Interdisciplinary approach to sustainable building

Experiences from working with a Norwegian demonstration building on retrofitting

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TOPIC: ARCHITECTURE IN A RESOURCE PERSPECTIVE

Abstract:

Several factors, such as functionality, area efficiency, energy demand, technical systems, materials, etc., influence the environmental load of a building. When planning a complex building, people with different competences and skills are needed to optimise different elements to find a suitable, holistic solution. A synergy effect of various actors' skills is achieved when the planning process is successful.

A Norwegian demonstration building, the Borgen Community Centre, is used to exemplify objectives and strategies when aiming for sustainable building. Some results of building performance analysis are also described.

Keywords:
Sustainable building, Planning process, Building design, Environmental assessments

THE BORGEN COMMUNITY CENTRE

INTRODUCTION

The Borgen School in the municipality of Asker was built in 1970 and retrofitted and converted to a place for the whole neighbourhood in 2005.

For the pre-project phase of Borgen Community Centre an accompanying research and development project was initiated to assist the goal setting and planning of the main building, which is now renewed and extended. Within this R&D project SINTEF had the role as facilitator, and researchers from SINTEF and NTNU were involved as expert advisers regarding environmental issues [4]. The task of sustainable retrofit did not have a purely technical focus, but a more integrated approach was used, combining building design and energy technologies, also including more «soft issues» such as process and social issues. In order to create a vital local community and meet the need for more efficient use of resources, joint location and coordinated use of facilities were emphasised. In addition to a secondary school there are facilities for health care services and leisure time arrangements.

The retrofitting of the main building was comprehensive, making the building suited for new working methods in the school and for a diversity of activities as a result of new tenants from the neighbourhood. The plan layout has been totally changed.

In the period 2004–2008 the Borgen Community Centre was part of the EU project «Bringing Retrofit Innovation to Application in Public Buildings» (BRITA in PuBs). The aim of the BRITA project was to increase the market penetration of innovative and effective retrofit solutions for energy conservation and implementation of renewable energy sources, with moderate additional costs. Eight public buildings of different types were chosen as demonstration buildings to boost awareness about ecobuildings to groups of differing age and social origin.

BUILDING PROGRAM WITH ENVIRONMENTAL OBJECTIVES

The starting point of the planning process was uncovering the state or condition of the building to be retrofitted, followed by a description of the project idea and the users' requirements.

The old building was poorly ventilated, had minimum daylighting, and was not suited for modern working methods and cultural and social activities. Users were involved in the planning process of the renewal of the building. Early during the programming stage, the representatives of Asker municipality involved the local population, requesting their comments, needs and wishes which later, to a large extent, were imbedded into the urban and architectural solutions. The user participation in the planning process has been comprehensive and very well organised.

The researchers' role at this stage was to give input to discussions about plan layout and functionality as well as input to discussions about environmental issues.

Analyses of various solutions followed next and ended up with a building program including statements of ambitions and intentions. Objectives regarding building suitability, energy demand and building materials were emphasised and put into specific terms:

• According to standard practice the school department should be space efficient and adaptable to various working methods and social events. A large part of the building should be accessible and suitable for various groups in the local community.

• According to the Norwegian assessment method «EcoProfile» the building and yard should obtain the best quality class for each of the three main areas: *Environment, Resources, and Indoor climate.*

• Purchased energy consumption for space heating, ventilation and artificial lighting should be halved by means of applying energy efficient solutions and utilising renewable energy.

DESIGN PHASE WITH ENVIRONMENTAL ANALYSIS

The professional knowledge of architects and engineers should be combined in the design phase, co-optimising a wide number of parameters. In this phase the designers should repeatedly estimate how different building layouts, structures and envelope designs, influence the indoor climate and energy use for heating, cooling, ventilation and lighting. This was an important issue to deal with at Borgen, as goals were rather ambitious.

Pictures showing the main building before and after retrofit. Most visible features are the new daylight openings on the roof and new façades. The air inlet tower and a heat recovery unit (roof top) can be seen in the picture to the right. Architects for retrofitting: Hus Arkitekter AS.
Photo left: B. Matusiak.
Photo right: J. Rollan.

