærsgaard, F.; Haugbølle, K; Hansson, B.; Huovila, P; and Karud, O. J. SBi 2010:16.
- CREDIT Report 4 (2010). *Project Assessments in Construction and Real Estate. Analysing management of end-user needs and ensuring performance in the building life cycle.* Hansson, B.; Widén, K.; Pemsel, S.; Bertelsen, N. H.; Haugbølle, K.; Karud, O. J.; and Huovila, P. SBi 2010:17.
- CREDIT Report 5 (2010). *National and International Benchmarking.* Huovila, P.; Porkka, J.; Bertelsen, N. H.; Hansson, B.; Haugbølle, K.; Hietanen, P.; Karud, O. J.; and Widén, K. SBi 2010:18.
- CREDIT Report 6 (2010). *CREDIT Summary and National Recommendations. Indicators and benchmarking framework for transparency in construction and real estate in the Nordic and Baltic countries.* Bertelsen N. H.; Hansson, B.; Huovila, P; Haugbølle, K.; Karud, O. J.; Porkka, J.; and Widén, K. SBi 2010:19.

CREDIT case study reports

- CREDIT Case DK01 (2010). *22 Student Housing Estates. Stakeholder evaluation of user satisfaction, housing quality, economy and building process.* Olsen, I. S.; Bertelsen, N. H.; Frandsen, A. K.; and Haugbølle, K. SBi 2010:20.
- CREDIT Case DK02 (2010). *The Benchmark Centre for the Danish Construction Sector (BEC). Applying and improving Key Performance Indicators (KPI) in the Danish construction sector.* Olsen, I. S.; Bertelsen, N. H.; Frandsen, A. K.; and Haugbølle, K. SBi 2010:21.

– CREDIT Case DK03 (2010). *Public Housing. User needs and benchmarking of economy.* Frandsen, A. K.; Saaby, T.; Bertelsen, N. H.; Haugbølle, K. and Olsen, I. S. SBi 2010:22.

– CREDIT Case DK04 (2010). *University Buildings and Energy Labelling. Directives for and benchmarking of energy demand.* Frandsen, A. K.; Olsen, J. R.; Borggren, K.; Bertelsen, N. H.; Haugbølle, K.; and Olsen, I. S. SBi 2010:23.

– CREDIT Case DK05 (2010). *Benchmarking Private Housing. Search engines at estate agents*. Haugbølle, K. and Bertelsen, N. H. SBi 2010:24.

– CREDIT Case DK06 (2010). *Benchmarking Commercial Property. Retail, office, residential and industrial buildings.* Gottlieb, S. C.; Haugbølle, K.; and Bertelsen, N. H. SBi 2010:25.

– CREDIT Case DK07 (2010). *Operation of an Office Building Benchmarking. Danish Facilities Management.* Olsen, I. S.; Bertelsen, N. H.; Frandsen, A. K.; and Haugbølle, K. SBi 2010:26.

– CREDIT Case DK08 (2010). *Defects in Housing, Musikbyen. Danish Building Defects Fund (BSF).* Olsen, I. S.; Bertelsen, N. H.; Frandsen, A. K.; and Haugbølle, K. SBi 2010:27.

– CREDIT Case FI01 (2010). *Tulli Buiness Park.* Nykänen, V. and Porkka, J. SBi 2010:28.

– CREDIT Case FI02 (2010). *Baltic Sea House.* Julin, M.; Pousi, J.; Nissinen, K.; Möttönen, V.; and Porkka, J. SBi 2010:29.

– CREDIT Case FI03 (2010). *Lappeenranta Tax Office.* Hietanen, P.; Tuomainen, T.; Huovila, P.; Häkkinen, T.; Pulakka, S.; and Porkka, J. SBi 2010:30.

– CREDIT Case FI04 (2010). *Vuorimiehentie 5 Office Building.* Vesanen, T.; Peltonen, J.; Porkka, J.; Huovila, P. SBi 2010:31.

– CREDIT Case FI05 (2010). *Shopping Centre 1.* Parhankangas, J.; Nissinen, K.; Kauppinen, T.; Kovanen, K.; and Porkka, J. SBi 2010:32.

– CREDIT Case FI06 (2010). *Shopping Centre 2.* Parhankangas, J.; Nissinen, K.; Kauppinen, T.; Kovanen, K.; and Porkka, J. SBi 2010:33.

– CREDIT Case NO01 (2010). *Statistics Norway, Kongsvinger.* Edvardsen, D. F. and Karud, O. J. SBi 2010:34.

– CREDIT Case NO02 (2010). *University of Stavanger, Building 302.* Edvardsen, D. F. and Karud, O. J. SBi 2010:35.

– CREDIT Case NO03 (2010). *Stortorvet Kjøpesenter, Kongsberg.* Edvardsen, D. F. and Karud, O. J. SBi 2010:36.

– CREDIT Case NO04 (2010). *Skattens Hus, Oslo.* Edvardsen, D. F. and Karud, O. J. SBi 2010:37.

– CREDIT Case SE01 (2010). *Creation of a New Centre in a University. Analysing management of end-user needs and ensuring performance in the building life cycle.* Pemsel, S. SBi 2010:38.

