1 Introduction

The relationship between building design and energy demand is truly very complex. Buildings must be regarded as holistic, dynamic units where several factors influence the energy demand; e.g. area efficiency, building shape and orientation, technical systems, façade construction, etc.

Usually there are several considerations to attend to in a project. The architects have their visions and want the building to reflect their view, users require high comfort levels, consultants have the challenge of new technology applications, and contractors have to focus on programme and economy. The building owner must additionally have the long-term operation, maintenance and adaptability in mind. The final solution will therefore often be a sum of compromises.

Furthermore, there is a need for knowledge about how different user groups experience and use physical structures, i.e. technical solutions, buildings and outdoor space. The concept of sustainable built environments must never be reduced to just technical matters. Of course concepts of sustainable built environments also include functional and aesthetic aspects, which over time still are decisive for a building's total economy.

2 Co-optimising many different elements

Regarding sustainable retrofit of buildings the task is not having a purely technical focus on individual technologies and sub-systems, but taking a more integrated approach, combining building design and energy technologies, also including more «soft issues» like process and social issues. A holistic and multi-disciplinary approach is called for.

It is a complex task to optimise many different elements at the same time. The conceptual phase of a larger building project should involve people with different competences in order to create a constructive dialogue about sustainable development. A synergy effect arises between the various professional skills when the process is successful.

Engineers may tend to focus on technical aspects. Mainstream architects have less technical know-how. Their training and working methods encourage them more to consider a holistic approach to building design. The architects often feel that they have to fight for the functional and aesthetic qualities in the project, to avoid getting too entangled in all the technical aspects. Communication problems might also occur when engineers and architects do not «talk the same language». The project partners are dependent on each other's input, and they should be equally responsible for creating a dialogue, something which is necessary when developing sustainable building projects.

In general, there is often a gap between the broad and qualitative objectives set in the beginning of a planning period, and the precaution taken to be able to fulfil the objectives. Time for planning is often the critical factor.

3 Choosing a design team

An interdisciplinary planning process is essentially based on the idea of an optimised teamwork, which should start in the pre-project stage to make clear definition of goals. Further, there should be a qualified design process management, and tools for analyses and assessments should be applied, taking into account a variety of options from the very start. The knowledge of different specialists should be introduced at an early stage. [1]

Integrated energy design often require specialists, e.g. for daylighting, to be added to the conventional team of architects and engineers.

Some designers say they have had experience in sustainability and environmental matters. But once you get to know them further, this has been more of a wish to get involved rather than real credible experience. The prob-

lem with this is that when the pressures of the project come to bear, they subconsciously fall back on previous experience which pushes good environmental design to one side. The project might end up with a few token measures. Therefore it is essential to spend time, as a client, in choosing a good design team that really does have credible experience in sustainable design. This will mean taking up thorough references and checking out their claims with regard to their experience. Unfortunately good designers will not necessarily be the cheapest designers, although they also do not need to be the most expensive. A focus on simply appointing the most economic design team will, most probably, result in rushed and poorly thought out designs.

An external process facilitator should be added to the team in cases where the architect lacks knowledge of environmental issues connected to buildings or where the performance goals are especially challenging. The facilitator will have the task to raise performance issues throughout the process and bring specialized knowledge to the design team. [1]

4 Building program

The starting point of the design process is uncovering the state or condition of the building to be renewed, followed by a description of the project idea and the users' requirements. The first step includes information about the neighbourhood and the development plans for the area. Features of the site; topography, vegetation, sun and wind directions must be identified.

Analyses of various solutions follow next and should end up with a building program including statements of ambitions and intentions. Objectives regarding energy demand, building materials and conditions for construction workers should be emphasised and put into specific terms.