Pictures showing the indoor communication area before and after retrofit.
Photo left: B. Matusiak.
Photo right: K. Buvik.

Strategy for energy efficiency
In aiming to reduce the consumption of energy, the strategy «trias energetica» was used, i.e. initially apply energy efficiency measures, then utilise renewable energy resources, and lastly supply remaining demand with an effective fuel burner.

• Area use
Space efficiency and building flexibility are probably the factors that contribute the most to reducing the consumption of resources in a life cycle perspective. In the community centre public entities and private organisations share rooms and equipment.

• Insulation
Roof and facades are upgraded with respect to thermal insulation.

• Daylighting
Daylight is used to reduce the expenditure of electrical power for artificial lighting. Daylight sensors control the use of artificial lighting.

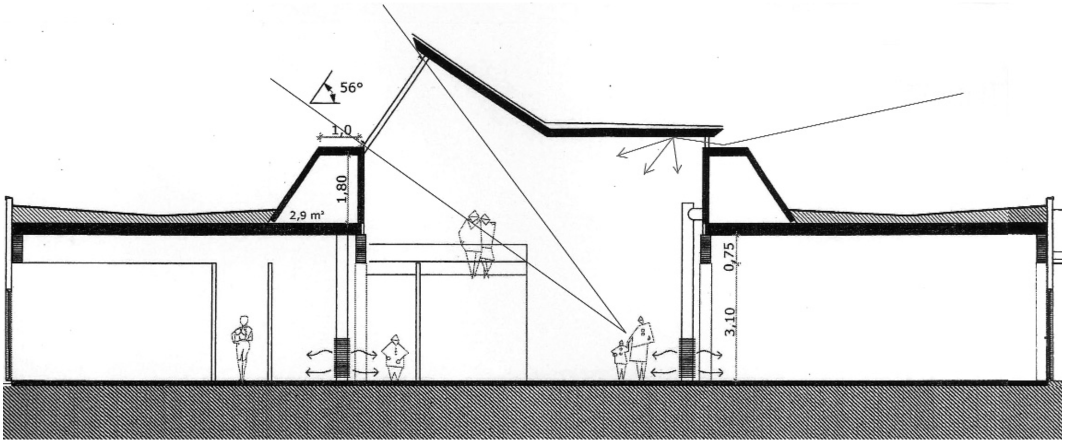
Due to new regulations on snow loads the roof construction had to be strengthened. The roof surface had to be replaced, and that allowed for daylighting openings. The windows in the facades are enlarged and upgraded with respect to thermal insulation and solar shading.

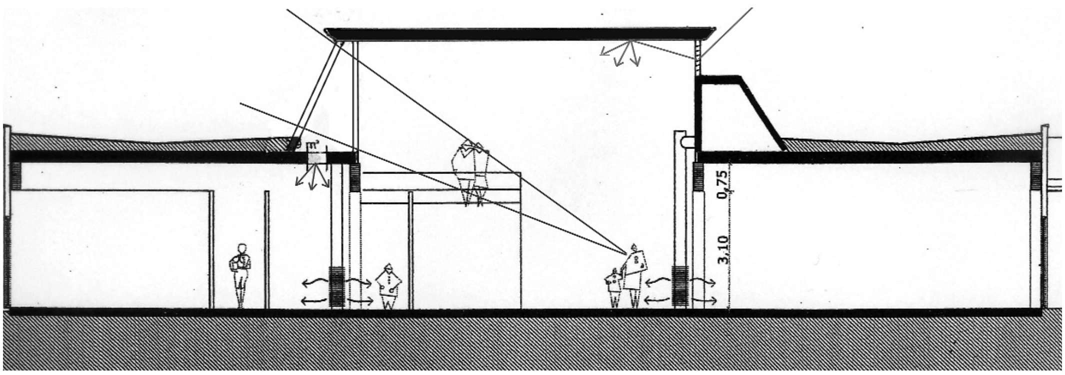
• Ventilation
The building is provided with decentralised hybrid ventilation systems utilizing natural driving forces, buoyancy and wind, in order to reduce the demand for fan power. Demand control of airflow, heat recovery and low-emitting building materials further contribute to the energy savings.

