LoRe-LCA

Low Resource consumption buildings and constructions by use of LCA in design and decision making

Report on experiences on national, European and international level of use of LCA in design

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Table of Content

Executive Summary

Specific LCA methods and environmental rating tools are considered useful by practitioners in achieving environmental goals beyond regulation all the way from early stages of a construction project. For both LCA methods and environmental rating tools simplicity and ease-of-use are important factors.

Key drivers for setting environmental goals beyond regulation include public institutions addressing societal demands, local authorities, contractors, developers need for spearhead projects for profiling of municipality or company and client branding. Access to public subsidies or incentives can provide additional drivers for high environmental ambitions and/or use of LCA in the design process, for example to contribute to higher LCA competence in the design team and the possibility to perform LCA calculations.

The use of LCA in construction projects is still rare but case studies in which LCA was introduced very early in the process display better design options in environmental terms that would have been taken without using LCA. Such successful processes are characterized of including environmentally conscious and experienced key stakeholders (project managers, clients, consultants).

1 Purpose and scope

The main objective of WP4 is to collect experiences on national, European and International level of use of LCA in design processes. The WP is aiming at finding examples where active use of LCA and environmental assessments has resulted in more sustainable constructions.

The WP covers a number of different case studies. The first type of case study covers the use of LCA tools in practical examples, in cooperation with architects and others involved in the process. These cases are specifically covered in this deliverable, D 4.1. The second kind of case study focuses more specifically on LCA features which were pointed out as important and challenging by WP3 of this project. One such feature includes the use of different scenarios in LCA´s of buildings or building-related products, which is covered specifically by deliverable 4.2 of this work package. Deliverable 4.3 lists case studies used in the entire LoRe-LCA project and also includes full reports the LCA case studies performed by project partners for the project.

2 Methods

For the present report, a number of real cases were studied aiming at collecting more of in-depth qualitative information about extra interesting and information-rich construction projects/programs in which life-cycle approaches were/are used. There were two main aims:

1. To provide in-depth process information about why and how life cycle approaches were used and how it might have affected practice (providing input to D4.1).
2. To provide input if particular LCA scenarios were used and if so what scenarios were used and why (providing input to D4.2).

Cases were identified by each partner. Cases were also sought for outside Europe, however no such cases are referred to in this report. There are two main reasons for this, firstly it was difficult to find interviewees who could provide us with the in-depth, qualitative descriptions that we aimed for. Secondly, the case examples provided by the partners seemed to cover the range of issues we wanted to highlight and it could be assumed that only limited new information could be provided by more cases outside Europe.

The interviews were performed with one or more key persons who had insight into the process of using life cycle approaches in the construction projects. The interviews were quite open in their character, mainly searching for information about why and how decisions were taken, but based on an interview guide which is found in Appendix 1.

In extrapolating from the specific case studies above to general conclusions about how higher environmental performance can be achieved in construction projects it is well to keep in mind how the method applied in this study (i.e. mainly deep interviews) delimits the range of the conclusions that can be drawn. Firstly it should be pointed out that the assembled case studies are not intended to represent an exhaustive survey of (as near as) all the ways in which high environmental targets for buildings are achieved in practice. Rather these case studies should be viewed as positive examples where processes and tools have been applied in practice with positive results, that may be applied with benefit elsewhere. That is, cases which we can learn more from.

3 Introduction: Experiences of use of LCA in design processes

Despite the existence of numerous LCA tools for buildings and the proportional high environmental impact of the building and construction sector, the implementation of life cycle thinking progresses slowly and quite few practical examples exist of how the use of LCA (or at least life cycle thinking) has actually affected construction projects. The focus in this deliverable lies on use of *life-cycle* approaches regarding environmental assessments. In addition, it should also provide process information about why life cycle approaches were used and who initiated it and how it affected practice.

The cases studied are reported below as narratives under a number of themes. The outline of each case follows in most cases the following structure:

1. Brief description of building, construction, etc
2. Brief description of the assessment tool/life cycle approaches used in the process
3. Why was the tool/life cycle approaches used in this project? Who (asked for)/demanded it and for what reasons?
4. Which topics/indicators where targeted?
    a. Was resource consumption over the life cycle an important issue?

5. How was the tool/life cycle approaches used in the process
    a. What input data was used, sources of information?
    b. Who was actively engaged in using the tool?
6. Did the use of the tool, calculations, etc influence the final design? If so, how?
    a. Why was the final design influenced? Which actors played important roles in this process?

4 Results of interviews and studied cases

4.1 Swedish case studies

4.1.1 New design driven by environmental rating/certification schemes - Kungsbrohuset in Sweden

Description of building, construction, etc

A current Swedish example of how environmental assessment tools can impact the design is Kungsbrohuset in the middle of Stockholm. The client is the company Jernhusen which owns, operates and develops properties along the Swedish railway system (stations, offices, depots, etc). The building Kungsbrohuset with a total area of 27000 m^2 is under construction and the first tenants will move in during early 2010. It is a 13 floor building with parking, recycling station, bicycle garage in floors 1-3, restaurants and retail space in floor 4 (2500 m^2) and offices in the rest of the floors (19500 m2). The building is situated just above the main railway station in Stockholm.

Description of the assessment tool used in the process

The ambition was to be certified according to GreenBuilding (GreenBuilding, 2011), P-labelling (SP, 2011) and to acquire the highest rating (gold) according to Miljöbyggnad (www.sgbc.se) (Malmqvist et al., 2009). Miljöbyggnad is a comprehensive rating tool which assesses the following main environmental aspects: bought energy, energy demand, energy source, noise & acoustics, thermal climate, indoor air quality, daylight conditions, legionella and content of hazardous substances in construction materials. For each aspect, one or more indicators are assessed according to criteria for the levels gold, silver, bronze and classified. A bronze level for most indicators relates to compliance with current building norms, recommendations by authorities, etc. The tool was developed to cover the most significant aspects related to buildings over a life cycle, however, life cycle calculations are not performed by the tool.

In addition, in the design stage LCC calculations were used to provide decision support regarding specific HVAC installations (e.g. ventilation heat recovery, choice of heating system and the design of the building envelope).

Why was the tool used?

It was decided early in the process that this building should be an environmentally leading building, and constructed and credible tools were sought in order to be able to make such statements for marketing the building and its premises. The underlying cause was both to use the project for creating a general positive image for the property company and in light of demands posed by current office tenants. A review of potential tools to communicate the environmental image was performed, resulting in the client choosing 3 environmental labelling/rating tools for buildings that the building should comply with. The three tools include the European Green Building (GreenBuilding, 2011) certification (where the focus is on energy efficiency and energy management systems), P-labelling (a Swedish tool focused on quality of the indoor environment, SP, 2011) and Miljöbyggnad (Environmentally rated building), described above (Malmqvist, et al., 2009). There were a number of reasons that the client's steering committee selected these tools specifically. Miljöbyggnad was more explicitly chosen as the main tool for a comprehensive environmental assessment since it was perceived to be robust and adapted to Swedish conditions and building standards. The P-labelling was found to be interesting for the project since it includes requirements to follow-up the performance of the building constantly during the operation stage. The Green Building tool was chosen mainly because it is a well-known brand in Europe, and therefore increased the potential for marketing and profiling the project outside of Sweden. A general perception in the project steering committee was that these three tools complemented each other positively and that it would facilitate the environmental management of the project by using the indicators of the tools as targets for the project, instead of developing a specific tool for the project itself, that may not be able to be used for future projects.

Targeted indicators

Due to the connection to the three tools used, their content guided the choice of focused indicators. Main targeted indicators include: bought energy, energy demand, energy source, noise & acoustics, thermal climate, indoor air quality, daylight conditions, legionella and content of hazardous substances in construction materials. These three tools are all focused on the operation stage of buildings and regarding resource use, it is therefore mainly the use of energy during the operation stage that is focused. The tool Miljöbyggnad has so far omitted environmental assessment of the embedded emissions and resources use of building materials, a reason for which is that it was focused on being developed for use in existing buildings. Thus, resource use *per se* has therefore not been of high focus for this project. Actually, it can be mentioned that the client demolished an office building built in the beginning of the 1980s to make room for Kungsbrohuset. The reason for dismantling this building was that it had numerous problems regarding PCB, radon levels and bad indoor environmental quality in general.

The use of the tool/life cycle approaches in the process

The criteria in Miljöbyggnad were used as environmental targets for the design team during the planning process and thereby influenced the final decisions taken on the design and technical solutions. Input data therefore mainly consisted of drawings and simulations in different steps of the design process. The assessment tools were mainly used by the environmental consultant of the design team.

Tool use and the influence of final design

The building had very high ambitions from the beginning and for instance it was already decided that Kungsbrohuset should be heated partly by the excess heat from the approximately 200,000 people who pass through the Central Station each day. This heat goes through a heat recovery system and transferred to water, where it is then pumped into Kungsbrohuset where it is used for base-load heating. In the process, it was verified that this solution made it possible to reach the highest rating (gold) for the indicators in the rating tool Miljöklassad byggnad related to energy use. However, the client also demanded glass facades and this fact provided problems to reach the highest rating due to the high solar loading it would create. The use of the rating tool in this case led to rethinking of the way in which windows/glass facades were used in the design. The result of this is that Kungsbrohuset is now constructed with an energy efficient façade, with window glazing that lets in visible solar radiation year round, but not the thermal radiation in the summer. The innovative construction of the glazing will let everyone in the building enjoy a maximum amount of daylight (even in wintertime), while requiring a minimum amount of cooling in summer.

The design team concludes that the tool provides a simple and practical way to work with construction adjustments in the design stage in order to reach higher rating by the tool.

Concerning LCC calculations, these were also used for providing decision support in choice of HVAC installations and the design of the building envelope. For example, geothermal heat pumps were chosen as prime movers for the heating system (apart from making use of the excess heat of the Central station terminal) and these calculations also led to the decision to not install individual metering and billing of heating for the tenants.

Sources of information

Interview was carried out with:

Anders Lood, environmental consultant of the design team

Lectures by:

Klas Johansson, environmental manager of the property owner Jernhusen

Karl Sundholm, project leader for Kungsbrohuset both at Kungsbrohuset (2011)

4.1.2 Evaluation of environmental targets for a new city district - Hammarby Sjöstad, Sweden

Description of building, construction, etc

Hammarby Sjöstad is Stockholm´s largest urban development project for many years and involves the reconstruction of old brownfield areas situated immediately South and South East of Stockholm city centre. The construction of the new city district started in the end of the 1990´s and is currently planned to be entirely completed in 2017, at which point it will comprise approximately 11 000 apartments for 25 000 inhabitants and 10 000 work places.

The City of Stockholm declared in the early 1990´s that Hammarby Sjöstad would have a high sustainability profile and serve as a forerunner for both ecologically sustainable construction and living. The overall target set out for the development was “twice as good as today”, that technical solutions should be improved by a factor 2. The underlying reasons for the environmental visions for Hammarby sjöstad were the current environmental debate and more specifically, that Stockholm City worked with an application for holding the Olympic Games in Stockholm in 2004. Hammarby sjöstad was then meant to be built as the Olympic village. On the one hand, the International Olympic Committee had increased the environmental focus and put environmental requirements on the applications. On the other hand, the application had major and vociferous opponents both among some political parties and among environmental NGO´s. Establishing a cutting-edge environmental program was also strategy to appease opponents to this plan. Another argument from leading politicians and proponents of the Olympic Games application, was that a cutting-edge environmental city district would be a good way of marketing the City of Stockholm as well as Swedish environmental technology and skills.

In light of these conditions, an environmental program was produced in 1996. Adoption of this program politically occurred two months before the Olympic application was sent in and the program with it’s environmental targets were therefore established quite quickly. While the program’s overarching quantitative target was “twice as good”, the main quantitative (and much-debated) target was an energy demand for the buildings of 60 kWh/m^2.

However, the subsequent development processes did not ultimately strictly follow the environmental program. A key issue here was that the distribution of land permits did not include legally binding environmental requirements. Developers were only bound to “strive towards” reaching the goals. This was considered expedient at the time since inclusion of binding environmental requirements in the permitting process would only make it even more complicated. Other examples include goal conflicts in the development process, where the environmental requirements were deprioritised. Specifically, a harbour view for residents was a highly-valued quality objective, which resulted in large windows facing North and a high window/façade ratio, leading to a higher heat demand (since windows’ heat resistances are lower than those of wall constructions). In the development process in general it was expressed that whereas the environmental program established specific goals, guidelines and other assistance as to how these cutting-edge environmental goals were to be achieved were lacking.

Description of the assessment tool used in the process

For the purpose of following up the target “twice as good”, a tool called the Environmental Load Profile was developed. The tool is life-cycle based and enables calculation of environmental impacts from the level of an individual resident up to total impacts for the entire city district. When used for Hammarby Sjöstad as a whole, the project was divided into different activities that were each analysed in terms of their respective environmental impacts. The different activities divided the project into time periods of the project such as from zero to user-ready building, management during building use and demolition (including e.g. recycling and landfilling of the building materials). Emissions to air, ground and water are quantified for significant activities related to the construction, operation and dismantling of the city district and its buildings. Contributions to the impact categories global warming, eutrophication, acidification and photochemical ozone formation, production of radioactive waste, use of non-renewable energy and water use is then calculated based on the emissions.

The tool has been developed in a collaboration between Stockholm City, a technical consultant (Grontmij AB) and the Royal Institute of Technology (KTH) in Stockholm.

Why was the tool used?

Despite that the environmental program of Hammarby Sjöstad could have been a more governing document, Stockholm City stressed in communication with the developers that it would evaluate the fulfilment of the targets established in the program. This is the specific purpose for which the ELP tool was developed, although it was developed after the fact. When the environmental program was developed the practical evaluation of the targets was not yet concretized.

The Hammarby sjöstad project was initiated in a time when adapted LCA-based building tools or rating tools were still quite absent, which was a reason why the ELP tool was developed more or less as part of the project. A main aim with this development was to clarify the “twice as good” objective more in detail and in a quantitative way.

Targeted indicators

Key environmental targets for the development included:

- Establish a local eco-cycle for resources
- Minimum consumption of resources
- Reduce energy consumption
- Reduce tap water consumption
- Utilize sewage for energy extraction
- Building materials are to be renewable or recyclable
- Total soil decontamination
- Restore the lake
- Reduce transport needs
- Stimulate community feeling and ecological responsibility among the residents

Regarding resource use, the environmental targets have been very focused on recycling of household waste. Secondly, a target regarding wasted materials in the construction stage has been used focusing at avoiding the waste to end up in a landfill. There is also a target related to limiting the use of natural gravel and sand. An important reason for this target is probably that that it is a environmental target in the Swedish National Quality Objectives.

The indicators calculated by the ELP tool are:

- Contributions to climate change (g CO_2-eq.)
- Acidification (mol H^+-eq.)
- Eutrophication (g O_2-eq.)
- Tropospheric ozone production (g C_2H_4-eq.)
- Radioactive waste (cm^3)
- Non renewable energy use (kWh)
- Water use (m^3)

The use of the tool/life cycle approaches in the process

The use of the evaluation tool ELP was strictly introduced as a means for the City to follow-up the fulfilment of the environmental targets. The developers did not use the ELP tool themselves. Developer involvement was limited to compiling input data for the City of Stockholm and the consultant they used for making calculations and evaluations with the tool. Already the land permit contracts contained clauses that the developers were required to deliver input data for the evaluation of the environmental targets to the City. Therefore, even though life cycle thinking was in some sense an overarching aim in project development, life-cycle calculations did not guide the projects and their design, urban form, etc.. Rather they have only been used for project evaluation against the authorities and probably not even as feedback to developers.

The input data for the evaluations which were performed with the ELP model comprised mainly simulated data, and not actual, measured values. Around 10 developers of around 20 estates have collected information about quantities of different building materials, calculations of energy use during the operation stage and some technical solutions in the building properties.

Tool use and the influence of final design

It is very unclear from both interviews and written material about Hammarby Sjöstad, whether the use of the ELP has had any influence of the final design of buildings. Since the tool was not used in the design processes, it is likely that it is rather the detailed environmental targets which have played a role. A conclusion from this process may be that a number of these detailed targets (like the target regarding energy demand and targets to select non-hazardous construction materials) were highly debated among the developers at the time, with many expressing that they were impossible to reach. In the event, these targets were not reached, at least not in the first project phases. However, these targets probably played an important role for increasing competence and knowledge related to these issues since at least large developers now have integrated more such goals into their daily practice (as can be inferred from especially the Vattenfall case study in this report).

Sources of information

Interviews made with:

Kerstin Blix, environmental officer of Hammarby sjöstad at Stockholm municipality

Lars Fyrhake, developer of the Environmental load profile tool

Written information:

(Svane, 2007), (Green, 2006)

4.1.3 New Office Headquarters for Vattenfall AB

Description of building

The building in question is a new office headquarters for Vattenfall Norden AB, Vattenfall AB's Business Group in the Nordic countries. It is a new build on a brownfield site called Arena Staden, which is situated on the northern side of the City of Stockholm. It has 40 000 m^2 climate-controlled area and will provide workspace for approximately 2000 employees.