– CREDIT Case SE02 (2010). *Developing Process and Product in a Housing Company.* Pemsel, S. SBi 2010:39.

– CREDIT Case SE03 (2010). *System for Evaluating the Construction Process.* Pemsel, S. SBi 2010:40.

– CREDIT Case SE04 (2010). *Managing Tenants in Housing Company.* Pemsel, S. SBi 2010:41.

– CREDIT Case SE05 (2010). *End-user Participation in New and Rebuild of a Hospital.* Pemsel, S. SBi 2010:42.
– CREDIT Case SE06 (2010). *Measuring Change in a Sector.* Olander, S. and Widén, K. SBi 2010:43.
– CREDIT Case SE07 (2010). *A Housing Project in the South of Sweden.* Svetoft, I. and Pemsel, S. SBi 2010:44.
– CREDIT Case IS01 (2010). *Nursery Schools - Reykjanesbær.* Marteinsson, B. and Magnússon, Ó. P. SBi 2010:45.
– CREDIT Case EE01 (2010). *Paldiski Road.* Liias, R. SBi 2010:46.
– CREDIT Case LT01 (2010). *VGTU Laboratory Building.* Kaklauskas, A. SBi 2010:47.
– CREDIT Case NN00 (2010). *CREDIT Case Study Guideline.* Bertelsen, N. H.; Haugbølle, K; Frandsen, A. K.; and Olsen, I. S. SBi 2010:48.

References

Andersson, T., Bergman, I., Björk, O. & Ericsson, L.-G. (Eds.) (2006) Value Managment - skapa värde i projkt, program och projektportförljer, Stockholm, SIS Förlag.

Campbell, L. & Finch, E. (2004) Customer satisfaction and organisational justice. Facilities, 22, 178-189.

Gray, C. & Huges, W. (2001) Building Design Management, Oxford, Elsevier Ltd.

Hua, G.C., Sher, W. and Pheng, L.S. (2005) Factors affecting effective communication between building clients and maintenance contractors. Corporate Communications, 10(3), 240-251.

Kashiwagi D. T. & Savicky, J. (2003) Identifying the true value of construction. AACE International Transactions, IT31-IT36.

Lawson, B., Bassanino, M., Phiri, M. and Worthington, J. (2003) Intentions, practices and aspirations: Understanding learning in design. Design Studies, 24(4), 327-339.

Love, T. (2002) Constructing a coherent cross-disciplinary body of theory about designing and design: some philosophical issues. Design Studies, 23(3), 345-361.

Luckett, P.F. and Eggleton, I.R.C. (1991) Feedback and Management Accounting: A Review of Research into Behavioural Consequences. Accounting, Organizations and Society, 16(4), 371-395.

Othman, A. A. E., Hassan T. M. & Pasquire C. L. (2004) Drivers for dynamic brief development in construction. Engineering, Construction and Architectural Management, 11, 248-258.

PMI (2008) A guide to the project management body of knowledge: PMBOK guide -4th ed., Pennsylvania, Project management institute, Inc.

Preiser, W. F. E. (1983) The habitability framework: a conceptual approach towards linking human behaviour and physical environment. Design Studies, 4, 84-91.

Preiser, W.F.E. and Vischer, J.C. (2005) The evolution of building performance evaluation: an introduction. in Preiser, W.F.E. and Vischer, J.C. (eds.) Assessing Building Performance. Oxford, Elsevier Butterworth Heinemann, 3-13.

Shen, G. Q. P. & Chung, J. K. H. (2006) A critical investigation of the briefing process in Hong Kong's construction industry. Facilities, 24, 510-522.

Thomas, J. and Mullaly, M. (2007) Understanding the Value of Project Management: First Steps on an International Investigation in Search of Value. Project Management Journal, 38(3), 74-89.

Thomson, D. S., Austin, S. A., Devine-Wright, H. & Mills, G. R. (2003) Managing value and quality in design. Building Research and Information, 31, 334-345.

Van Ree, H., Van Meel, J. and Lohman, F. (2006) Better Briefing for Better Buildings - An innovative Modelling Tool for Specifications Management. in Sivyer, E. (ed. COBRA 2006 The construction and building research conference of the Royal Institute of Chartered. University College London, RICS

Zhai, L., Xin, Y. and Cheng, C. (2009) Understanding the value of project management from a stakeholder's perspective: Case study of mega-project management. Project Management Journal, 40(1), 99-109

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In this report a generic model for the capture and assessment of end-user requirements and needs, CREDIT carpenter model, has been developed. The main determinants of the model is the need for the project organisation (including the facilities management organisation) to ensure a thorough understanding of the end-user requirements and needs as well as an assessment through out the project process. The processes from begin of the brief to the end of construction have well developed routines as a part of the project management system. These routines are good enough to successfully fulfil the studied project and the control of the process in order to get internal efficiency in the short run perspective. Building Information Models have the potential of acting as an information carrier within a project, storing all types of information needed for assessing a number of different aspects. This is done in the case of Falk in Skanska (in Norway).

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