• Energy supply
Geothermal heat (heat pump) is utilised for space heating, preheating of ventilation air and domestic hot water. Under normal conditions the geothermal heat is enough, and the backup system of oil burners are used only a few days during winter.

Daylighting analysis

The section drawings show studies of alternative daylighting designs [10]. Daylight is used to reduce the consumption of the high-grade electric energy for artificial lighting and, at the same time, enhance architectural values. Separately operating zones for artificial lighting, and control by daylight sensors contribute to the energy savings.
The daylight solution developed in the preliminary project is based on the upper drawing.
A large glass surface to the north placed highly over the floor gives a high and even daylight level in the middle zone of the building.
The daylight will also penetrate to the side zones through the glazing in the partition walls and will considerably increase daylight level in these areas.
The glazing area was calculated to meet daylight factors required for this building. The optimal sloping was calculated to avoid shading devices and at the same time to ensure en extensive penetration of diffuse skylight.
The north oriented glazing is supplemented with a narrow stripe of daylight opening from the opposite direction, to enable sunlight penetration to the building.
The roof over the ventilation duct functions as a light-shelf.





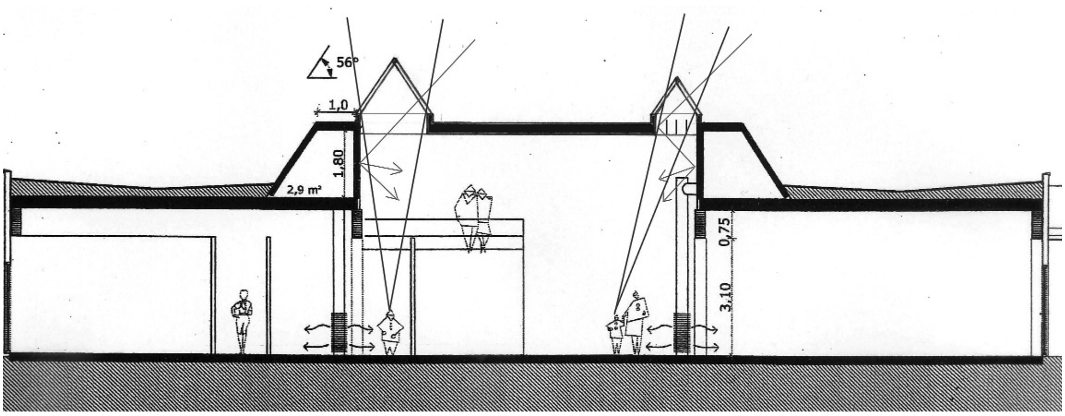
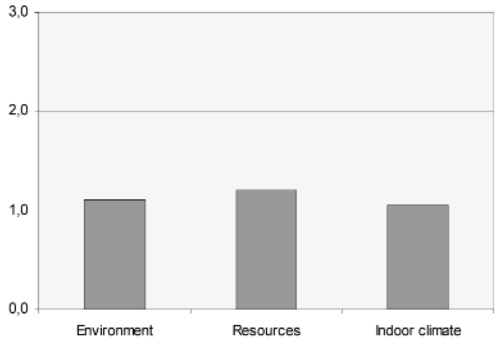
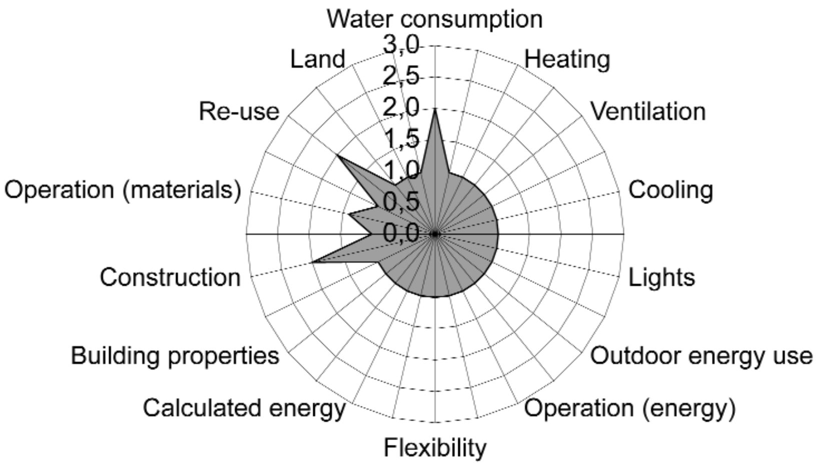