Description of actors

The main building contractor on the project was PEAB, a large publicly-traded Swedish construction company. The building owners and developers are Fabege, a publicly-traded Swedish real estate company and the tenants are Vattenfall Norden AB, the state-owned Swedish energy company will be tenants.

Vattenfall AB

Vattenfall AB is a multinational energy company (owned by the Swedish government). They pay significant attention to environmental aspects and have an environmental management system certified according to ISO 14000. As such the company has an environmental manager on concern management level, as well as line managers for environmental aspects in each department. As an energy company it has high public visibility from an environmental and specifically greenhouse gas point-of-view. The company has the expressed intention of taking account of environmental aspects beyond the relevant regulations and legal mandates. This can be seen in yearly sustainability reports (carried out according to global reporting initiative (GRI) standards) and environmental product declarations (EPD's) for electricity (Vattenfall AB, 2011).

Amongst the factors that may contribute to the relative importance of environmental aspects at the company is a long-standing environmental tradition. Vattenfall's home country, Sweden has a long tradition of renewable energy (with hydroelectric power since the early 20th century, from which the company derives its name) and over the past 2 decades policies have been introduced that promote energy with low greenhouse gas (GHG) intensity (e.g. the carbon tax). Vattenfall also owns a significant nuclear portfolio producing electricity (with a low GHG intensity) in Sweden and Germany. Having said that, in recent decades Vattenfall has acquired significant coal generation (primarily in Germany and Poland) and has a significant presence in the Dutch fossil gas market.

As such Vattenfall has a tradition of environmentally benign energy services, and latterly energy services with significant negative environmental impacts that drive Vattenfall's engagement in environmental management from both sides.

Fabege

Fabege is a publicly-traded company that owns, leases and operates commercial properties in greater Stockholm. Fabege's building stock comprises principally office space, and to a lesser extent retail, industrial and warehouse facilities. They are a large actor in greater Stockholm, with 6 % of the market for office space in central Stockholm (and a total of 502 000 m^2 rental space), and 33 % of the office market in the City of Solna (a suburb immediately north of the city centre, where the Fabege owns 462 000 m^2 of total rental space) (Fabege, 2011).

Fabege has an environmental policy where "concern for the environment should be a natural and integral part of our activities in property management, project development and property transactions" (Fabege, 2011). The policy is based on ISO 14001 and identifies key environmental aspects and areas to address such as waste prevention and treatment, resource efficiency and depletion, pollution prevention and reduction of hazardous chemicals.

In addition to this overall environmental policy, Fabege's specific energy efficiency goal is to reduce specific energy demand for space heating and hot water from the 2009 average of 83 kWh/m^2 rental space to 70 kWh/m^2 rental space by 31 December 2014. In addition, Fabege carry out all new construction and renovation of office facilities according to the EU's Green Building environmental rating tool.

Fabege perceives energy and environmental aspects as becoming ever more important in the commercial property markets. In valuing a property Fabege analyses energy-consumption data as well as other environmental aspects. It is also noted that clients/tenants are becoming increasingly environmentally aware in general, as well as that share-holders perceive a value in a sound environmental management policy. A notable business advantage for using the EU's Green Building tool is that rated buildings are considered very attractive on the commercial property market and attract higher prices than otherwise similar properties.

PEAB

The general contractor on the project, PEAB also has certain experience working with building projects with higher environmental goals beyond the project described here. For example, they have numerous clients who have requested EU Green Building labelling, have certified buildings according to LEED (in Finland), and have an interest in certifying employees in BREEAM. Further examples of environmentally motivated work are the application of environmental rating tools for specific materials, where they have collaborated in industrial consortia to develop industry standard rating methods (PEAB, 2011).

Why was the assessment tool used?

Reasons for which environmental aspects were given such high consideration by Vattenfall were:

To have a main office with a good environmental performance is perceived by Vattenfall (as expressed at the level of the project management team) to be very positive from the point of view of attracting clients and possible clients.

Such an office is also perceived by Vattenfall to be a way of expressing an environmental profile to attract a talented and environmentally-motivated workforce.

Other effects noted by Vattenfall is that as a large company with a public profile, the building serves to raise the profile of green building in general, as well as increasing the expertise in green building and green building processes amongst all actors involved in the process.

Description of the assessment tools used in the process and why they were selected

The need for a new office was identified and expressed initially from Vattenfall's corporate management. The desired qualities for the new office were communicated to a project management group in the company using 5 guiding phrases, of which the single worded phrase "environment" had the highest priority.

From this point Vattenfall's project management group specified a brief with the purpose of communicating the need for a new office to real estate companies, and calling for expressions of interest from said companies. From the beginning the brief was short, describing desired climate-controlled floor area in the building and other such basic functions, as well as that Vattenfall AB wanted to be seen to be the market leader in environmental issues.

Based on this brief, Vattenfall received expressions of interest from a large number of real estate companies, a large majority of which were worthy of serious consideration. This procurement procedure continued through rounds of negotiation between Vattenfall and contending companies, where Vattenfall's project management group communicated successively more refined specifications for the building.

It was during negotiations with possible property owners (amongst others Fabege) that it was established that the building achieve gold rating according to the Swedish environmental rating tool Miljöbyggnad (MB). That Vattenfall chose Miljöbyggnad was based on an initial evaluation of available rating tools. While tools such as LEED and BREEAM were given consideration, it was judged that the simple additive method of point aggregation, and the fact that these tools were not developed with respect to Swedish building standards, regulations and climate, were such that a relatively high rating could be achieved without Vattenfall achieving the desired environmental performance in the building.

In contrast, Miljöbyggnad was developed collaboratively between leading Swedish universities, construction companies, property management companies, consultants and architects. Secondly, it is intended specifically for Swedish weather conditions, while other tools (eg. LEED and BREEAM) are developed for conditions reflecting the countries in which they were developed. Thirdly, MB has a limited number of indicators (14 in total), and an aggregation method that ensures that buildings with a high score have high performance for all indicators. These aspects of the tool mean that important environmental aspects are not lost in indicator aggregation (as is the case for LEED and

BREEAM with a large number of indicators). All these reasons were cited by Vattenfall's project management group as reasons to favour specifying MB for their new office building. These were also sited as advantages by Fabege. A further insight presented by Fabege was that in spite of these apparently functional advantages for Miljöbyggnad, LEED and BREEAM were often favoured by international companies hiring properties from Fabege, due to the fact that these tools had better international recognition, and in some cases were even mandated by environmental management procedures at these companies.

Of the tools mentioned above, MB establishes the strictest requirements for energy consumption. Having said that, Vattenfall had already specified in their brief a target for total bought energy use for property electricity, heating and hot water at 50 kWh/m^2, year, which is much lower than that specified even in MB. A target for user electricity at 35 kWh/m^2, year was also adopted in the brief, an area where MB does not have any requirements.

Vattenfall's project management group also identified the European Union's Green Building rating tool to be used for their new office building. There are 2 main reasons that they wanted to use this tool. The first is that it is a well-accepted tool that is recognized internationally. Secondly Green Building requires the implementation of an energy management plan for the building. Green Building does require that the building achieve 20 % lower energy consumption than new-build standards, however, this goal was essentially already specified according to the voluntary energy target shown above, and Green Building did not establish any novel goals in this respect.

Contract between Tenants and Building owners

Vattenfall's final decision as to which company's bid to accept was based on evaluation of multiple criteria, of which environmental aspects were a major component. Vattenfall contracted Fabege as building owners, and developers (since it is a new build project) for the building in question. The agreement reached between the two companies included such elements as that:

User electricity: Responsibility for energy-efficient general lighting fixtures and energy efficient appliances was assigned to Fabege, whilst Vattenfall is responsible for IT solutions (laptop computers because of their lower energy consumption as well as goods with low stand-by consumption).

A key issue is how any situation where the established energy goals for the project were not met is dealt with by the parties to the agreement. Whilst an option such as penalty fees paid by Fabege to Vattenfall was considered, in the end it was established that such a failure to meet energy goals would be deemed a breach of contract, legally requiring Fabege to carry out measures to remediate the problem.

It is worth noting that achieving a contract that both parties could agree upon was an all-encompassing process, involving significant collaboration on many different issues. In particular, both parties agreed that it was important that the technologies to be implemented in the property should be well-established technologies. This required collaborative investigation into what sort of technologies they could use, including drawing on experience from reference buildings where these technologies had been implemented.

Expression of environmental goals later in project

After the contract was signed, it was essentially left to Fabege to express the environmental goals in subsequent stages of the project. This was ultimately managed by the use of an environmental program, consisting of well-defined environmental goals (based on the contents of the contract) for each stage of the process, that are subsequently being expressed to PEAB, the general contractor. The project is currently in the construction phase and will be ready for occupation in 2012.

As per the aim of the LoRe-LCA project where this project follow-up is a part, the question of the application of life-cycle methods was also raised in this follow-up. Only in relatively limited areas of the project was life-cycle cost analysis (LCC) applied, specifically for energy intensive installations, such as lighting fixtures. Otherwise, on top of MB, all materials were required to have reached a certain standard according to an industry standard environmental rating system for materials, byggvarubedömning (official English translation is lacking, this roughly means: construction product evaluation). This system does take into account environmental impacts in production, use and final disposal phases, and it is relevant to think about it as based in life-cycle thinking.

General remarks about the process

The Vattenfall management group for the project expressed that the importance of environmental aspects is well-established with Vattenfall’s corporate leadership and the project management team. This high prioritization of environmental aspects was also considered to be reflected at Fabege and the other competing building owner/developers at the level at which negotiations were carried out.

Having said that, the communication between Fabege and PEAB was considered to be more problematic with respect to environmental aspects. Reasons for this may be that specific construction project leaders may work according to established norms and habits that need to be changed in order to achieve the standard of an environmental building. It is also possible that professionals in these kinds of positions have not received requisite training in environmental issues. In general the human aspect of the process is an area that needs to be developed: Attitudes need to be changed, a sustained commitment is required, and practitioners need training. That it is technically and economically feasible to build with greater environmental performance is in contrast well known (if only at certain levels in the process).

It was further pointed out that this project is an example of a collaboration between tenant and developer/owner that was considered by both parties to be successful, where the establishment of measurable goals for environmental performance, including penalties for not meeting these goals was seen as a factor that ensured a clear understanding between the parties. It was further pointed out that this process is not common in construction in Sweden, rather that environmental goals are often established during a project phase after which decisions with significant negative repercussions for environmental performance have already been made. Understandably such project processes (involving significant "rework" or alternatively reduced ambitions) are much less satisfactory for developers than the Vattenfall case.

It seems that this case represents a leading example of a project process where environmental goals have been established and implemented all the way through the project so far. In this case it is instructive to analyse what lessons may be learned from the project that may be applicable to other projects.

Specific areas in which the environmental goals affected the design were in choice of heating source (heat pump) and in dimensioning of windows (where size needs to be optimised to meet MB's requirements for day-lighting, reduction of solar loading and heat loss coefficient).

Interviews were carried out with Mia Östman, environmental manager, Fabege and Linn Dahlberg, Vattenfall's project management group, Vattenfall Power Consultant.

4.2 Spanish Case Studies

4.2.1 Renovation of apartment building – Playa de Palma, Mallorca

Description of building

This study focuses on refurbishment of a multi-family residential building with a total surface of 1,600 m^2, built on four floors and comprising 9 apartments. It was built in 1974 and it is located in Playa de Palma on the island of Mallorca, Spain. The life-cycle study was performed for the Playa de Palma Consortium (which comprises members from Palma City Council, the Llucmajor City Council, The Mallorca Island Council, the Balearic Regional Government and the Spanish Government). The consortium was set up in 2005 with the aim of promoting the refurbishment of hotels, complementary tourism services, buildings and the area in general. The consortium aims to achieve a new tourism model for Palma Beach including sustainability, climate change, global change, social and residential cohesion, as key issues and further aim a new model for a tourist destination.

Description of assessment tool used

A simplified life cycle assessment (LCA) was carried out to provide decision support for the renovation project, for which a custom simplified tool was developed. This particular project is seen as a pilot project for the further renovation of the entire Playa de Palma district, and it was therefore desired that the tool be public, or at least available at very low cost.

In the tool, two databases, TCQ 2000 and BEDEC PR/PCT were used for the analysis of material production, building maintenance and waste management strategies, both of which were developed at the Catalonia Institute of Construction Technology – ITeC. Official Spanish programs LIDER and CALENER were used to calculate energy consumption and CO_2 emissions during building use. Both have been developed under the auspices of the Spanish Government. Spreadsheet tools were specially developed or adapted to calculate water balances for the buildings. Very simple LCC calculations were included in the simplified tool. As much as possible, free and public data related to climate, statistics, reference prices, etc. were used.

This tool enabled an assessment of energy and water use, waste generation and CO_2 emissions in great detail, whilst for transportation, construction, maintenance and end-of-life, assessments were made based on available studies and sources.

Why was the tool used?

The motivation for using the tool is based in the expressed environmental strategy for the Playa de Palma district. This strategy aims to take into account resource consumption (energy, water and materials) and resource use (depletion and emissions to water, air and soil) and is intended to be applied to transport, urban infrastructure, public spaces as well as the hospitality industry, which is important for the district and the island as a whole.

From the point of view of the building in question, the specific aim is to reduce energy consumption, CO_2 emissions, water consumption, material use and construction, use-phase and demolition waste by at least 50 % with respect to conventional renovation over a life cycle of 50 years after building renovation.

These specific targets were set by Playa de Palma Consortium's technical support team, and at their recommendations were adopted by the Consortium as a whole.

Whilst ultimately it is the Consortium leadership that was decisive in establishing the environmental goals for the renovation project, the technical support team was also instrumental in terms of the motivation and expertise (environmental training and awareness, management skills, responsibility and rigour, discipline) that they provided.

Regarding building owner's motivations, the most greatly appreciated aspects of the integral refurbishment are: the reduction of energy consumption, the functional enhancements, the improvement of habitability, the security enhancements, etc. and also the economic aid from the consortium.

What were the targeted indicators?

As mentioned previously, targeted indicators are energy consumption, CO_2 emissions, water consumption, material use and construction, use-phase and demolition waste. Emissions to air, soil and water other than CO_2 are not specifically targeted. The study also includes an economic assessment of the solutions proposed, carried out on a life-cycle basis (LCC).

A target percentage of 50% reduction was established for energy consumption, CO2 emissions, water consumption, material use and construction, use-phase and demolition waste with respect to conventional renovation, over a life cycle life of 50 years after building renovation. Having said that, maximum values for energy consumption, CO2 emissions, water consumption, etc., were not established.

The use of the tool/life cycle approaches in the process

So far the tool has been used to evaluate simplified LCA profiles for three main renovation scenarios: a. the existing building, b. the renovated building (including environmental improvements), c. The renovated building (according to standard practice), d. Demolition and rebuild under current regulations.

The conclusions of the simplified LCA study that has been performed for this renovation process have demonstrated the feasibility of achieving the desired environmental targets with the renovation (according to scenario b. above). At the time of writing the project is being developed further and the conclusions from the study are being included as far as possible in this development. It is however considered that budget limitations will restrict the implementation of all the environmental improvements.

At the moment, the conclusions have been included in some documents for the programming phase. The programming phase is established by the consortium, but it involves a range of stakeholders and includes building owners' opinions.

How the use of the tool influenced the final design

The project is ongoing, and it is not possible to evaluate with certainty how the renovation has been changed as a result of the LCA study. Whilst standard renovations may only include addition of insulation to the climate envelope, the solutions proposed and analysed according to the LCA tool include bioclimatic solutions, and novel HVAC and lighting solutions. Since the proposed renovations are still in a development stage it is not possible to comment on how the LCA study may affect the actual renovation.

General comments

In general, it is difficult to find a case of application of LCA/LCT in Spanish buildings. There are very few, since there are no established requirements in the Spanish legislation. This involves lack of knowledge of the LCA methodology between the architects, engineers, urban planners, property developers and clients.

There is also a lack of simplified and user-friendly tools to perform LCA studies in buildings. Consequently the demand for these studies is not significant. Construction companies such as Acciona have built some zero emission buildings (including one located in Zaragoza), but they do not really consider life cycle, they just compensate the CO_2 emissions associated with the use stage.

At present, the refurbishment of buildings is not a common practice in Spain. Therefore some building owners have a short-term perspective. In order to tackle this issue, within the "The Plaga de Palma Project", some dissemination activities are planned.

