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Integrated energy design – an approach for regenerative design based on evidence

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Abstract: The second semester of the Master course "Sustainable Architecture" topic "Integrated Energy Design" at the Faculty of Architecture at the University has 20 students and 8 teachers in spring 2011 to investigate opportunities for energy and environmental transformation of existing buildings. The project tries to develop knowledge in integrated solutions that link energy and design of existing buildings. Centrally important is the dissemination of information about energy and environmental-and climate-friendly solutions in housing and building and sustainable living and building / architecture. Three different buildings were examined:

- Linesøya school building
- Fire station in Surnadalsøra
- Rotvoll barn at Camphill / Steiner school in Trondheim.

What became obvious is that the ambitions of a project are an important factor. They not only define the success of the project in terms of measurable CO2 emission reductions but also predefine sets of solutions that are applicable.

Keywords: architectural design, energy efficiency, community commitment.

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1. Introduction (M_Heading1)

The second semester of the Master course "Sustainable Architecture" topic "Integrated Energy Design" at the Faculty of Architecture at the University has 20 students and 8 teachers in spring 2011 to investigate opportunities for energy and environmental transformation of existing buildings. The project tries to develop knowledge in integrated solutions that link energy and design of existing buildings. Centrally important is the dissemination of information about energy and environmental-and climate-friendly solutions in housing and building and sustainable living and building / architecture [1].

Three different ones buildings were examined:

- Linesøya school building
- Fire station in Surnadalsøra
- Rotvoll barn at Camp Hill / Steiner school in Trondheim

1.1. Linesøya school building

An old school building on the coast near Trondheim, in close proximity to the actual rehabilitation project is being planned under the auspices of Eggen Architects. Linesøya Passive House is a Nordic pilot project in sustainable and energy efficient architecture. A school built in 1952 will be converted to a display building for passive and operated as an environmental center [2]. The building will consist of a living area and gallery, and will offer visitors exciting outdoor activities in the community [3].

1.2. Surnadalsøra fire station

The project will assess how ambitious energy renovations in existing buildings can be. Here special focus is on using environmentally friendly materials and the integration of public hand in environmental work. There are all local players integrated into the regional spread of knowledge, skills, showcase projects and quality assurance of these.

1.3. Rotvoll barn building

An old barn in Rotvoll, Trondheim, in close proximity to the actual rehabilitation project is being planned under the auspices of Beredsen Architects. Rotvoll barn is a Nordic pilot project in energy efficient architecture and selvsuffisient lifestyle. A barn is to be converted to condominiums and offices for passive and operated as part of Camphill Norway. The building will consist of a living areas, workshops and office parts, and will show the concept of a zero emissions society.

The teachers in the integrated energy design course are all experts in various aspects of energy, environment and resource use in architecture, with experience in consulting, research and practice [4].

We were therefore contacted by builders with information about the projects, and request that could be of interest to us to involve a student-development project in parallel with the current projects on Linesøya, Surnadalsøra and Rotvoll.

Students are given three different frameworks to explore the possibilities inherent in the projects. Linesøya project will investigate the possibilities of the transformation of passive and plusenergihus, Surnadalsøra fire station to see the possibilities of transformation in urban development and Rotvoll project will focus on the local environment and culture.

By "research by design" explores and highlights the architectural students the opportunities associated with energy and environmental transformation of existing buildings, focusing on materials and energy, features, local communities and culture. The project includes largely cooperation with the local building industry and population, such as to contribute to the mutual knowledge and - dissemination.

Continuously stricter building regulations make it necessary for architects to gain expertise in environmental design and careful resource use in architecture [5, 6]. There is great need for projects that show that the more stringent requirements do not mean a reduction of architectural quality but also helps to produce good architecture. Students can, through their projects, help to explore and highlight the good opportunities, and question the established practice.

2. Results and Discussion

2.1. Linesøya

Is it possible to lower resource use and at the same time increase the quality of the built environment? Is there necessarily a conflict between low-energy design and usability? Can architecture and planning actually contribute to lowering a local community's carbon footprint? And can this be achieved while maintaining a high quality of life and a stimulating built environment?

Figure 1. (a) Linesøya school building; (b) view through the window

These questions form the background for the renovation of a 1950's school building at Linesøya. Building owners Sukhi Karlsen and Thomas Flower-Ellis of the LiPa Environmental Project invited students to contribute to its development: the conversion of a 1952 school building to passive house standard [3]. The overall goal for this project is to raise awareness regarding resource efficiency measures in architecture and particularly in existing building mass, and to provide a hands-on example with regards to energy efficiency, architectural design and craftsmanship for a low-carbon society. Linesøya Passive House is an interdisciplinary project in which all of the participants are driven by a

strong environmental engagement and a desire to raise awareness and increase competency regarding sustainable architecture in the building sector and society in general. In order to maximise the transfer of knowledge and learning experiences on a local, national and international level, marketing, demonstration and dissemination activities have been given high priority [4].