Illustration: B. Matusiak





Results of the EcoProfile assessment. The bar chart shows the levels of the areas Environment, Resources and Indoor climate. The star diagram shows the area «Resources» with sub-criteria. The parameters on the right side of the star, from Heating to Calculated energy, belong to the category «energy use». The parameters on the left side, ranging from Building properties to Re-use, deal with the characteristic of materials. [1] Illustration: I. Andresen.

Balancing different measures

One major challenge was handling goal conflicts. Measures had to be balanced for several goals, e.g.:

• Exploitation of daylight. This 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. This 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. This will benefit users' contentment and well-being. The desired reverberation time will vary according to functions, and contradictory considerations may have to be taken into account regarding multi functional spaces. The placement of absorbers must be considered in relation to the request for thermal mass.

Environmental assessments

A simplified environmental assessment has been performed during the design of Borgen Community Centre [1]. The assessment was based on the Norwegian EcoProfile methodology [12]. Due to the fact that the EcoProfile is primarily used for existing dwellings and office buildings, some adjustments of the method had to be done in order to make it suitable for school buildings still in the design phase. The assessment was carried out by the researchers, who also gave guidance to daylighting design and solar shading and were consulted in the design of the ventilation systems. Further the researchers made studies on exploitation of solar energy and application of double skin façades.

EcoProfile classifies a building based on three main criteria: *Exterior Environment, Resources*, and *Indoor climate*. These main criteria have many subcriteria. The criteria are assessed in three levels: level 1 is «low environmental loading», level 2 is «medium environmental loading» and level 3 is «high environmental loading».

The assessment showed that the building design performs relatively well on all environmental criteria. The bar graph shows the result of the EcoProfile analysis. The project was classified in the best category: «low environmental loading» for all the main criteria. The star diagram allows more detailed information on the resources subcriteria.

Based on the assessment a focus list for further work was elaborated.

MONITORING AND EVALUATION

The energy consumption has been estimated to 111 kWh/m^{2}a. The estimates are based on simulations with the Norwegian computer program «Energy in buildings» [11]. Measurements after retrofitting show some lower consumption than estimated in the design phase. Measurements before retrofitting show 280 kWh/m^{2}a. The average energy consumption for new school buildings is 220 kWh/m^{2}a.

Reports on building performance (measurements and user evaluations) and lessons learnt from process, concepts and applied technologies are now available at the BRITA project's website [5], including a description of the development of Borgen Community Centre [3].

Statement from the municipality
«Borgen Community Centre stands as a very successful project, representing a major contribution to improve environment and indoor climate. I register with pleasure that our goal of reducing energy consumption by at least 50 % has been achieved by a good margin. Our experience with the technical principles applied to the building represents a good foundation for future buildings in our municipality. The building has also been awarded a prize for being an environmentally friendly building, and the response from the users is very positive.»
– Head of project department

LESSONS LEARNT

CHOOSING A DESIGN TEAM

An interdisciplinary planning process is essentially based on the idea of optimised teamwork, which should start in the pre-project stage to make a clear definition of goals. Furthermore, 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. [6, 9, 13]

The owner of one of the other BRITA demonstration buildings had been told that the design team had experience in sustainability and environmental matters. But when getting to know them further, it became clear that this has been more of a wish to get involved rather than real credible experience. The problem with the lack of knowledge is that when the pressures of the project come to bear, the designers subconsciously fall back on previous experience which pushes good environmental design to the 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 demanding 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. However, a focus on simply appointing the most economic design team will most probably result in rushed and poorly thought out designs.

New concepts and new technology applications are challenging for building owners, architects and consultants. If the design team lacks knowledge of environmental issues or if the performance goals are especially challenging, an external process facilitator should be added to the team. The facilitator will have the task to raise performance issues throughout the process and bring specialised knowledge to the design team [7, 9].