Information sources

Interviews have been carried out with Fabian López, Albert Sagrera and Gerardo Wadel (Societat Orgànica): flopez@societatorganica.com; +34934307653

4.2.2 Comparative study of the structure of two apartment buildings – Vitoria-Gasteiz, Spain

Description of building

This project is a follow up of the construction of 2 apartment buildings (for social housing) built in 2008-9 on Zabalgana in the City of Vitoria-Gasteiz, Spain. The buildings are as follows:

- Building 1 is a multifamily apartment building for social housing (conventional construction), comprising a total of 126 apartments, with 2 basement floors (both parking garage), a ground floor (used for retail) and between 6 and 7 residential floors above the ground floor.
- Building 2 is likewise a multifamily apartment building for social housing with 156 apartments (prefabricated construction), 2 basement floors (parking garages), ground floor (retail), 8 residential floors above the ground floor and an attic floor.

The client for both buildings was VISESA - Housing and Land Public Company of Euskadi SA *(Sociedad pública Vivienda y Suelo de Euskadi S.A.)*

Description of assessment tool used

Life cycle assessment (LCA) methodology was used for impact assessment. The database used in the study was Ecoinvent (system process). The software was SimaPro 7.1.8 (Pré Consultants, 2011). The impact assessment methods selected were CML 2001 (baseline, as shown in Table 1, and part of the Sima Pro package) and Cumulative Energy Demand.

Table 1: Indicators used in CML impact assessment method.

Abiotic depletion
Acidification
Eutrophication
Global warming (GWP100)
Ozone layer depletion
Human toxicity
Fresh water aquatic ecotoxicity
Marine aquatic ecotoxicity
Terrestrial ecotoxicity
Photochemical oxidation

Three other indicators were also assessed: water consumption, electricity consumption and waste generation. They were calculated from real data from the construction.

Why was the tool used?

The architecture firm involved in the 2 projects (Pich-Aguilera) is very interested in innovation and is therefore motivated to analyze the strengths and weaknesses of the more usual prefabricated construction solutions. The outcome from the follow up is intended to increase knowledge and contribute to a continuous improvement policy. In particular, Pich-Aguilera are interested in taking into consideration environmental performance when assessing the feasibility of a building. This environmental goal is also expressed by iMat, a non-profit R and D organization funded by the *construction material* industry. Both Pich-Aguilera and iMat are interested in promoting decision-making from a global approach taking into account both economic and environmental aspects.

The building owners, the Housing and Land Public Company (VISESA) were interested in analyzing the design and construction processes as well as analyzing environmental impacts, in order to optimize costs, but maintaining product quality. They are also interested in promoting R&D, industrialization and innovation in the building sector in order to overcome some conservative attitudes of this sector.

Manufacturers of the prefabricated elements were less interested in the project and for example did not even contribute with data on their production processes.

Sima Pro and CML 2000 were used based on the confidence the practitioners have that together they represent an objective and quantitative method for environmental impact assessment.

What were the targeted indicators?

The aim of this follow-up project was to evaluate and compare the environmental impacts associated with the structure and the external walls of two buildings of similar size, volume, age, function and location, but where one is built using prefabricated elements and the other built with conventional construction methods. The goal is to identify key factors and, therefore, to know the key points in order to decrease the environmental impacts. The scope of the impact assessment was established such that only the construction of the building was analyzed, and not the use phase of the building.

All indicators in CML 2000 were used, as well as water consumption, electricity consumption and waste generation.

The use of the tool/life cycle approaches in the process

The tool was applied post-construction for follow-up and improvement purposes. The relevance of the tools involvement in the actual process is only the fact that input data for the LCA was taken from measured data from the actual construction processes.

Having said that, data collection was carried out by the architectural firm, Pich-Aguilera, an activity that entailed additional effort for them.

How the use of the tool influenced the final design

It is essential to note that the impact assessment was applied by iMat as a post-construction evaluation tool and that possible actual benefits from this follow-up may come from dissemination of the information gained in this project to decision makers in future projects

Important aspects that were identified as a result of the LCA were the distance from the material supplier to the building site, dimensioning of materials as well the use of cranes and construction machinery on site.

In this case, LCA has been an adequate tool in order to assess the impact of prefabricated elements vs the impact conventional construction. Since the Architecture Studio (Pich-Aguilera) is very interested in the use of prefabricated elements, the results of this study will assist them to decide which option (prefabricated/conventional) is the environmentally best option in given circumstances.

Information sources

Interviews have been carried out with Glòria Díez (iMat – Centre Tecnològic de la Construcciò - Unidad de Medio Ambiente): gdiez@imat.cat; +34935539795

4.3 French Case Studies

4.3.1 New design of training Centre and logistics building

Description of building

The focus of this study was a building intended to be used for education and logistics with a total area of 3938 m^2 and an assumed life-span of 30 years. It was built and will be used by the professional association FCMB, Formation Compagnonnique des Métiers du Bâtiment.

Assessment tool used

The French assessment tool HQE (Haute Qualité Environnmentale, High Environmental Quality) was applied. The method is owned by the Association HQE, which can be considered to be the de facto French Green Building Council. The tool can be applied for residential and non-residential buildings, and identifies a total of 14 environmental aspects, as shown in Table 2 (Lowe & Ponce, 2008). These aspects relate to the external environment and to the internal building environment. As far as external environmental aspects are concerned, the tool covers both aspects to do with the site and building materials (aspects 1 to 3), as well as the environmental aspects due to building function (aspects 4 to 7).

For each aspect, the tool assigns one of three levels of performance: “basic” (conforming to current regulations), “good” or “very good”. The minimum level required to be certified according to HQE is that at least 3 aspects must be rated “very good”, and at least 4 must be rated “good”.

Table 2: Aspects that are applied in French HQE rating tool (Lowe & Ponce, 2008).

Exterior environment	Interior environment
Site and eco-construction 1. Relation between building and immediate surroundings 2. Integrated choice of construction products 3. Low-impact construction site	Comfort 8. Hygrothermal comfort 9. Noise and acoustics 10. Lighting 11. Odours
Eco-management 4. Energy management 5. Water management 6. Activity waste management 7. Maintenance – environmental performance conservation	Health 12. Health conditions of spaces 13. Indoor air quality 14. Sanitary quality of water

Why was this tool used?

The primary motivation for environmental certification came from the building owner. One motivation for certification for the owner was the opportunity to craft a green image in the eyes of the public. That this particular certification tool was chosen was due to the fact that this was the only French tool available, and because at the time there was little information about how international tools (such as LEED or BREEAM) could be practically applied according to French regulations and conditions.

Targeted indicators

In order to achieve the desired rating, the project was carried out with the aim of achieving “very good” ratings for energy management (aspect 4), indoor air quality (aspect 13) and odours (aspect 11), site integration (aspect 1) and maintenance (aspect 7).

“Good” rating was targeted for hygrothermal comfort (aspect 8) and lighting (aspect 10), low impact construction site (aspect 3), and activity waste management (aspect 6).

“Basic” rating was targeted for water management (aspect 5) and quality (aspect 14), noise and acoustics (aspect 9), sanitary performance of spaces (aspect 12), and choice of products (aspect 2).

The use of the tool/life cycle approaches in the process

The development of an environmental profile for the building occurred during the programming phase of the project, in discussion between the building owner and an HQE-consultant. The established environmental functions were then expressed in later project documents, such as calls for tenders, schematic design, design development and construction documents.

How did application of the tool affect the final design

As part of the choice of construction products (aspect 2) HQE sets a requirement that 50 % of the materials used have an environmental product declaration (EPD). Having said that, it was considered that this requirement did not directly affect the final design, based on the fact that no specific performance mandate was set according to this requirement, simply that an EPD *exist*, irrespective of the *actual* environmental performance of the substance.

Sources of information

Inteview was carried out with NOBATEK, a consultant in low energy and green buildings.

4.3.2 Public Laundry, Paris suburb

Description of building, construction, etc

The focus of the study is the office and administrative building connected to a public laundry plant in a major suburb of Paris, with an area of 1000 m^2. The project that is described here is the process of putting together a successful tender in an open tender process for a design and construction project. The client in the project was a major city in the Paris suburbs, and the authoring of the tender was carried out by VINCI Construction France, a major contractor with significant experience in low energy and green buildings.

Environmental target for the project

The design team put together the tender with the aim that the building reach the target for a Bâtiment de basse consommation énergétique (BBC), low-energy building, defined at 50 kWh/m^2, year for conventional primary energy (heating, cooling, ventilation, auxiliaries, production of domestic hot water and lighting facilities) (Concept Bio, 2011).

This target was set by the authors of the tender in an attempt to differentiate themselves from competitors. The evaluation and assessment tool that was used in the process was used partly to demonstrate to the potential clients the environmental friendliness of the solution.

The authors of the tender knew that the clients had a general interest in environmental issues and when the client found out that VINCI had applied LCA methodology in the process of putting the tender together, became very interested, and requested that some scenarios with alternative materials be studied.

Description of the assessment tool used in the process

In this process the French tool EQUER was used. It is a life cycle simulation tool based on a building model and is compatible with the thermal simulation tool COMFIE. The tool covers indicators as shown in Table 3 and takes into account all phases in the life-cycle of the building including construction, operation and maintenance (heating, cooling, other electricity use, domestic waste, waste production, daily transport), and end-of-life (Ecole des Mines, 2011).

Table 3: Indicators used in EQUER tool

Depletion of abiotic materials	-
Primary energy consumption	MJ
Water consumption	m^3
Acidification	kg SO_2 eq
Eutrophication	kg $PO_4{}^3$ eq.
Global warming potential (GWP 100)	kg CO_2 eq.
Non-radioactive waste	kg
Radioactive waste	dm^3
Odours	m^3 of polluted air
Aquatic ecotoxicity	m^3 of polluted water
Human toxicity	kg
Photochemical ozone (smog)	kg C_2H_4 eq.

Why was the tool used?

The tool was used precisely because it was considered to be the only integrated LCA tool where environmental impacts from a change of material can be directly evaluated on a life-cycle basis, which is not possible with tools such as ELODIE. Furthermore, EQUER is directly linked to a thermal simulation tool, which was considered very important in the case of the laundry that was studied.

Targeted indicators

Most important in this project was to show reduced GWP for all phases (construction through operation and maintenance phase and end-of-life) and reduced energy demand during the operation and maintenance phase of the building.

The use of the tool/life cycle approaches in the process

The tool was used to evaluate several possible solutions and associated impacts over the life-cycle of the building.

Tool use and the influence of final design

The tool was applied at a very early stage in creating the tender for this project, in collaboration with architects, commercial and technical teams. This had the result that the environmental costs and benefits could be studied easily and that the application of the tool had great effect on the final design. An example of this is where the effect of solar shading elements was modelled using EQUER, showing a reduction of CO_2 emissions over the life-cycle of the building by 33 % as well as that other environmental aspects were not affected. This led to the decision to choose a construction without air conditioning that may otherwise have been chosen. Another example is where the tool was used to select the best window alternative on the basis of the optimal environmental impacts to cost ratio.

Sources of information

Aside from the references mentioned above, this information has been taken from an interview with Maxime Trocmé, VINCI Construction France, a major contractor involved in the design, construction and management of low-energy and green buildings.

4.4 Norwegian Case Studies

4.4.1 Background

Five cases of Norwegian building projects where environmental assessment tools have been used or considered are presented. Case information has been collected by in-depth interviews of key personnel involved in five building projects. The projects have been conducted during the last three years. The interviewees are familiar with the process of using life cycle approaches in the design and construction phase. Five of the presented projects are completed and one is under construction (to be completed in 2012). Three office buildings, one self-build housing project and a centre of competence are amongst the selected cases. The cases represent different regions of Norway.

In a working group report from the Ministry of Local Government and Regional Development (BE, 2010) it is stated that increased energy efficiency of the built environment is important and necessary in order to:

- Obtain a reduction of carbon dioxide emissions
- Increase the reliability of energy supply
- Contribute to meet obligations towards the international society, and implement the Building energy and Renewable directives.
- In addition, a majority of these measures will be both socio-economic and private-economic profitable.

Pubic visions, aims, and energy efficiency measures play an increasing role in the Norwegian building and real estate industry. Environmental rating tools are important to fulfil these targets. Planning and building legislative requirements are intensified, thus imposing builders to meet expectations. Governmental incentives play a vital role in the process of implementing environmental measures for many developers. Currently there is a wide array of methods and tools available to utilize in Norwegian building projects. These methods and tools enable developers to keep up with increasing environmental requirements from authorities and users, contribute to raise awareness, and increase competence among builders. Regardless of approach, all LCA methods and tools contribute to the effort of reaching a sustainable building mass in Norway.

To better understand the tools and methods used in Norway, a brief description of each method is presented.

4.4.2 Main assessment tools used in Norway´s building and construction sectors

BREEAM

BREEAM (BREEAM, 2011) is the world´s foremost environmental assessment method with 200,000 buildings certified and over a million registered for assessment since it was first launched in 1990. The method was first introduced in Great Britain, and aims at setting the standard for best practice in sustainable building design, construction and operation. It has become one of the most comprehensive and widely recognized measures of a building´s environmental performance. The BREEAM method uses recognised measures of performance set against established benchmarks. These are representative of a broad range of categories and criteria from energy to ecology. A Certified BREEAM assessment is delivered by a licensed organisation at various stages in the building's life cycle. The method uses a straightforward scoring system that is transparent, flexible, easy to understand, and supported by evidence-based science and research. The categories that are assessed include: energy, water use, indoor climate, pollution, transport, materials, waste, ecology, and management process. BREEAM is selected to be the official Norwegian life cycle assessment method and is currently undergoing translation and adaptation to Norwegian conditions.

FutureBuilt

FutureBuilt, a national Norwegian project based program, initiated by The National Association of Norwegian Architects (NAL) in the year of 2000, has a vision of creating climate neutral urban areas, and promotes high quality architecture. The project is ongoing and aims at realizing between 25 and 35 projects in coming years. The goal is that these projects will use 50% less energy in comparison with equivalent projects, including transport and green house gas emissions. The projects are meant to serve as ideal examples to follow. Four areas are prioritized. Preparing integral greenhouse gas emissions calculations as part of the planning-, design-, and construction process; developing quality programming, with clear environmental goals for each pilot project; focusing on integrated and interdisciplinary work early on in the design process; obtaining environmental documentation for the most important building materials. The program is an alliance between NAL, municipalities, Green Building Alliance, and Norwegian state owned public service organizations (NAL, 2011).

ECOproduct

ECOproduct (ECOproduct, 2011), Environmental Product Declarations (EPD) is a brief document whose objective is to sum up the environmental profile of a component, a finished product or a service in an objective standardized manner. The acronym EPD is an internationally recognized abbreviation used in both national as well as international contexts.

LEED

Leadership in Energy and Environmental Design (LEED), is an internationally-recognized green building certification system developed by the U.S. Green Building Council (USGBC) in March 2000 (LEED, 2011).

In promoting sustainable building and development practices LEED provides building owners and operators with a framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions. The rating system is flexible enough to apply to all types of buildings and is developed through an open, consensus-based process led by committees and groups of volunteers representing a cross-section of the building and construction industry.

Nordic Ecolabel

"Svanen" is the official Nordic Ecolabel for the Nordic countries and a flagship product for Nordic collaboration. It was established in 1989 by the Nordic Council of Ministers. Its purpose is to provide a labelling scheme that promotes sustainable consumption. The Nordic Ecolabel is an established and internationally recognised brand. A recent Nordic market survey showed that in the Nordic countries 94% of respondents recognized the trademark as an Ecolabel (Svanen, 2011).

The Nordic Ecolabel has a life-cycle perspective. Important environmental issues that are considered in the development of the Nordic criteria are: energy usage, climate aspects, water usage, source of raw materials, use of chemicals, hazardous effluents, packaging, and waste.

NAL/Ecobox

NAL/Ecobox is a self-funded department under NAL that promotes environmental knowledge and interdisciplinary cooperation among architects, planners and others stakeholders in the Norwegian building sector (NAL, 2011).

Norwegian Wood

Norwegian Wood is a collaborative effort to turn the Stavanger region into a showcase for environmentally friendly architecture, in connection with the city of Stavanger being the European Capital of Culture in 2008. The project was led by NAL. Guidelines set for the program aimed at developing building projects that display high architectural quality, low energy use, universal design, and a use of materials with low environmental impact. As the name indicates it also was an effort in promoting a new rational use of wood in building projects (NAL, 2011).

Energy Performance Certificates

As part of the EU directive for energy consumption in buildings, an energy labeling scheme for Norway was passed in December of 2009. From July 1st, 2010, all buildings that are leased, sold or built are required to have Energy Performance labeling or Energy Performance Certificates. From January 1st in 2012 energy assessment will be a requirement for technical installations as well.The energy labelling scheme is organized and managed by Norwegian Water Resources and Energy Directorate (NVE, 2011).