The project aims to provide a hands-on example with regards to energy efficiency, architectural design and craftsmanship for a low-carbon society. The building will incorporate housing as well as environmental demonstration and meeting facilities.

2.1.1. Energetic renovation of the existing building

The students were encouraged to work on integrated design solutions in which architecture and technology support and enhance each other. They needed to combine good indoor comfort with energy conservation, including energy supply and use of renewable energy. To this purpose, the students are taught a range of tools that can be used to document energy performance, such as ECOTECT and PHPP [7, 8]. In addition to energy use during operation, the students evaluate the embodied energy of the materials and components used in the building, the durability of the component design, the flexibility of the connections, and the generality of the floor plan and building geometry to facilitate a second service life.

2.1.2. Connection to local history, context and community

Linesøya is an island of 17 km2 with 37 km2 of shoreline. There are six farms, about 30 main and 100 second homes. Currently a local ferry constitutes the only transport to and from the island, but a bridge is under construction. Most of the around 60 permanent inhabitants have a distinct relation to the old school building, and have even used its classrooms as a child. The basement of the building is currently used as local gym while the building owners use some of the rooms on the ground floor as their residence. Therefore, a delicate balance needs to be designed between the public and private spaces in the building, along with a close connection to the landscape on the island, its traditional building style and vast vistas to the fjord. In addition, it is very important to create a distinct identity for the new environmental centre that is carefully related to the need for refurbishment and protection of the old structure.

2.1.3. Usability, local climate and site

The student projects needed to show a thorough understanding of the nature of the site and its connection to the surrounding environment, such as orientation, view, traffic, and green infrastructure. The functional programe includes housing facilities, kitchen, conference facilities, exhibition area, entrance and toilets; also accommodation can be included. The students explore flexibility and usability during the building's entire lifecycle, with different patterns of use according to season and type of visitors. Based on these assessments, a space-efficient design is created in accordance with the occupancy of different types of rooms and the corresponding need for heating, shading, ventilation and lighting.

2.1.4. Project outcome

Figure 2. Linesøya project proposal after renovation

The students submitted four A1 posters containing project and site plans along with schematic diagrams showing the environmental and architectural strategies used in their design. Student calculation reports show that most of the designs for the renovated building barely reach passive house standard. However, the students do report an increased awareness and knowledge about the vast challenges building professionals need to overcome to unite technical details and high user quality into good environmental performance. Close contact with the building owners and project team have provided the students with the unique opportunity of intensive interaction between clients' wishes, practical limitations in building design, and their own design practices as students. In addition, the students have taken part in blower-door tests and thermographic measurements in the building, lead by the teaching staff, which has given the students insight in some of the more practical considerations in building renovation. The posters have been exhibited at the university for two weeks, after which they were moved to the Linesøya school building to present the ideas to the local population.

2.2. Surnadalsøra

The long history of the Surnadalsøra fire station form the background for the renovation wishes in order to preserve the historic value of the site and its former role in the village.

A group of permanent residents from Surnadalsøra supported the idea of regenerating with help of a refurbishement and reinvention of new functions to an old building structure. Therefore they invited students to contribute to its development right from the start. The overall goal for this project is to raise awareness regarding resource efficiency measures in architecture and particularly in existing building mass, and to provide a hands-on example with regards to energy efficiency, architectural design and craftsmanship for a low-carbon society. The refurbishment of the old fire station is a project in which all of the participants are driven by a strong conservational engagement and a desire to raise awareness regarding sustainable development of Surnadalsøra and villages in coastal Norway in general. The project aims to provide a hands-on example with regards to energy efficiency, architectural design and craftsmanship for a low-carbon society. The different student groups decided on different functions for the building in order to regenerate the more and more abandoned village centre.

2.2.1. Energetic renovation of the existing building

The students were again encouraged to work on integrated design solutions in which architecture and technology support and enhance each other. They needed to combine good indoor comfort with energy conservation, including energy supply and use of renewable energy. To this purpose, the students are taught a range of tools that can be used to document energy performance, such as ECOTECT and energyplus [9]. In addition to energy use during operation, the students evaluate the embodied energy of the materials and components used in the building, the durability of the component design, the flexibility of the connections, and the generality of the floor plan and building geometry to facilitate a second service life.