CREATING A DIALOG

Usually there are several considerations to attend to in a building project. The planning team should provide suitable facilities with high comfort levels for the users and have the long-term economy of operation, maintenance and adaptability in mind. In general, when broad and qualitative objectives are set at the beginning of a planning period, precaution should be taken to be able to fulfil the objectives. Professionals with different competences as well as users should be involved already in the conceptual phase, and the building's environmental footprint should be assessed through out the planning process. Sufficient time for planning is often a crucial factor.

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 functional and aesthetical aspects as well as the semantic messages of a building communicating values. The architects might sometimes feel that they have to fight for the «soft issues» of 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.

ASSESSMENTS

Different solutions have different strengths and weaknesses, and the project team at Borgen had to optimise the solution as a whole, and not on a component-by-component basis. From the assessment of different solutions the project team can identify parameters that make a difference and gain an increasing awareness of the environmental impacts of the design.

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 key targets as well as the measures required for energy efficiency. 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.

Many countries have developed tools to support the design phase, ensuring sustainability is properly considered [7]. In the UK a helpful tool is *BREEAM* (BRE Environmental Assessment Method) [2]. Other countries have similar tools to ensure consideration of the wider sustainability and energy efficiency issues.

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 short-comings, 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. 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 at the same time as the design fees; otherwise they are likely to be quite high. For the building operating staff of Asker municipality a training course, lasting for two days, has been carried through at the Borgen Community Centre. This training course was financed by the EU, as part of the BRITA project.

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. what have been the critical factors from the point of view of the architects, consultants, contractors and clients.

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LITERATURE

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(1) ANDRESEN, I AND HESTNES, A.G. (2005). *Environmental assessment of the re-development project of Borgen Community Centre.* Norwegian University of Science and Technology. Project report. http://edit.brita-in pubs.eu/fundanemt/files/Borgen_Environmental_assessments.pdf

(2) BUILDING RESEACH ESTABLISHMENT. *BREEAM: BRE Environmental Assessment Method.*
Assessment tool. http://www.breeam.org/

(3) BUVIK, K. (2008). *Rethinking the design of school buildings.* Lecture manuscript. http://edit.brita-in-pubs.eu/fundanemt/files/Borgen_Rethinking-the-design-of-school-buildings.pdf

(4) BUVIK, K. (2003). *Miljøvennlige skoleanlegg.* Thematic booklet. Norwegian Directorate for Education and Training. http://www.skoleanlegg.utdanningsdirektoratet.no/index.gan?id=1993&subid=0

(5) EU PROJECT. *Bringing Retrofit Innovation to Application in Public Buildings* (BRITA in PuBs). Project website. http://www.brita-in-pubs.eu/

(6) HESTNES, A.G. (2008). *Integrated design processes – a must for low energy buildings.*
In «The Future of Civil Engineering».
ISBN 978 8772510.

(7) HESTNES, A.G. (1999). *Integrated Design of Solar Buildings: The Work in IEA Task 23.* Proceedings of Intelligent Building Design Conference, Stuttgart.

(8) HESTNES, A.G. AND ANDRESEN, I. (2007). *Smart prosjektering*, pages 29-43 in «Smarte energieffektive bygninger». Tapir Akademisk Forlag. ISBN-978-82-519-2237-1.

(9) LARSSON, N., POEL, B., HESTNES, A.G., AND LÖHNERT, G. (2003). *Solar Low Energy Buildings and the Integrated Design Process.* Proceedings of ISES Solar World Congress, Göteborg.

(10) MATUSIAK, B. (2005). *Daylight conditions at Borgen Community Centre.* Norwegian University of Science and Technology. Project report. http://edit.brita-in pubs.eu/fundanemt/files/Borgen_Daylight_conditions.pdf

(11) PROGRAMBYGGERNE. *Energi i Bygninger.* http://www.programbyggerne.no/

(12) STIFTELSEN BYGGSERTIFISERING. *ØkoProfil – Miljøvurdering av bygg.* Assessment tool. http://www.byggsertifisering.no/oekoprofil/

(13) VOSS, K, LÖHNERT, G. ET AL. (2006). *Bürogebäude mit Zukunft. Konzepte–Analysen–Erfahrungen.* Karlsruhe, Germany: BINE Fachinformationzentrum. Project report.