Implementation of energy labelling for buildings have following goals:

- Reduction of carbon dioxide emissions from energy use in buildings
- Increase interest for implementing energy saving measures
- Ensure basic information about the buildings energy status
- More knowledge and awareness regarding energy use in buildings

ENOVA

ENOVA, is a Norwegian government-owned public service corporation, established in 2001, promoting environmentally friendly production and consumption of energy. Their strategic goal is achieving passive house standard by 2020 for all new construction and comprehensive rehabilitation in Norway. By offering incentives to building programs and rehabilitation projects their aim is to increase energy efficiency and to bring a change to the building industry.

Municipalities manage in excess of 25 million square meters of building mass in Norway and play a major role in energy conversion and efficiency. Enova encourages municipalities to reach far and beyond the current building regulation requirements and invest in ambitious energy efficiency measures to show the way for the private construction sector (ENOVA, 2011).

4.4.3 Design of new office building, Oslo

Building description

The new five story office building was completed in the first quarter of 2011. It has a compact and simple form. The main construction is a steel framework with prefabricated concrete floors. Facades combine the use of glass panels and exterior plaster cladding. The project is conducted as a turnkey project.

Assessment tool used in the process

The FutureBuilt method (see subheading above) used in the project aims at a reducing the total energy consumption by 50% in comparison with an equivalent new-build project. Environmental Product Declarations (EPD) were used for comparing and selecting environmentally sound materials. The aim of reaching an Energy Efficiency Rating of 84 kWh/m^2 per year was surpassed. Governmental incentives were utilized and universal design was implemented.

The life cycle approach, in this case, addresses some of the challenges facing the construction industry at present, namely energy source, energy use and environmentally hazardous materials.

Why was the tool used?

All stakeholders involved in the project were highly motivated and experienced. The Project Manager played a central and important role in reaching desired goals. Demands from the main tenant were the initial driving force. Their aim was to obtain an office building designed with a life cycle approach using documented solutions. The contractor took on the challenge of implementing a verifiable environmental project. Governmental incentives, as subsidy schemes, were vital for setting high aims for the project.

Use of tool in the process and influence on final design

Various aspects were taken into account *en route* and played a role in the final outcome. Alterations of the original program gradually elevated the project into being an ideal example for other building projects. In this way this project turned into a pilot projects for FutureBuild projects to come. One important aspect was to keep air leakages in exterior walls to a minimum, to achieve a high energy efficiency rating. Life-cycle thinking was not introduced early enough to influence the choice of the main construction.

The life-cycle method used both reasoning and calculations. The system and tools were administered, implemented and operated by an external special advisor on environment and energy issues. Facade materials, suggested by the Architect early on in the process, were evaluated through an iterative process taking green house gas emission and content of hazardous substances into account. In addition the materials had to meet fire and maintenance requirements. All additional materials were compared and selected using EPDs. A final calculation was conducted using emissions data from the materials actually used.

Costs were evaluated continuously and the turnkey contractor made final decisions in approving or discarding materials and solutions proposed. A shortage of suppliers offering environmentally-sound solutions, were in some situations the reason for having to chose alternatives that were less environmental friendly. The developer suggests a 10% increase in costs due to an initial time-consuming process, in which systems and materials had to be evaluated. The introduced interdisciplinary design process was new to the design team.

No specific scenario was selected for the project. Single elements were assessed separately throughout the process. All materials had to be recyclable. A 60-year life expectancy on materials and energy resources was included in the tools. Other important factors, such as location of the materials, construction issues and performance criteria were taken into account. This requires experience, common knowledge and frequent visits to the construction site.

Conclusion

In this building project there has been high ambitions and focus on energy efficiency and low emissions. Driving forces have been an aware tenant and governmental incentives in form of subsidy schemes. All consultants involved in the building process have been highly skilled and ambitious. The Project Manager and the LCA method consultant contributed to a successful result.

4.4.4 New design of office building using BREEAM, Oslo

Building description

The new office building with a gross net area of 13 000 m^2 includes five stories and a basement. It will be completed in the spring of 2012. The building has a simple and compact form using steel framework and prefabricated concrete floors. Two separate contractors share responsibility in the project.

Assessment tool used in the process

Passive house principles were made possible through governmental incentives. The project is a pilot using BREEAM. The contractor raised ambitions of sorting waste from the building site from required 60% to 80%.

Use of tool in the process

The project is conducted as two separate turnkey contracts, with separate agendas and responsibilities, sharing a common goal of achieving a sustainable building. The tenant and part owner, responsible for technical solutions, introduced requirements for high energy efficiency in an ongoing design phase, which enabled them to obtain a building that reflected their values on environmental issues. The contractor, a member of the Green Building Alliance[1], took on the task of implementing a pilot, using BREEAM. This contractor will use the project as a marketing tool strengthening their market competitiveness. In order to maintain a good working environment and interdisciplinary cooperation, both turnkey contractors contributed to the design process through joint design group meetings.

One important issue was keeping air leakages in exterior walls to a minimum. The process of assessing alternatives for exterior wall construction lead to a final choice of insulated beaches (Iso3) that would simplify exterior wall construction and facades using less resources. Due to an early policy, perforations for technical installations in exterior walls were kept to a minimum.

Materials were originally assessed on u-values in order to achieve a passive house standard. The newly introduced LCA method (BREEAM) will evaluate materials continuously based on given criteria. Due to the late introduction of BREEAM none of the main construction materials have been assessed using a life cycle approach.

In the process of reducing air leakages the contractors have played an important role in proposing, evaluating and improving solutions throughout the process. All stakeholders are knowledgeable, motivated and contribute to achieving a sustainable building.

The project is still in the early stages of the building process and the materials are yet to be assessed and selected.

Conclusion

[1] Green Building Alliance is an environmental network providing a venue for active Norwegian developers with ambitions of being in the forefront on environmental issues. GBA provides expertise and information to its members in the construction and real estate industry.

In this building project the prime focus has been energy efficiency. The assessment method was introduced late in the design process, after concept and main structures had been decided on. Driving forces were corporate image and market competitiveness for both of the contractors involved. Governmental incentives were one of the driving forces. One contractor had in-house competence on energy calculations, and was the main initiator. The other had assigned advisors to cover this discipline. The Architect has made a big contribution in affecting and simplifying facades in order to obtain the requisite air tightness.

4.4.5 New design of centre of competence, Bergen

Building description

The five storey centre of competence in Bergen was completed in 2010. The main structure consists of prefabricated concrete elements and brick veneer. The project was implemented as an ordinary turnkey.

Assessment tool used in the process

No single specific life-cycle method was used. A mix of various assessment tools based on reasoning were chosen, all of which are recognised in Norway. All stakeholders were urged from the start to focus on environmental issues. During design, leading environmental certification methods inspired the accomplishment of the project. BREEAM was used to assess the main construction, Nordic Ecolabel was used in assessing materials, Energy Performance Certificates was implemented, and the national standard for clean and dry building was utilized. Universal design was obligatory. Project budgets did not take into account governmental incentives or other financial support.

Targeted indicators/use of tool in the process

There was a joint agreement amongst stakeholders to achieve an energy efficiency rating of less than 100 kWh/m^2 per year. Theoretical simulations and calculations were carried out, and an operational period was contractually included to insure that the goal was realized. Zoning and parameters for good indoor climate was assumed. Specific requirements for air tightness were demanded. Life cycle assessment used in selecting materials was carried out through discarding chemicals and materials harmful to the environment. Tropical woods were banned and there were specific requirements for sealants, plasticizers and paints. There was complete control of waste separation and contaminated ground. District heating was used as an alternative energy source to cover peak loads. Concrete flooring was preferred instead of massive wood elements due to lack of time and a poor and unconvincing presentation from the supplier. The building materials and processes are well documented in this case.

The initial idea of using scaffolding with tarpaulin during construction to achieve a clean and dry building was abandoned due to costs. The project was completed within the economic framework and did not apply for governmental incentives.

Personal commitment by the developers´ Project Manager was crucial to complete a successful project. As a member of the Green Building Alliance, the turnkey contractor had a focus on environmental issues, and had the opportunity to show their competence and commitment in this project. It is difficult to give all credit to one single participant for leading the environmental efforts. It has to be accredited to a majority of the stakeholders being a unifying and constructive joint effort.

The life-cycle approach was used by all stakeholders and contributed to an integrated, interdisciplinary process, supervised by engaged environmental advisors. In this manner the project differed significantly from today’s norms. It was a time-consuming process with initial weekly meetings, including designers, craftsmen, and technical suppliers. Later the design team split into two groups handling technical and building aspects separately. The project manager and project leader actively participated in all meetings, discussing matters and solutions which lead to a steady and smooth process. The time consuming and hard effort in obtaining hydraulic mortar failed due to a negative approach of the supplier.

New and improved solutions were achieved throughout the project almost without additional expense. Different stakeholders contributed to fine tuning of control systems optimizing energy use. Consultants were brought in from abroad to give their expertise on alternative ventilation measures. Colt facades were used (Colt, 2011). The mortar used in the brick veneer caused it to be non recyclable, despite the efforts of obtaining hydraulic mortar.

Assessment was carried out on single building elements, and not as a whole. Many of the choices were based on experience. Robustness, plain detailing and maintenance were important issues.

Conclusion

The focus in this project has been wide, due to the use of several different environmental evaluation tools, involving all the stakeholders. The organizational hierarchic structure has been flat regarding environmental responsibilities, approaches and mentality. The assessment tools were implemented by the engaged specialists initially, already early in the interdisciplinary design phase. The personal commitment by the developers´ Project Manager was the main driving force, and played a major role both in initializing and implementing the use of tools for environmental evaluation. Even though governmental incentives were not part of the funding, the result of this project demonstrates that it is possible to obtain an environmentally friendly building project within owners´ financial frames. Despite early efforts to choose environmentally friendly materials, the outcome of the selection process seems to be somewhat arbitrary. Less environmentally-sound materials were selected on the expense of the early selected more environmentally sound materials. This was due to chance.

4.4.6 New design of self-build houses, Stavanger

Building description

The self-build low-energy project in Stavanger includes 73 building units. Construction began in 2004 and was completed in 2008. The use of wood dominates the main framework. Construction of walls on the first floor is poured *in situ* concrete. The building units are in part built by a contractor and the buyer of the unit.

Why was the tool used?

The projects aim was reducing the energy use by 35 – 45% from regulation requirements. The design illustrated a well insulated envelope with defined u-values, super insulating windows and minimizing of cold bridging. Lower floor living units met the requirements for life cycle standards. Requirements, as such, were implemented early in the process and enabled the project to qualify for loans from the Norwegian State Housing Bank.

Stavanger Municipality wished to participate in efforts reducing energy consumption in buildings. Earmarked funds for three pilot projects in the area were utilized to meet the increasing demands for energy efficient housing from residents. Special consultants were hired to contribute to the process.

Assessment tool used in the process

The life cycle approach was an integrated part in the energy efficiency program. There was focus on using less harmful components in materials such as paints and glues. Everyone involved in the project used the method and guidelines for Norwegian Wood. Ecoproduct, a database using classified materials, was used for choosing materials. It was newly introduced, incomplete, and further developed through the progress of the project. New materials were used, that were not yet documented were classified. Assessment of materials did not have an impact on the choice of main construction materials. Wood was already being used as the most environmental choice. All requirements were set early on in the design process and did not alter the final result.

Use of tool in the process and influence on final design

The design process deviated from a normal process in regards to the high requirements for air tightness in the exterior wall construction. A high energy-efficiency approach was new for everyone involved. Although there was no management tool for such an approach at the time requirements were implemented early in the design process. Unlike previous low energy projects these row houses featured terraces and were more complex in form. Once finished the houses were pressure tested twice.

Personal commitment from the municipalities´ Project Manager had the greatest impact on the design and outcome of the project. The carpenter was crucial in developing solutions that contributed to minimizing air leakage in exterior walls. Focus was on keeping the vapor barriers intact during construction and avoiding perforation in case of future changes and repairs. The solutions were improved continuously. Early involvement of carpenters did not alter the overall design.

A kickoff involving all stakeholders created a sense of pride and ownership. The project accounted for a raised the level of knowledge and was a great learning experience for all involved.

A life expectancy of 15 years on exterior materials was used. Recycling of materials was not assessed. There were no “smart” solutions implemented controlling light or faucets. The floor heating featured nighttime temperature reduction. All the buildings were designed simply and with first-time establishing families in mind. There was a focus on promoting information to the owners of units to ensure efficient operations after take over.

4.4.7 New design of lower secondary school, Drammen

Building description

The school is owned and operated by Drammen municipality, and is a medium size lower secondary school. The project was completed during the summer of 2010 and taken into use in September of 2010. The three storey building has a compact and simple form. The building consists of a steel frame work with concrete floors and supplementary walls.

Assessment tool used in the process/Why was the tool used?

The project was initially carried out as a competition. The task was to design a school building on a plot close to the city core. After a winner had been selected, the real estate department in the municipality, introduced the project as a pilot using FutureBuilt. Passive house principles were implemented and special advisors were brought in to help guide the project. The International standards for passive houses principles were not yet translated. This had to be done alongside the development of the building design. Main focus was on energy consumption during the operational phase. Governmental incentives were utilized.

Use of tool in the process

Building physicist and HVAC consultant used calculation programs and generated measures preconditioning the design of exterior walls and roof. Focus was on energy relating issues and an hour was set aside to discuss matters related to the topic design meetings held every second week. Early in the process the building physicist worked closely with special consultants, contractors and the design team in an integrated process. Details were developed as collaboration between the design team, contractor and Building physicist. Materials were not selected using a life cycle approach. Instead representatives for operation and management with experience from schools helped select materials that were robust and had little need for maintenance. The process contributed to a change of initially proposed facade materials. No changes were made in the layout.

Representatives for operation and management had great influence on the selection of materials, which were assessed with focus on low maintenance. All stakeholders were highly-motivated and the project felt like a research project, due to the involvement of special consultants.

The main focus on low energy use put a limit to the number of hinged windows and the ability to override automatic blinds steered by the suns´ movement.

Conclusion

In this building project the main focus was on energy efficiency and low maintenance. Life cycle issues were not a discussed topic. Driving forces were environmental effort from the municipality and an ambitious design team contributed to a energy efficient, low maintenance building.

4.4.8 Conclusions from Norwegian case studies

General reflections of the cases studied

The study has shown that there are still few cases available in which life-cycle thinking and associated tools have been used. It has also shown that there are few projects fully implementing a life-cycle program/method.

It seems to be increasingly more common that environmental approaches are on the agenda in the design and the accomplishment of the building process. Yet it seems that economy and mere coincidences are still the most important drivers in terms of both choosing materials and life-cycle methods.

Project that have been successful depend heavily on a specific driving force. One of the most important role is the Project Manager.

Strengths and weaknesses of tools with life-cycle methods

Strengths: Complementary tools takes in account many similar and coinciding aspects.

The many tools with life-cycle methods flourishing the market permit the increase the usage of methods promoting an environmental approach. Different methods and tools appeal to different clients, investors and buyers of buildings. In case of monopolization, dynamics and further development could be hindered.

Weaknesses:

Too comprehensive, not complete, confusing due to multiple systems tools.

No single assessment tool can be used to the full, evaluating materials, management and maintenance at the same time without an experienced user. Location of materials, construction in the building, and performance requirements have to be taken into account when using the tools with life-cycle methods. Long experience and common sense is a part of the process. An assessment cannot be performed merely in the office using standard life-cycle assessment procedures, but is best done in combination with on-site inspections.

Drivers:

Many contractors/owners claim that the use of tools with life-cycle methods is an additional expense in already tight budgets, due to time-consuming operations and assumed more expensive and complex solutions. This indicates that the building industry is rigid, clinging to traditional methods and solutions.

Governmental incentives have proven to be important drivers, especially in initializing high ambition environmental building projects. Nevertheless, one of the case projects indicate that this is not necessarily a requisite feature in order to obtain environmentally friendly building projects.

4.5 Hungarian case studies

4.5.1 LCA used for refurbishment of an existing nursery school - Szendtendre, Hungary

Description of building, construction, etc.

The building is situated in Szentendre in the housing estate of Püspökmajor. The owner of the building is the local government.

The plot the building is placed on has a slope. It is a corner plot on which the free standing building functioning as a nursery school and a crèche was built in the early 1970's. Due to the slope, the floors of the one-storey building are on different levels and so it looks like a terrace house. One part of the building is the nursery school and the other part is the crèche. The two different functional units show their back to each other. The plot has the entire infrastructure, like electricity, water and gas. The building complex has a flat roof with internal roof outlets.

In 2010 there was a retrofitting of the cladding, the roof and some internal parts for the crèche. For the nursery school, which is the subject of the current design task, the old metal windows have already been replaced as well during this retrofitting by new windows with thermal insulated double glazing. In addition, part of the cladding above the windows has also been retrofitted using FINNFOREST boards similar to the crèche. There were some changes inside the building as well, a new WC was built for disabled people and the internal floor finishes have been replaced.