Many countries have developed tools to support the programme phase. A Norwegian tool for environmental programming of urban development is called *Miljøprogram.no*. The tool will help determine environmental performance requirements for urban areas and facilitate the follow-up of the environmental program and the documentation of achievement of performance. [2]

5 Design phase

There is a need to consider sustainability and energy efficiency at the start of the design phase. It is essential to establish, during feasibility studies, the measures required for energy efficiency as well as the key targets. If this is not done at an early stage, such measures will tend to either be forgotten or be pushed out due to pressures from budget or programme. In the UK a helpful tool in ensuring sustainability is properly considered, is called *BREEAM* (BRE Environmental Assessment Method) [3]. Other countries have similar tools to ensure the design team properly consider the wider sustainability and energy efficiency issues.

The professional knowledge of architects and engineers is combined in the design phase, co-optimising a wide number of parameters. In this phase the designers should repeatedly estimate how different building lay-out, structure and envelope design, influence the indoor climate and energy use for heating, cooling, ventilation and lighting. This is an important issue to deal with, as sharpened requirements on energy use is coming, according to the EU Directive on energy performance of buildings (in Norway from January 2007).

One major challenge is handling goal conflicts. Measures must be balanced to several goals, e.g.:

- Exploitation of daylight will benefit users' contentment and well-being. At the same time exploitation of daylight will reduce the consumption of electric power for artificial lighting. On the other hand, an extended use of glazing may cause a higher demand for heating and possibly cooling energy.

- Air quality and comfort temperature will benefit users' contentment and well-being. A high performance ventilation system is thus required. On the other hand, energy consumption for the system should be kept as low as possible.

- Adequate acoustics will benefit users' contentment and well-being. The desired reverberation time will vary according to functions, and it may be contradictory considerations to take into account regarding multi functional space. The placement of absorbers must be considered in relation to the request for thermal mass.

Different solutions have different strengths and weaknesses, and the project team has to optimise the solution as a whole, and not on a component-by-component basis. From the assessment of different solutions the project team identifies parameters that make a difference, and gain an increasing awareness of the environmental impacts of the design. The success criteria should be related to achieving the objectives and intentions stated in the program. The final form and expression should be a synthesis of architectural and engineering considerations.

6 Post Construction Report

Contractors and design teams should revisit their buildings and make a post construction report. This should be made a contractual matter at an early stage.

The post construction report should make visible the various dilemmas faced in the design and building process. Even when the building owner from the starting point is determined to choose environmentally friendly solutions, it might turn out that it is not an easy task in practise. The report should include a description of how the objectives

of the project have been met, fulfilments and shortcomings, including adequate indicators and relevant performance requirements (compared with the national average).

The post construction report should have one year's worth of actual energy performance figures compared with the design target figures. (The design targets are not met in many buildings, or no one even checks.) This will help to encourage the design team to properly train the building users in operating the low energy technologies, again a matter often overlooked. But a word of warning, the fees for post construction monitoring should be negotiated with the design fees; otherwise they are likely to be much higher.

The design process should also be reported, making the team aware of their working methods. The experiences of the participants should be presented, i.e. who have played a central role, and what have been the critical factors from the point of view of architects, consultants, contractors and clients.

7 References

7.1 Compilation

This guideline is written as a part of the project Bringing Retrofit Innovation to Application in Public Buildings (acronym: BRITA in PuBs), EU 6th framework programme, Eco-building (TREN/04/FP6EN/S.07.31038/503135). The authors are Karin Buvik, senior researcher at SINTEF Building and Infrastructure, Norway, Gilbert Snook, Head of Estates, Educational College Plymouth, UK, and Anne Grete Hestnes, Professor at the Norwegian University of Science and Technology. The professional editing was closed in October 2007.

7.2 Litterature

[1] Voss, Karsten, Günter Löhnert et al. (2006). *Bürogebäude mit Zukunft. Konzepte–Analysen–Erfahrungen*. Karlsruhe, Germany: BINE Fachinformationzentrum.

[2] SINTEF in cooperation with Statsbygg and the municipality of Oslo. (2006). *Miljøprogram.no* (Norwegian tool for environmental performance requirements) http://www.miljoprogrammering.no/

[3] BREEAM: BRE Environmental Assessment Method http://www.breeam.org/

8 Disclaimer