The external environment of the nursery and the crèche is in a good condition, there are plants around, and the plot is surrounded by a fence.

In a second step, the local government intends to continue the retrofitting of the nursery building using ecological, environmentally friendly products and materials. The planned retrofitting involves three main building parts as follows: the uninsulated external walls below the windows, the flat roof (partly green roof), and an area enclosed by a glazed curtain wall in front of the entrance and covered by polycarbonate sheets.

Detailed description of the external wall

Under the window strips additional thermal insulation material needs to be placed on the external walls. The U-value requirement for the external wall was 0,30 W/m^{2}K. Considering the existing wall structure, which is a 38 cm thick solid brick wall with an external and internal plaster layer, this can be achieved by a 11 cm thick insulation layer with a thermal conductivity of 0,04 W/mK, or equivalent. The thermal insulation of the plinth wall must be a thermal insulation material with closed cells with low water absorption. The top of the plinth wall insulation is 30 cm above the ground level, and the bottom is 70 cm below the ground level. The thickness of the plinth wall insulation is the same as the wall insulation below the windows. Thermal insulation must be put on the window sills as well with a thickness of 10 cm to avoid thermal bridges. The thermal insulation must turn at side jambs with a minimum thickness of 5 cm. The total surface area of the external walls to be insulated is 201 m^2.

Detailed description of the flat roof

The existing layers of the flat roof remain. On the top of the existing layers additional thermal insulation must be laid. Before placing the new layers, the existing waterproofing membrane needs to be perforated. The U-value requirement for the flat roof is 0,15 W/m^2K. The new waterproofing membrane must cover the parapet wall around the flat roof and the top of the parapet wall needs to be covered by metal sheets minimum 20 cm above the flat roof level. A new roof outlet is needed above the gym and all the existing outlets need to be checked. The total surface area of the flat roof to be retrofitted is 480 m^2.

Description of the assessment tool used in the process

The Ecoinvent database was used in the calculation adapted to Hungarian conditions. Calculations were carried out for different constructions of the external envelope with a surface area of 1 m^2 as the functional unit. The calculation was performed without normalisation and weighting, taking into consideration a life-span of 60 years. The heating system of the building is district heating, which remains the same during the refurbishment.

Why was the tool used?

One of the most important aspects of the design was to achieve ecological and environmentally friendly building constructions; that was the reason why an LCA assessment was carried out. The different options for insulation materials and building constructions were analysed and compared using the LCA assessment to help decision making.

Targeted indicators

The following indicators were used in the assessment: cumulative energy demand, global warming potential, ozone depletion potential, acidification potential, photochemical oxidant formation and eutrophication potential.
Cost per square metre of the different constructions was also analysed.

The use of the tool/life cycle approaches in the process

The U-value requirements for the external wall and flat roof are given as 0,30 W/m^2K and 0,15 W/m^2K respectively.

For the external wall the following three options were taken into consideration to achieve the U-value requirements:

Option 1

- existing brick wall
- adhesive
- polystyrene thermal insulation
- thin render system

Option 2

- existing brick wall
- adhesive
- mineral wool thermal insulation
- thin render system

Option 3

- existing brick wall
- timber frame
- cellulose thermal insulation blown in
- cement bonded particle board as an external skin
- thin render system

For the flat roof the following three options were considered:

Option 1

- existing roof structure
- EPS boards thermal insulation
- PVC waterproofing membrane
- gravel ballast layer and protection

Option 2 (inverted roof)

- existing roof structure
- 2 layers bituminous waterproofing membrane
- XPS boards thermal insulation
- extensive green roof

Option 3

- existing roof structure
- glassfoam thermal insulation
- 2 layers bituminous waterproofing membrane
- gravel ballast layer and protection

It was assumed that the different building structures have the same U-values for walls and roofs separately and there was no difference in the energy loss through these building elements when the various options were applied.

The LCA assessment was made on the different options described above and the environmental effects were compared and analysed.

Tool use and the influence of final design

The project is still at design stage and final options have not been chosen yet. The LCA study will probably have an influence on final design as there is a chance that Option 1 for both the wall and roof will be selected, which has the lowest environmental impact.

4.5.2 New design of family house – Szombathely, Hungary

Description of building, construction, etc.

The new family house, which is for a four-member family, is situated in the garden suburb area of Szombathely.

The corner plot on which the new family house is designed is flat. The direction of the longitudinal axis of the plot is SW-NE. The family house has a ground floor and a built-in attic and there is no basement planned.

The layout of the building is organised on two axes which are perpendicular to each other. The entrance can be found on the north side behind the garage. The kitchen, the dining room, and the pantry can be reached from the corridor and the den, the guest bedroom with a bathroom and the toilet can be found in the other direction. The living room is opposite the entrance. There is a patio connected to the living room and dining room. The stairs to the built-in attic can be accessed from the corridor. The built-in attic consists of further bedrooms and bathrooms which can be reached from a longitudinal corridor. There is a hobby room above the garage.

Description of the assessment tool used in the process

The Ecoinvent database was used in the calculation adapted to Hungarian conditions. Calculations were carried out for different external envelopes and heating systems. The calculation was performed without normalisation and weighting, taking into consideration a life-span of 80 years. The functional unit considered was the whole building.

Why was the tool used?

The owner, a married economist couple with two children, has an ecological and environmentally friendly lifestyle. An important design criterion was from the owner side that the building should have a minimum environmental impact during the construction and use over its lifetime. That was the reason why a life cycle assessment was carried out so that different options and technical solutions could be compared and the optimal version could be chosen.

Targeted indicators

The following indicators were used in the assessment: cumulative energy demand, global warming potential and acidification potential.

The use of the tool/life cycle approaches in the process

At the beginning of the design it was determined that three options would be compared from the point of view of energy consumption.

Option 1

To meet the current building regulations laid down in 7/2006 TNM Ministerial Decree. It requires a minimum U-value of 0,45 W/m^2K and 0,25 W/m^2K for external walls and roofs respectively.

Option 2

Passive house category.

Option 3

Nearly zero energy building.

The different options can be achieved using different thermal insulation thicknesses for the external envelope and considering different heating and ventilations systems and renewable sources.

The LCA assessment was made on the different options described above and the environmental effects were compared and analysed.

Tool use and the influence of final design

An alternative between Option 1 and Option 2 has been chosen for the final design (better than the current requirements and worse than the passive house category). Although an LCA has been carried out, mainly short term cost issues had to govern the decision making. However, it was achieved that an alternative better than the current requirements was selected.

4.6 Austrian case studies

4.6.1 LCA use in design of new passive house kindergarten – Ziersdorf, Austria

LCA or even LCth in the Austrian construction sector hardly can be found. There are no requirements by building regulations to perform LCA for buildings or other construction projects. Simplified LCAs can be found in different provinces, where environmental requirements for the receipt of subsidies in the social housing sector are set. In case of this, ambitious LCA studies in Austria mostly have been performed in research projects. The following case study “Passive House Kindergarten Ziersdorf” has been part of the Austrian research project ”Buildings of Tomorrow“, a research programme of the Federal Ministry of Transport, Innovation and Technology. LCA studies and additional measures concerning sustainability aspects mentioned in this report have been conducted and supported within the framework of this research programme.

General description of the project

In 2000 the municipality of Ziersdorf, a small village in Lower Austria, decided to construct a new kindergarten with four group rooms. As Climate Alliance partner the municipality of Ziersdorf wanted to construct a showcase in matters of sustainability. So sustainability targets for social, environmental and economical aspects have been implemented in all stages of the construction process, whereby it has to be stated that the main focus has been on environmental aspects related to construction products and energy consumption in the use stage. In the following chapters a short overview of the integration of LCA in different planning stages is given and most important results are highlighted.

Project development and architectural competition stage

In 2000 the municipality of Ziersdorf performed a call for tender for a kindergarten with four group rooms. The client invited 15 architect, having experiences with sustainable building design, to join an anonymous architectural competition to find the best design solution. In the project development stage members of the municipality and external sustainability experts set ambitious sustainability targets for following aspects:

- Energy consumption in the use stage with a maximum heating energy demand of 15kWh/m2 net floor area/year, as stated by the Passive House Institute Darmstadt. Calculation tool used was PHPP from the Passive House Institute in Darmstadt.
- Use of renewable energy sources (like active solar energy use for heating and DHW)
- Criteria for indoor quality (summery overheating, indoor air quality, etc.)
- Use of environmental friendly construction products. Assessment of the environmental performance of building products was based on the criteria and the assessment tool of IBO (Austrian Institute for Healthy and Ecological Building)
- LCC targets for construction, energy consumption and maintenance in the use stage

In the architectural competition the participating architects had to perform calculations for energy (with the PHPP calculation programme) and for the environmental performance of construction products for selected indicators (primary energy demand, acidification potential, CO_2-equivalents).

In the pre-check stage two external experts for energy and environmental aspects (Prof. Mag. Arch. Ing. Helmut Deubner, Danube University Krems and DI Thomas Zelger, IBO - Austrian Institute for Healthy and Ecological Building) proofed and assessed the designs and calculations of the bids. For the jury meeting the two experts provided a document with the results of their proof, which was used for the competition jury to assess the sustainability quality of the projects.

Preliminary design stage – tendering and construction stage

The winning project was designed by the office ah3 architects and this office was assigned for the further planning work. The project was a wooden construction (walls, ceilings) in Passive House standard, fulfilling the ambitious sustainability targets set in the project development.

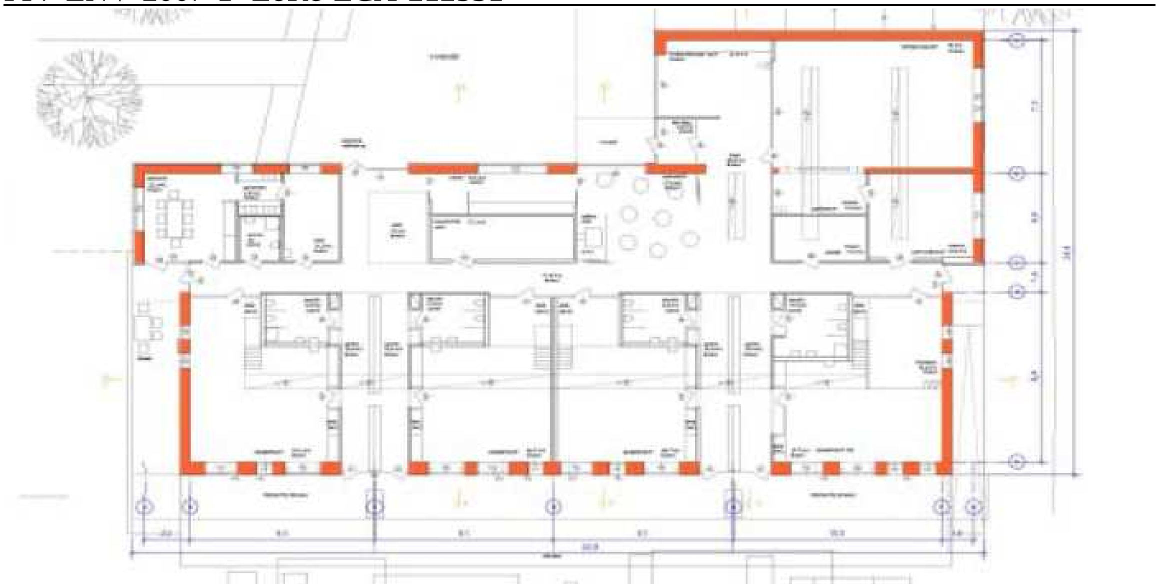

Fig. : Floor plan of the winning competition project, ah3 architects

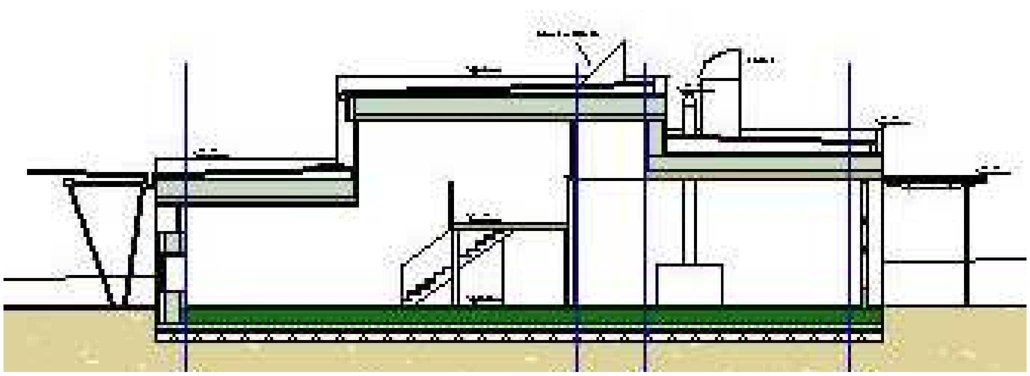

Fig. : Cross section of the winning competition project, ah3 architects

Calculations of the construction costs pointed out that the budget frame for this ambitious project was too small. Financial support for the additional costs for the integration of sustainability aspects (costs for LCA studies and additional construction costs) have been raised by funds of the research program “Buildings of tomorrow”, as the kindergarten Ziersdorf has been selected to be a demonstration project for sustainable construction. To fulfill the ambitious targets in the field of sustainability an inter-disciplinary team of building experts was integrated in the whole planning process. Based on the competition project different scenarios for the energy demand in the use stage and the environmental performance of the construction products have been developed:

- Scenario 1

Scenario 1 was the competition project.

- Scenario 2

Scenario 2 was the project which was used for the procurement of the construction works (call for tender). In this scenario the project has been optimized from energetic, environmental and cost point of view. Scenario 2 is the finally constructed project.

- Scenario 3

Scenario 3 was a building based on the energy requirements for heating and cooling of the existing building regulation of Lower Austria. Choice of construction products and construction system was based on “business as usual” parameters (conventional and common way of construction for kindergartens in Lower Austria).

The environmental performance of building materials has been assessed with the Austrian ECOSOFT LCA tool, developed and supervised by IBO. Energy calculation has been done with the PHPP and a dynamic thermal simulation program. The Following figures give an overview of the most important LCA results of these 3 different scenarios:

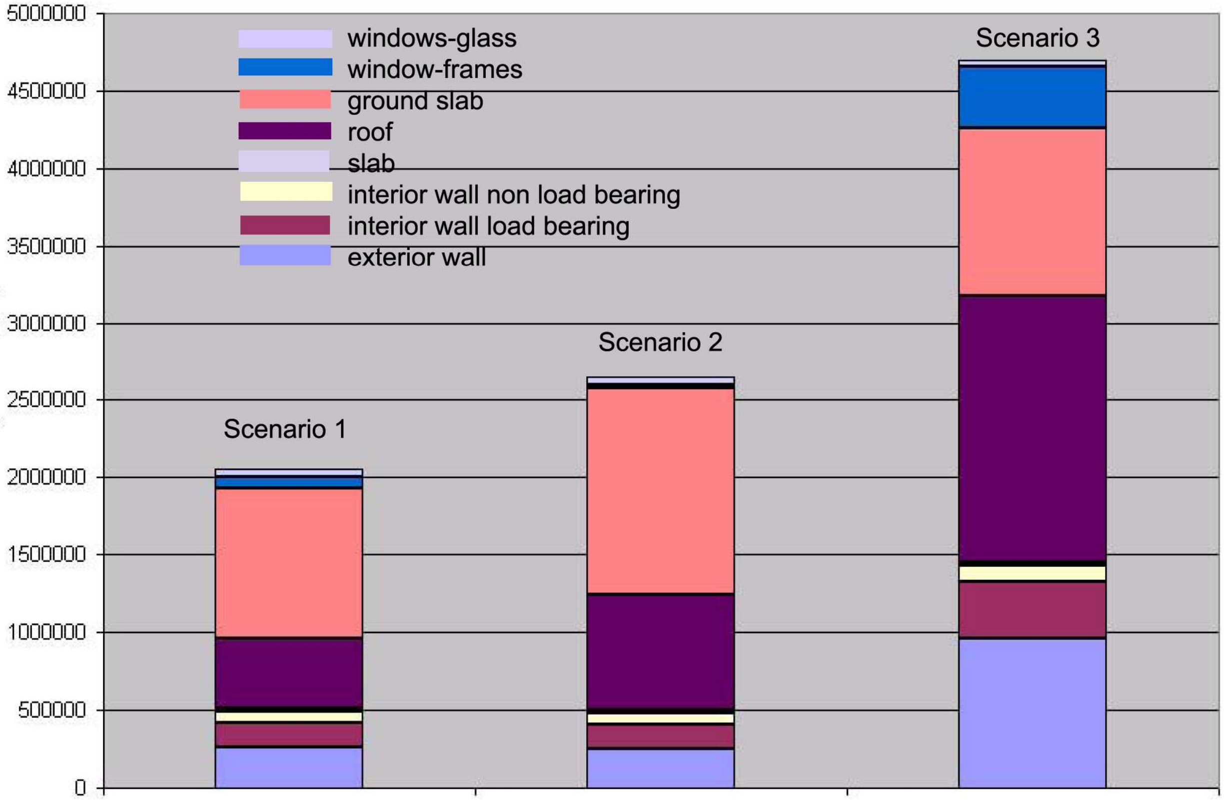

Fig. : Primary energy demand of different building components in the 3 scenarios (life cycle stages covered: product and construction process stage)

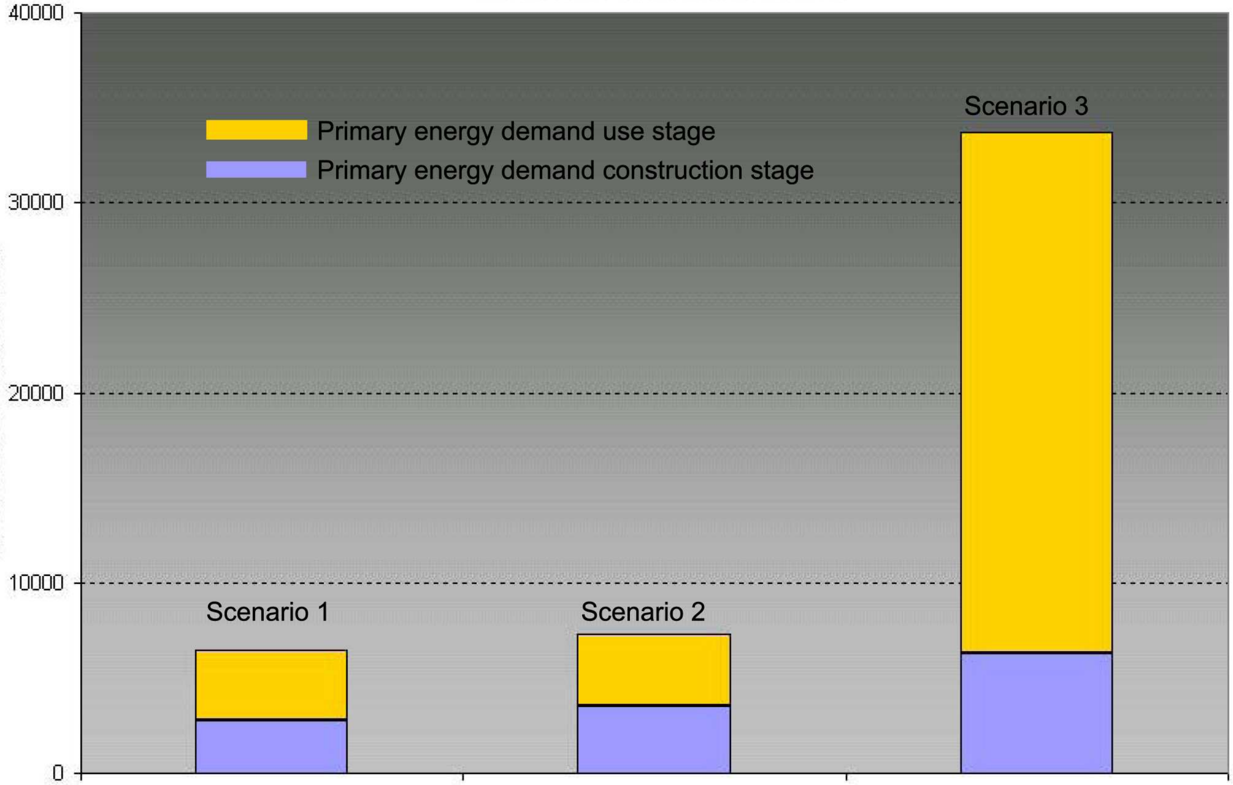

Fig. 4: Primary energy demand in MJ/m2 net floor area within a life span of 50 years

To improve the indoor comfort, the client and the planning team decided to implement a second heating system besides the mechanical ventilation system with heat recovery (balanced ventilation). The choice of the system was driven by an LCA of different solution for heating. A little stove heated with wooden pellets turned out to be the most environmental friendly and cost effective solution.

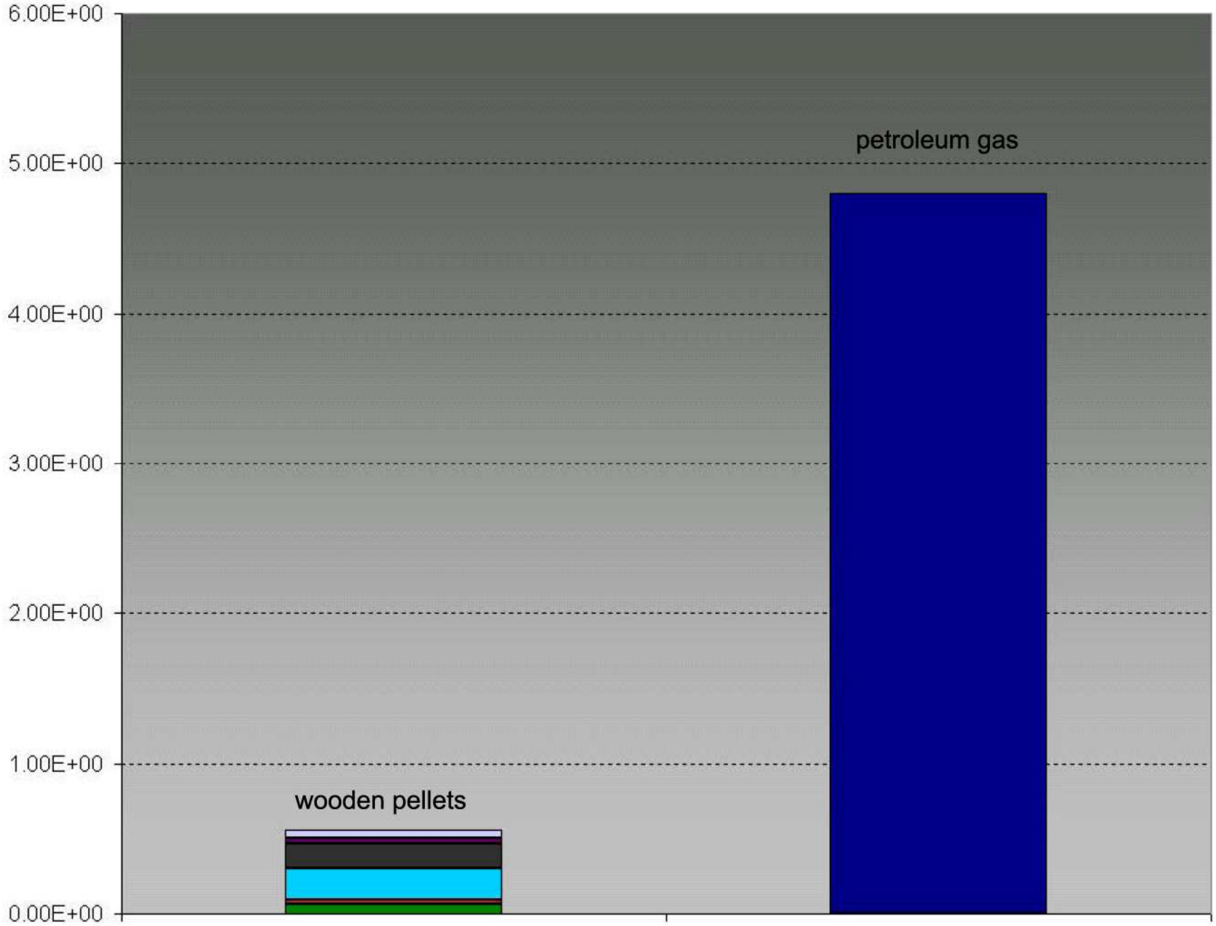

Fig. : LCA of different energy sources/systems for heating. Primary energy demand non renewable for the combustion of 1 kWh final energy from the pellet stove and from petroleum gas.

Procurement process

The tendering process for the construction works turned out to be quit complicated as the assessment of the bids was based on investment costs, operation costs, durability and environmental benchmarks. Most tendering positions in the different assembly sections included conventional requirements and requirements concerning sustainability aspect mentioned above. To adapt the tendering documents concerning sustainability (environmental friendly construction projects, energy system) the architect was supported by specialist in this field. Both for tendering experts (architect, consultants) and bidders this approach was difficult to handle and a lot of additional work for all actors was required. As there was a restricted budget frame for the construction of the building, especially the optimization of the cost aspects with LCC approach and the environment benefits of measures selected, turned out to be very complicated. At the end a comparison of the construction version to a low energy solution with conventional construction products, showed around 14% additional construction costs.

In 2003 the construction started and it was finished in 2004. To assess the planned targets (energy consumption, indoor air quality) comprehensive evaluation measurements have been conducted.

Fig.: Kindergarten Ziersdorf under construction, ah3 architects

Fig. : View from the entrance, ah3 architects

Fig. : View from the garden, ah3 architects

Conclusions

The case study “Kindergarten Ziersdorf” points out the great benefits and big challenges of the use of LCA in the building sector. The use of LCA has contributed to the environmental improvement of the building, providing quantitative and verifying results for planners and clients. An important factor of success has been the implementation of LCA issues in the whole planning process (project development - architectural competition - implementation planning - procurement stage). The supply of adequate instruments, fitting to these different planning stages and the integration of LCA experts into the whole building process turned out to be a very important point. As there is only little expertise on LCA under architects and building consultants an integration of LCA experts in an interdisciplinary planning team is one of the key factors for sustainable construction. Knowledge gaps and a lack of adequate LCA strategies/instruments especially appeared in the preliminary design stage/architectural competition (use of simplified LCA) and in the procurement stage (setting of technical specification for sustainability issues, proof of bids). Leaving large wiggle room, also weighting of economical aspects (LCC aspects) in relation to other sustainability aspects (environmental and social aspects) was quite difficult to handle.

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4.6.2 Study of Architectural Competitions

Background

Architectural design competitions are considered as a favourable instrument to obtain design proposals revealing different architectural approaches towards a construction project and thus leaving a possibility for choice to the client. Although they are not a pre-requisite in general they are commonly used by public sector clients in Austria and likewise in all European countries. The regulatory basis is thus the EU procurement directive and its national implementations, e.g. in Austria the "Bundesvergabegesetz", which however does not deal with architectural competitions in particular. Competition rules are often provided by the national union of architects or similar achitects' organisations, like the WOA/WSA (former "Wettbewerbsordnung", since 2010 "Wettbewerbsstandards für Architektur") in Austria.

Competitions either call for new design ideas only or for the design of a construction project that should be realized subsequently. The brief of the competition contains the relevant information on the project's aim and programme, on the site, on visions of the client and on participation conditions. In Austria it usually comes in two parts, a chapter on general rules, like eligibility, the jury, prize money, timetable, etc. and a project-specific chapter issuing in specific aims and aspirations, the assessment criteria and submission requirements. In a 1-stage-competition the jury announces the winner after the decision. In a 2-stage-competition the authors of the best contributions are asked to elaborate their scheme further and the winner is elected after a second round among this reduced number. Thus the ineffective effort for participants is limited.

The submitted schemes in a design competition always try to impress the jury. Although 3D and even photorealistic pictures of buildings are presented it is by no means clear which materials will be employed and what will be the performance of the components. Cost calculations are often demanded but have to be rough estimations for the same reason. This description is true for both the 1- and 2-stage competition; but it is not true for the general contractor competition ("Bauträgerwettbewerb") that is quite popular e.g. in Vienna residential housing projects. In this type of competition not only a design has to be submitted but also a specified performance. The costs have to be guaranteed and must not be exceeded unless exceptional circumstances occurred. Participants are mainly property developers or builders in a team with other professionals.

For the implementation of sustainability aspects the most important phases of the building life cycle are the programming stage and the preliminary design stage which is exactly covered by the competition. To create sustainable buildings the right decisions have to be taken during these phases. Therefore setting of environmental targets and proving how and to what extent they are achieved should play an important role in the design competitions.

Even though the following chapters are based on the Austrian situation, it can be stated that it will be of similar relevance to all European countries because structure, content and procedure of these competitions correspond to similar rules. Especially all public authorities are obliged to follow the European procurement directives. Amongst other requirements they have to announce the invitation to tender across Europe if certain threshold values for the budget of the project are exceeded.

Structure and Methods of the study

To arrive at a comprehensive impression of the present situation of the Austrian architectural competition sector concerning energy and sustainability aspects the study was conducted in three parts:

- Online survey among Austrian architects
- Workshops with stakeholders
- Study of 51 architectural competitions

The results from the online survey deliver a quantitative picture of how common energy requirements are and to what extent architects perceive these requirements as problematic.

The stakeholder workshops were designed to collect information on the perceptions of clients and competition promoters. What are their demands and their experiences? What driving forces towards energy/sustainability integration into architectural competitions do they experience? The discussions in the workshops provide qualitative statements and shed light on barriers and synergies.

This quantitative-qualitative picture is fleshed out further by the analysis of competition documents. What are typical paragraphs that contain text and requirements and in what manner do they occur in the competition documents? Are there (big) differences between various competitions? Especially the connection between the jury’s statement and the promoter’s competition documents was considered interesting: What constellation leads to energy/sustainability acknowledgement in the jury’s decision?

Perception of the relevance of energy – online survey among architects

Additional information was derived by an online survey among architects.

The intention of the online survey was to gain an impression on the relevance of energy aspects in architectural design competitions and on how the present situation is perceived by architects. The request to participate in the survey was sent to the members of the Federal Chamber of Architects and Engineering Consultants of Austria by e-mail in 2009. 1500 persons received the request, 806 started the online survey and 430 completed the forms representing a return rate of ca. 30%. 50.5% of the survey respondents had participated in more than 6 design competitions in the last 3 years. But only 30% had acquired more than 25% of their projects by winning of competitions.

Only a short list of questions had been prepared to ensure a good response rate and to not only reach “eco-architects”/environmentally conscious architects. The 6 main questions of the online survey and their answers were:

- What is the importance of energy in your work?
- What is the importance of energy in architectural competitions?

Energy is without doubt an important topic in the design process rated as important or very important by 95% of the respondents. However, concerning the relevance in architectural design competitions the opinions are split: for 47% it is also important and very important in this early stage, whereas another 47% say it is less or not important.

- Are tendering documents clear with respect to energy to allow for an objective assessment of the competitors?
- Are jury decisions transparent and comprehensible with respect to energy related criteria and weighting?

Concerning the clear wording of energy targets in tendering documents only 2.7% find it fully granted, 53% consider this is partly true and for 33% this is not the case. Even more evident are the answers concerning the jury decision: for 50% it fails to be transparent, 35% assume it is partly transparent, 1% say it is fully transparent.

- Which problems exist if energy aspects are integrated in architectural competitions?
- What should be changed in today's competition practice with respect to energy aspects?

The last two questions provided multiple choice listed answers and the possibility of own answers. The main barriers for integration were: Assessment criteria are not detailed enough (27%), related design effort is too big (25%), design stage does not support energy calculations (23%). There is still uneasiness: the whole topic seems to be too complex (18%); but only 6.6% state as a problem that energy targets could delimit their design options.

4 items were listed that could improve today's practice. Not amazingly clear assessment criteria ranked highest with 30%. 27% voted for (simple) calculation tools. But also additional expertise in the pre-approval stage and in the jury was demanded (by 20% and 22%, respectively).

Several free responses dealt with the additional efforts needed to develop the energy aspects. Some respondents required that this effort should be rewarded.

The viewpoint of stakeholder clients – their perception of the relevance of energy

Whereas the survey showed the opinion of the architects, professional clients expressed their view of the questions listed above in two workshops. The workshops were conducted with representatives of 5 project partner organisations that are actively issuing architectural design competitions for their building projects (Styrian health care company KAGES, OeAD housing office for students, BIG Federal property owner, the building management of the Styrian administration, the Styrian Chamber of Architects).

The integration of energy aspects in architectural competitions was very high on the agenda of all workshop participants. They anticipate strict requirements in future by legislation and by political decisions of their organisations. To their opinion in practice jury decisions often do not reflect the energy specifications, thus the winning project does not always perform as well as desired.

Several clients have already started to develop their own criteria and assessment instruments. But quantitative criteria promising verifiable evaluations are still missing.

To reach a jury decision that is transparent and is also satisfying for the client, i.e. meeting the clients demands, it is prerequisite that tendering, criteria and weighting has to be prepared thoroughly to get design proposals that can be compared soundly.

Apart from general contractor competitions there is at the moment no guarantee that the claimed energetical performance of a proposal is reached or energy concepts are realistic. It is one of the problems that architects at the competition design stage (preliminary design) may claim to reach whatever energy target – albeit with significant higher costs if their design causes main energy losses e.g. by large glazed facades or by a disproportionately large building envelop.

Other barriers for energy specifications/calculations are the low level of detail in competitions that does not allow a detailed calculation of the energy index, the high effort also for the client if detailed specifications are demanded. The Energy performance certificate stated by the Energy Performance of Buildings Directive (EPBD) is considered to be too detailed, requiring inadequate efforts for all actors in architectural competitions.

More awareness of the energetical quality of the design would greatly be appreciated by all professional clients.

Environmental targets and their integration – analysis of competition documents

A study of 51 architectural design competitions for buildings in Austria was conducted with the objective to analyse the present situation and focus on how environmental aspects are integrated. The competitions were selected from an online platform (www.architekturwettbewerbe.at) operated by the Federal Chamber of Architects and Engineering Consultants of Austria that contains documentation of all major Austrian architectural design competitions.

From this platform 51 competitions were taken that showed ambitions concerning sustainability and that offered a range of building types and of representative clients (see below). The majority was issued 2006 – 2008. Documents comprised the tendering documents and jury panel protocols. Sometimes also reports from the design approval stage and additional competition materials (plans, project descriptions, expert reports, etc.) were available.

The competitions had been tendered by following clients:

- 27 Public authorities and third-party companies of public authorities (both subjected to the European Procurement Directives)

- 13 Housing companies
- 11 Private Companies

The building type mix was:

- 17 housing projects, 1 foster home, 1 guest house
- 6 office buildings, 2 hotels, 1 other conditioned building
- 9 nurseries and primary schools, 9 secondary schools and universities
- 5 hospitals

38% of the competitions dealt with new buildings, 12% with retrofit and 1% both with retrofitting plus new building parts.

The distribution of competition types was: 4 general contractor competitions, 2 ideas competition, 34 1-stage and 11 2-stage-competitions.

The analysis of the integration of environmental targets in design competitions followed the most important competition stages, which in general can be divided into:

- Programming (project development), aims and aspiration of the project, incorporated in the tender documents
- Tendering, in specific definition of assessment criteria and assigning their weights
- Design works of the participants and provision of the required calculations/diagrams (if any) by the participants
- Design approval through an expert (or several experts)
- Jury panel meeting and decision

The main focus of our study was on energy related aspects, e.g. targets for operational energy in the use stage, as in all competitions under study they represent the most important environmental aspect. Other requirements were primary energy demand, ecological properties of building materials, land use, life cycle costs and social aspects like e.g. indoor environment and health aspects. Overheating in summer was also important issue in many competitions; as a requirement it was linked either to energy demand, to operational costs or to comfort.

Envisaged environmental aims and energy standard

The tender documents of virtually all competitions contained a passage stating that the building is meant to be sustainable (this was also a selection criterion as mentioned before). The text however is not always going into further details.

Often the energy standard that the building should reach is given:

- 15 buildings should reach “low energy standard”; mostly an energy performance of lower than 30 kWh/m2/year is given as the target.

- 7 buildings should perform even better: 5 should be a Passive house, 2 should be better than low energy standard. In this category often the calculation method is also specified, e.g. according to PHPP ("Passivhaus Projektierungspaket").
- For 8 buildings it is stated that buildings codes are sufficient.
- For 21 buildings there was no instruction on this issue.

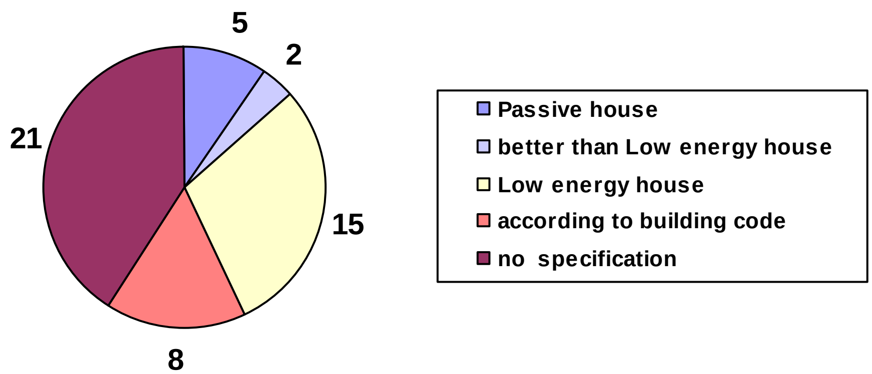

Fig 1: Specification of the energy building standard that should be reached

The use of renewable energy sources is also desired in several cases:

- 10 times passive solar energy use should be integrated in the design.
- 7 times active solar components should be integrated; 5 times for domestic hot water and 2 times additionally for heating and/or cooling.
- 2 projects should also have photovoltaics.

Solar energy use was expressed as an aim particularly for the low energy standard buildings. But seldom the fraction was specified that should be covered by solar energy.

An elaboration of the HVAC-concept was requested for all 4 general contractor competitions which should by the way all reach Passive house or better than Low energy standard. It was stated what should be the calculation basis (e.g. Passive house according to PHPP). In 18 tender documents the favourite energy source was named, which was 10 times district heating, 4 times renewable energy (e.g. biomass), 2 times "alternative energy" (e.g. heat pump) and 2 times other, already installed energy carriers (natural gas, fuel oil). In few tender invitations it was required to show that no overheating in summer will occur; but not always a method was determined how to fulfil the requirement.

Other environmental targets were not quantified and thus are not as unambiguous as the energy standard.

Some clients attached additional information brochures and studies, e.g. a Greenpeace leaflet on climate-conscious organization of construction processes and choice of materials or gave data hubs and sources. It was left up to the participants to draw conclusions for their design proposal and to elaborate their ideas in the description of their proposal. It was required in 5 of the projects by the client that sustainability aspects (apart from mere energy centred considerations) should be referred to in the description.

When environmental and life cycle statements were part of the tender documents the projects were often also designated as “pilot projects”. The vision that could clearly be recognized was to go beyond usual practice concerning sustainability. Nevertheless only few examples explained visions and objectives in detail or quoted measures how they should be reached (e.g. grey-water tank, etc.).

Assessment criteria and weighting

The criteria that the jury is going to apply to their decisions on all submitted schemes have to be disclosed in the tender documents in Austria. Commonly used criteria are “urban development”, “architecture”, “functionality” and “economical operation”; sometimes a 5th criterion “ecology” or “sustainability” is added, occasionally even more criteria are held. 4 of the 51 competitions did specify only the above stated first four criteria with no further reference to energy or sustainability and with no further explanation of them either. The remaining 47 competitions explicated sub-criteria for each criterion and are evaluated in the following paragraph.

Assessment criteria and weighting for energy

Energy and energy-related aspects are either contained in an own criterion (7 times), or they are part of another criteria group or they are not included in a criterion or sub-criterion (11 times) at all.

Energy supply and energy use requirements are often part of economical criteria (in 15 competitions). The corresponding wordings read e.g. that energy consumption is a factor of “economical operation”, it is determining the “follow-up costs”, it is causing the need for optimized solutions with respect to overheating in summer, etc. In 16 competitions energy aspects are a part of a sustainability or ecology criterion. In 5 competitions energy was also addressed in another criterion, e.g. within functionality.

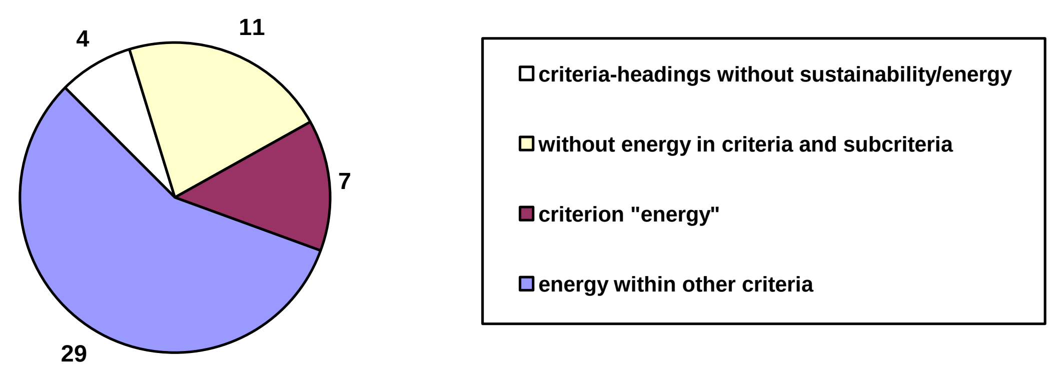

Fig. 1: Role of energy and energy-related aspects in the assessment criteria of the analysed competitions

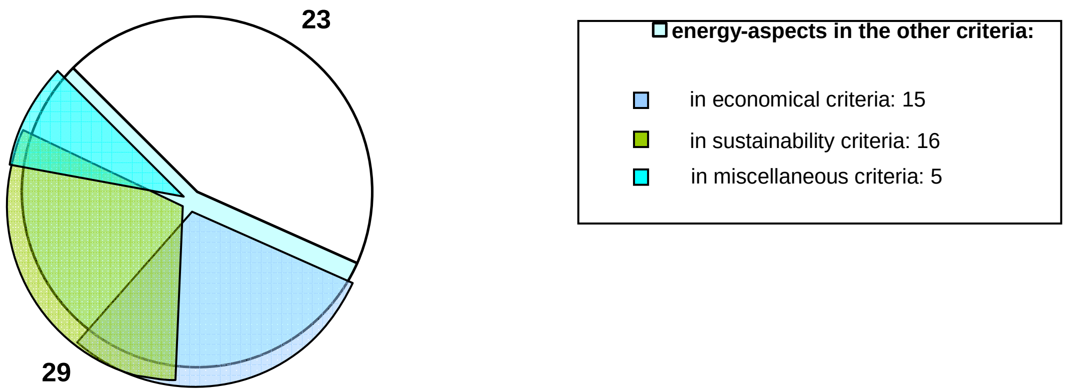

Fig. 2: Energy-aspects were mentioned 36 times in other criteria than energy (for 29 competitions).

Some tender documents had a weight (in percent or as a certain number of points) assigned to each criterion that the jury would reflect. Weights were indicated on the level of criteria; sub-criteria were not weighted. 15 competitions specified weights; in 5 of them the energy criterion was given a weight ranging from 33% (of 100% total sum) in 3 passive house projects, to an innovative façade renovation (15%), to a guest house committed to sustainability (4%).

Assessment criteria and weighting for sustainability

Sustainability was one of the assessment criteria in 21 competitions. Three times the sustainability criterion was extensively detailed and further subdivided. Eight times sustainability was a main criterion (usually one of 4 or 5 main criteria). In all other cases ecology or sustainability was either part of the criterion header (very often it was termed “Ecology and economy”) or a bullet point. There are some examples of tenders with no sustainability criterion in their list. Nevertheless they claim to be ambitious in terms of creating a sustainable building. In one of the competitions even an expert was hired to analyse all proposals with respect to the primary energy demand of the building materials; however the participating designers were not involved in this expertise.

Scope of submitted work

Defining one or more dedicated assessment criteria is a good possibility to ascertain that the applicants will respond to that issue. Another very strong possibility is to require specific documents for submission, e.g. certain drawings, diagrams or calculations. In the 51 scanned competitions no such requirements had been posed.

Requirements are also set forth/put down in the course of the text of the tender documents of some competitions. The formulation sounds often: “The scheme should react on…”. These references can either be visions explained in detail, or guidelines included or external studies that are attached. They are rather vague hints for the implementation of sustainability goals. A contradictory example – may be an exception proving the rule –

was a tender document stating in a sole paragraph that the design has to meet low operation costs and that this will be check in the design approval.

As a matter of fact, sustainability is often dealt with in written statements of the participants. Since there is no way to verify the usually exaggerated explanations the client and the jury cannot seriously count on them. On the other hand the designers do not know whether it is worth to invest time and effort since it is not evident that the jury will take these sections into consideration.

Design approval and jury

In Austria a pre-check of all submissions is customary to ensure that all designs meet the requirements, e.g. that they are compatible with the local building codes or with housing subsidy requirements. This check is performed by a professional architect, at times assisted by additional experts like energy experts or technical experts of the client. One important task is also to compile key indices to benchmark the submitted projects and to provide the numbers to the jury.

Time and effort of design approval will be enormously increased if complex key indicators have to be calculated, e.g. the total window area per orientation or an energy index. In some competitions those key indicators had been quoted as a relevant decision criterion, e.g. the area/volume ratio albeit this number has not been demanded from the applicants. In practice it can be assumed that this indicator was not available to the jury then and the jury decided “on instinct”. Alas, pre-check protocols were not available for all 51 analysed competitions.

Involvement of energy expertise

Energy experts had been involved in the design approval (pre-check) in 14 competitions, whereas in another 14 competitions they had not been. For 23 competitions not further information on this subject could be gathered.

The energy experts had evaluated all schemes, and information was included in the protocol, with the exception of 2 competitions showing no energy-relevant additional information. 12 of the 14 competitions can be termed ambitious with respect to energy and sustainability goals, 6 claimed to be pilot projects in this respect. 5 of the 14 competitions had been a call for passive houses, 7 had been a low energy house call. Strikingly many municipalities involved external (energy) experts.

Energy experts had been participating in 7 jury panels, although 5 of them were already energy-pre-checked. This is a particular firm basis for assessing how appropriate the future building will be in terms of energy performance. In all 7 competitions energy aspects are present in the jury protocol. But in another 12 competitions also energy aspects were apparently discussed and recorded. 7 of the latter had been energy pre-checked.

In Austria the jury examines every admitted scheme and puts down an outline of the decision. Often a detailed reasoning of the decision is recorded, especially for the winning projects. It was analysed whether energy-aspects were raised in the description of the winner project.

An overall picture gives the diagram below. So, if energy experts participate in the pre-check and/or participate in the jury energy aspects will also be mentioned in the jury's description of the winner. So the winner description gives some indication on the energy assessment.

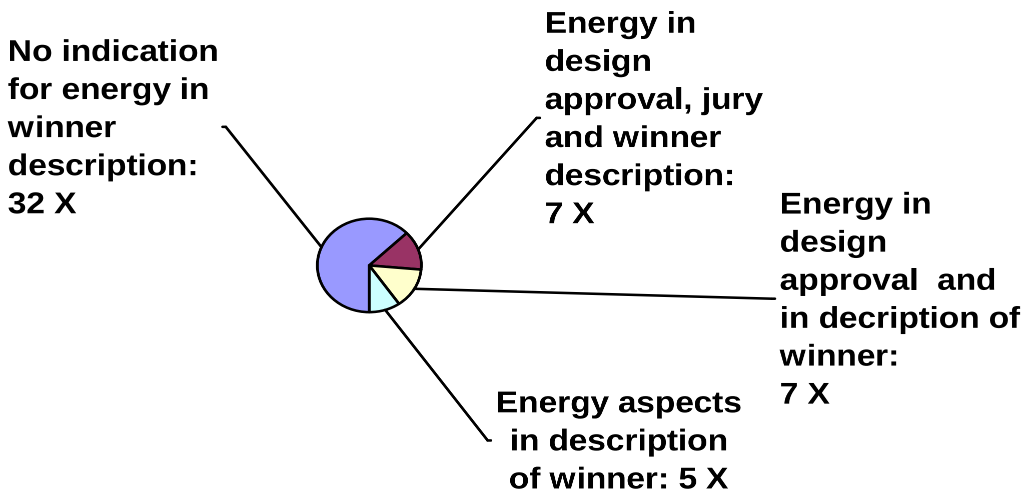

Fig 3: Consideration of energy in the description of winner project with/without energy experts involved in design approval / jury.

Sustainability aspects

From the jury protocols it is virtually impossible to recognize what weight sustainability was given in the jury or whether it was considered at all. In the minutes of the discussion the submitted design proposals usually are described in terms of the functionality, how they fit into the neighbourhood, the expressed "design statement", etc. but not the expected contribution to sustainability.

It would be very important though, that the jury values also aspects like resource efficiency and indoor quality (anticipated noise levels and lighting levels, moisture problem zones, etc.) and also puts forward demands for further improvements of the winning projects.

Conclusions from the Austrian study of architectural design competitions

Sustainability and high energy performance is very often a vision of clients nowadays. The EPBD has raised the need to set the tracks in this direction early. Professional clients and competition promoters perceive this challenge and have already started to develop own tools to evaluate pre-design. This was confirmed in the workshops with representatives of 6 national and regional authorities and institutions that are acting as competition promoters.

In the online survey architects approved the significant status of energy in architectural competitions: After all 47% rate it as a very important or important issue.

The analysis of the 51 architectural design competitions also reflected sustainability as a client's value. Tender documents contain sustainability information and requirements at various points of the competition brief, e.g. in the description of the project, in design guidelines and advice, or in the assessment criteria. The expectation was also often expressed that the submitted schemes should be an answer to these client's ambitions and that the winning project is also an outstanding sustainability solution. But detailed guidance was seldom given in the competition brief on what method to use or what evidences had to be included.

Problems that were mentioned to come along with early assessment of pre-design schemes that are submitted in architectural competitions are: time and effort that might be too high, details might be needed that are not developed yet, and criteria that are not clear and elaborated. These problems ranked equally important in the online survey. It is interesting to note that the concern that design options and variability might be reduced was not voiced.

Clients and competition promoters report the same problems related to assessments. They additionally complain about "empty promises" applicants make concerning the energy performance of their submitted scheme.

The situation was analysed in greater detail in the competition documents: Several competitions contained detailed energy-related text but no corresponding assessment criteria. The other way round was also found: there were energy-relevant assessment criteria (mostly under economic or ecology headings) but no explaining text and no further information indicating the seriousness and importance within the decision process. It can be stated that rarely any applicant knows how energy and sustainability aspects are rated and how he/she should illustrate how well his/her scheme is prepared to cope with it.

The most important phases for implementation of sustainability and energy aspects are programming and preliminary design which is exactly covered by architectural competitions. Energy and sustainability in architectural competitions is seen as important topic by architects and clients, but so far suitable strategies and instruments for successful implementation are missing.

In most architectural competitions energy and sustainability turns out to be a vague vision of the client without measurable targets and clear specifications in the tendering documents. This situation gives broad wiggle room for participants, pre-checkers and the jury. For participants the lack of transparent assessment criteria means ambiguity concerning their performances. Pre-checkers are not able to provide transparent, traceable documents for the jury, so that jury decisions are very much characterized by acquired or claimed experiences or maybe by a sense of relevant characteristics or even by "instinct".

Strategies for the integration of sustainability and energy aspects have to be done along all phases of architectural competitions both on organisational and on technical level. The development of practicable assessment tools turns out to be one of the most important issues. This has been quoted as well in the online survey by architects and in the workshops by clients. Compulsory use of the same assessment tool by all participants is the only way to get reliable and comparable results. The use of alternative tools should be excluded. As a starting point energy related objectives have to be integrated, but the awareness for the importance of sustainability for all actors of the competition sector has to rise also.

Indicators that can be used for the assessment and for subsequent tools have to be as simple as possible defaulting all those parameters that either are not known (e.g. materials in classic competitions). Any special aims of dedicated competitions like solar energy use or the use of materials with low environmental impacts can be covered by specific indicators. The recommended indicators for LCA-like assessment of the building materials offer the following advantages: On the one hand they are the most important indicators for building materials and on the other hand they are the same indicators as chosen for energy in the use stage, which enables a demonstrative comparison of impacts from the product stage and the use stage.

Strategies for enabling a fair comparison of all schemes have to be developed together with the key players in the competition business. Tools for this purpose need to be objective and transparent, at the best based on a standardized concept. Independently in Germany and Austria two research projects were conducted for energy performance rating in the early design stage. In both project a tool was the main result: the German ClimateDesignCompetion tool (Hausladen 2009) and the IEAA-Tool which has been developed by Staller (Staller, et al., 2010)

4.7 German Case Study

4.7.1 Offices for the Centre for Sustainable Building (ZUB), Kassel, Germany

Description of building, construction, etc

This case study focuses on the office building housing the Centre for Sustainable Building (ZUB) in Kassel Germany. It was planned with a vision of showcasing the possibilities for sustainable design. The building has three floors above ground and a basement, with a net floor area of 1347 m² and 6.882 m³ gross volume.

To follow-up the building’s environmental life-cycle performance, the life-cycle assessment software Gabi was used for LCA certification. Previous to this, life-cycle thinking had been deployed throughout the entire process. Gabi was selected for this certification as (along with LEGEP) it is one of the two well-established and mainly used tools for building LCAs in Germany.

Gabi is a software tool for modelling products and systems from a life-cycle perspective. Different models can built for any products, balance emissions and material and energy inputs and outputs and calculate LCAs. The GaBi software is packaged with the life cycle database of choice.

A superior environmental performance was preferred for the construction since the building houses offices for a company that promotes sustainable building.

Targeted indicators

As per the overall interest of the Centre for Sustainable Building (ZUB), and the stated vision for this specific building, it was planned as an example of environmentally conscious building. The following objects are covered especially:

The building is designed and equipped as a building with minimal energy demand

Use of environmentally friendly construction materials and technologies

A demonstration project for sustainable construction

The targets are set for researching on energy optimised office buildings. This building project was initiated by Prof. Gerd Hauser, Prof Gerhard Hausladen and Prof. Gernot Minke. In order to achieve the minimal energy demand as well as promotion of new construction materials and technologies, the energy and resource flows across the entire life cycle of the building were focussed on.

The use of the tool/life cycle approaches in the process

A multidisciplinary team was formed with actors from different sections as owner, project conception, architects, building services, energy conception and simulation, experts for cobwork, thermal and acoustic building physics and structural design.

These actors were involved from the start of the project, and they enabled a continuous information exchange yielding mutual benefit.

Tool use and the influence of final design

The tool was not used during the design and construction process. Aiming at DGNB certification, Gabi was used as a post-construction evaluation for calculate the environmental impacts of the building.

The LCA tool and calculations are only used after the completion of the building. So the complete LCA was not affected on the development process. But life-cycle thinking was involved since the beginning of the project conception and was considered through the entire development process.

Different models of construction and building plants are set for researching the optimal energy use and minimal energy demand for the building.

5 Discussion

5.1 The effect of Life-cycle thinking in cases

The case of the French public laundry is interesting because it involves the application of an LCA procedure (covering a broad range of mid-point environmental indicators), where it has been possible to identify specific areas where the application of the tool changed the design (no active air-conditioning, window optimisation). The Spanish case study on the renovation of apartment buildings in Playa de Palma is another example where, in this case a *simplified* LCA procedure was applied. The application of this procedure has recommended measures that may not otherwise have been carried out, however it is not clear whether these will all be carried out in light of the project budget. Interestingly, in both cases, simplicity-of-use were cited as reasons for applying each respective tool. In the French case this depended on the fact that the tool used was directly connected to an energy-modelling tool. In the Spanish case, a custom tool was developed, with a limited range of indicators. The Austrian case study on a new kindergarten is also an interesting example since LCA was introduced early and was integrated in the whole process. In this case actual numbers were also presented related to the reduction in primary energy demand that was achieved by making use of LCA in the design process.

In other cases where life-cycle thinking on the scale of an entire building has been applied, LCA has not been used specifically to analyse options in a pre-construction phase. A wide range of environmental rating tools do however feature prominently. Motives for using a rating tool of any sort that is cited in many case studies is that a rating tool facilitates the setting of targets for a given project. In this respect rating tools have an advantage compared to custom-target setting in so far as practitioners avoid spending considerable time establishing reasonable environmental targets specifically for a given project that may not be applicable again in another setting.

Some examples of rating tools applied in the case studies are the British tool BREEAM(see Norwegian case studies), and the EU’s Green Building tool (Swedish case studies Kungsbrohuset and Vattenfall’s office). In the Swedish case, a reason for implementing such international rating tools is specifically the international recognition that such tools offer, and the possibility these tools offer to communicate the green credentials of the building in question to international clients and other stakeholders. A property owner even went as far as to point out that some international tenants may have a policy that requires the implementation of a specific tool (e.g. LEED, BREEAM) for rented premises globally. Where EU’s Green Building was applied, a reason other than international recognizablity that was cited was that the tool included an element that focused on energy management processes during the use-phase of the building.

Additionally the French and Swedish case studies show examples where domestic rating tools have been applied, namely HQE (Haute Qualité Environnmentale, High Environmental Quality) and Miljöbyggnad (MB – environmentally rated building) respectively. In both the French and Swedish cases, the use of a domestic tool was desirable due to the fact that a domestic tool better reflects specific institutional (i.e. building regulations) and physical (i.e. climate) conditions in a way that international tools are not intended to do. Examples of where the application of these tools affected the final design come from the Swedish case studies where fenestration solutions for both Vattenfall and Kungsbrohuset were amended to achieve the desired grade in Miljöbyggnad. Miljöbyggnad was also considered a useful tool due its relative simplicity, with only 14 indicators in total, which made the tool easy-to-use, particularly in the sense that it was easy to communicate environmental targets for the project amongst the multiple practitioners that are involved in large construction projects.

Interestingly, the Austrian study of architectural competitions does not give examples where specific environmental rating tools are designated in calls for tenders. The studies further conclude that it would in fact be helpful in comparing rival tenders if the same assessment tool or a well-defined set of indicators was required to be used for each tender. It seems that this would be an ideal area to implement an environmental rating tool. Having said that, one issue may be that an assessment tool required for evaluating tenders early on in a design stage may not be available.

The case studies show many examples where life-cycle thinking has been applied on the level of building materials. This is of course the case for the Spanish and French LCA-based approaches, but also applies for many other cases.

Where environmental rating tools have been applied, material outcomes are based on how the issue of materials is treated in the tool in question. For example, the Swedish tool Miljöbyggnad requires for the highest rating that a range of materials with environmental/health hazard classification are not present in the building. For this purpose in the Vattenfall case, the tool for selecting environmentally adapted construction materials and products “Byggvarubedömningen” (approximately construction product evaluation) was used in the selection procedure for building material.

There are many examples where environmental product declarations were used for selecting materials. In one Norwegian study where this was the case, however, materials recommended according to EPD’s were not used in the final building solution due to the fact that they could not be sourced from suppliers. Material sourcing was cited as a barrier in at least one other Norwegian case study. Meanwhile, the French case study of the logistics centre also used EPD’s as a condition for selection of some materials, however it was considered that this did not change the actual solution chosen based on the fact that no specific target was set for the EPDs, the target being that the materials *have* accompanying EPDs rather than anything specific target based on the content of the EPDs.

5.2 Driving Forces

The overriding driver behind the projects covered in the case studies seems to be what can be termed the goal of creating an environmental profile. Here an environmental profile is considered to mean contributing to a public image of the organization in question as one that takes environmental performance seriously. The types of organization to which this applies according the case studies, and the ways in which an environmental profile are important are many. In the case of Hammarby Sjöstad, it was specifically the City of Stockholm for which an environmental profile was important in a bid for the Olympic Games. This also seems to be the case for the Playa de Palma consortium (a consortium of local governments) where a goal is to create a more sustainable model of tourism. Meanwhile for Vattenfall (a building tenant) such a public image is seen as important amongst other things, for attracting environmentally-motivated employees. Norwegian case studies give examples of contractors for whom having a reference project with high environmental goals is important for marketing purposes.

Organisations for which environmental profiling is important also implement environmental management systems, where green building can be seen as a way of addressing identified some of the organizations' identified environmental aspects.

Indeed, a separate motivation for building owners is that high environmental performance contributes positively to property value.

Separate to specific actors' motives, regulatory forces are also considered important, in particular the Energy Performance of Buildings Directive, as well as (in Norwegian cases) specific government incentives.

5.3 Stakeholder Influence

Unsurprisingly for projects on such a large scale as commercial building projects, many different types of actors are mentioned as significant as driving forces for buildings with high environmental performance. Hammarby Sjöstad, Playa de Palma, the Austrian kindergarten are examples were local governments have introduced high environmental goals. On the level of the project process, Norwegian case studies point out that the project manager is a vital actor to ensure that environmental goals are achieved in practice. Meanwhile, in the case of the French public laundry, the design team creating the tender was critical in advancing the high environmental goals. Having said that, in this example it is important to remember that the design team did this conscious of the fact that the clients themselves were environmentally minded. Following on from this, it seems from the assembled case studies that it is often the pull principally from tenants that initiates the high goals for environmental performance. This seems to be the case namely for Vattenfall and for Kungsbrohuset, as well as for at least 2 Norwegian case studies.

In this respect, it is interesting to note a specific comparison between the way that public bodies influence the process and the way that tenants do. Specifically, in the case of Hammarby Sjöstad, the City established a requirement that developers make significant effort to achieve the goals established in the environmental program, but that was not ultimately legally binding. By comparison, in the Vattenfall case, tenants (Vattenfall themselves) and building owners (Fabege) have a legally binding contract that the established environmental goals for the project be met.

6 Conclusions

In the areas discussed above, the following conclusions can be drawn:

Specific LCA methods and environmental rating tools are considered useful by practitioners in achieving environmental goals beyond regulation all the way from early stages of a construction project. For both LCA methods and environmental rating tools simplicity and ease-of-use are important factors.

Key drivers for setting environmental goals beyond regulation include public institutions addressing societal demands, local authorities, contractors, developers need for spearhead projects for profiling of municipality or company and client branding. Access to public subsidies or incentives can provide additional drivers for high environmental ambitions and/or use of LCA in the design process, for example to contribute to higher LCA competence in the design team and the possibility to perform LCA calculations.

The use of LCA in construction projects is still rare but case studies in which LCA was introduced very early in the process display better design options in environmental terms that would have been taken without using LCA. Such successful processes are characterized of including environmentally conscious and experienced key stakeholders (project managers, clients, consultants).

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Appendix 1: Interview guide for input to WP4 deliverables

Instruction

Despite the existence of numerous LCA tools for buildings and the proportional high environmental impact of the building and construction sector, the implementation of life cycle thinking progresses slowly and quite few practical examples exist of how the use of LCA (or at least life cycle thinking) has actually affected construction projects.

This interview guide aims at collecting more of in-depth qualitative information about interesting construction projects/programs in which life-cycle approaches were/are used. There are two main aims (providing input to deliverables D4.1 and D4.2 respectively) and therefore the interview guide is divided into two parts:

3. To provide in-depth process information about why and how life cycle approaches were used and how it might have affected practice.
4. To provide input if particular LCA scenarios were used and if so what scenarios were used.

The interviews should be performed with one or more key persons who have insight into the process of using life cycle approaches in the construction projects. To provide interesting information the interviews should preferably be quite open in their character which means that the questions below should be seen as overarching questions/help questions, but that you should feel free to pose additional follow-up questions to try to understand the process. **But again, note that we are interested more in understanding why and how decisions were taken, that is in-depth understanding and not just yes/no-answers.**

The interviews should preferably be reported as narratives/written summaries (one per each case study), with more or less the following outline:

1. Brief description of building, construction, etc (observe, only as background information to understand the context)
2. Brief description of the assessment tool/life cycle approaches used in the process (mainly to understand the “level” of the life cycle approaches
3. Why was the tool/life cycle approaches used in this project? Who (asked for)/demanded it and for what reasons?
4. Which topics/indicators where targeted?
    a. Was resource consumption over the life cycle an important issue?
5. How was the tool/life cycle approaches used in the process
    a. What input data was used, sources of information?
    b. Who was actively engaged in using the tool?

6. Did the use of the tool, calculations, etc influence the final design? If so, how?
    a. Why was the final design influenced? Which actors played important roles in this process?
7. Description of how scenarios were defined and treated (Part 2)

Interview questions

Part 1

1. Can you briefly describe the project (type of building, size, client…)?
2. Specify the environmental targets set for this project?
3. Why were these targets set? Who initiated it/demanded it? Why were these indicators/issues focused? (Was resource consumption over the life cycle an important issue?)
4. Was a particular environmental assessment tool used for the project? If so, which one and can you very briefly describe it? Is the tool including LCA calculations or is it merely based on life cycle thinking?
5. Why was this particular tool[2] chosen?
6. Who used the tool during the construction process and what was it used for? (e.g as a design tool in order to reach the environmental targets, post-construction evaluation tool….)
7. In what ways did the use of the tool/life cycle calculations have impact on the development process? Did it differ to a construction process without specific environmental targets and if so how?
8. In what ways did the use of the tool/life cycle calculations have impact on construction alternatives/decisions/choices, the final design, etc.?
9. Which actors played important roles in the process which affected the final design? What were important characteristics for these actors (high competence, motivated design team, strong client demands….)

Part 2 – specific questions on treatment of LCA scenarios

10. In the assessment/LCA calculations, in what ways were the following life cycle scenarios defined/treated? (Were scenarios defined by the client, by the used tool or from where? Did the tool only provide one way to treat the scenario, how then? Or is the tool open for treating this scenario in different ways – if so for what reasons was a particular scenario chosen in the calculations?)

[2] Tool is interpreted broadly and can include for example rating tools like LEED and BREEAM or EPD´s

   a. Life time (choice of anticipated life time), as design life, service life, maintenance intervals

   b. Maintenance/operation (is for example cleaning and other operation activities included in the calculations)

   c. Renovation (are for example exchange of building materials and renovation activities included in the calculations)

   d. End-of-life (is for example recycling of building materials accounted for in the calculations)

   e. User behaviour (are special considerations accounted for in the calculations in relation to the expected building user groups)

   f. Flexibility (has flexibility in relation to future building use somehow been accounted for in the calculations?)

11. Why were these scenarios chosen?

12. Were the assessments/calculations done by trying out different scenarios? If so, which?

13. Did any of these scenario choices play a role for decisions taken on the final design/construction choices, etc?