2.2.2. Connection to local history, context and community

Surnadalsøra is a small village about 150km southwest of Trondheim. There are a number of farms, about 30 main and few second homes. A group of permanent inhabitants have a distinct relation to the old fire station building, and were against the construction of the new fire station some kilometers away. The building is located right in the center of the village. Therefore, a focus was put on the public functions of the building, to create a distinct identity for the new centre and a regeneration of its links to the existing village structure, its traditional building style and vast vistas to the fjord. In addition, it is very important that its new role attracts people to come to visit the village but in a sustainable manner. Public transport links were proposed, partially trying to revitalize the historic transport ways on the fjord.

2.2.3. Usability, local climate and site

The student projects needed to show a thorough understanding of the nature of the site and its connection to the surrounding environment, such as orientation, view, traffic, and green infrastructure. The functional program included accommodation facilities, kitchen, workshop facilities, exhibition area, entrance and toilets; also kindergarten functions can be included. The students explored flexibility and usability during the building's entire lifecycle, with different patterns of use according to season and type of visitors. Based on these assessments, a space-efficient design is created in accordance with the occupancy of different types of rooms and the corresponding need for heating, shading, ventilation and lighting.

2.2.4. Project outcome

The students submitted four A1 posters containing project and site plans along with schematic diagrams showing the environmental and architectural strategies used in their design. Student calculation reports show that most of the designs for the renovated building barely reach passive house standard. However, the students do report an increased awareness and knowledge about the vast challenges building professionals need to overcome to unite technical details and high user quality into good environmental performance. Close contact with the building friends group have provided the students with the unique opportunity of intensive interaction between clients' wishes, practical limitations in building design, and their own design practices as students. In addition, the students have taken part in with the local communal representatives, which has given the students insight in some of

the more practical considerations in building renovation. The posters have been exhibited at the university for two weeks, after which they were moved to the fire station building to present the ideas to the local population.

Figure 3. Surnadalsøra renovation levels and CO2 emission accounting (student work)

2.3. Rotvoll

2.3.1. Energetic renovation of the existing building

The students were again encouraged to work on integrated design solutions in which architecture and technology support and enhance each other. They needed to combine good indoor comfort with energy conservation, including energy supply and use of renewable energy. To this purpose, the students are taught a range of tools that can be used to document energy performance, such as ECOTECT and Simien.

Figure. 4. (a) Rotvoll farm; (b) Rotvoll barn

2.3.2. Connection to local history, context and community

Rotvoll is a small community at the northern periphery of Trondheim. There are a number of buildings that form an old farm, with greenhouse, bakery, and ecological shop. Camphill owns half of the estate while the other half is owned by the local Steiner School. The inhabitants have a distinct relation to the old barn building, and were trying to reuse it and transform it into living space.

Definitions of regenerative design, regenerative development and regenerative thinking differ, but community engagement is an integral component of these definitions [10]. A critical aspect in regenerative approaches is the focus on the uniqueness of 'place' and the creation of a story of the place, with the local community playing a crucial role in developing this story. Practitioners have found that engaging communities in these efforts requires a different approach, one that is designed to elicit and clarify aspirations and values and which enables the community to recognize and feel its connections to the natural systems of which they are a part.

An approach to community engagement is to engage those parts of communities that have a generally good environmental mindset. Its basis is founded on establishing honest, deep and ongoing dialogue within the community and between the community and the project team. As case studies indicate, one of the most important benefits of a process of dialogue is a community that has developed shared goals and leaders to ensure progress toward those goals over time [11]. Wider implications for design and planning professionals include the potential to redefine their processes and services, examining responsibilities to the local community and working with the research community to develop a wider 'evidence base' [12].

2.3.3. Usability, local climate and site

The student projects needed to show a thorough understanding of the nature of the site and its connection to the surrounding environment, such as orientation, view, traffic, and green infrastructure. The functional program included housing facilities, kitchen, workshop facilities, nursing homes area, entrance and toilets; also theater and concert functions can be included. The students explored flexibility and usability during the building's entire lifecycle, with different patterns of use according to season and type of visitors. Based on these assessments, a space-efficient design is created in accordance with the occupancy of different types of rooms and the corresponding need for heating, shading, ventilation and lighting.

2.3.4. Project outcome

The students submitted four A1 posters containing project and site plans along with schematic diagrams showing the environmental and architectural strategies used in their design. Student calculation reports were developed together with climate engineering students from ntnu. However, the students do report an increased awareness and knowledge about the vast challenges building professionals need to overcome to unite technical details and high user quality into good environmental performance. Close contact with the building owners have provided the students with the unique opportunity for intensive interaction between clients' wishes, practical limitations in building design, and their own design practices as students. In addition, the students are taking part in seminars together with the local communal preservation representatives, which gives the students

insight in some of the more practical considerations in building renovation. The posters were exhibited at the end of the semester for two weeks, after which they were moved to Camphill in Rotvoll to present the ideas to the local community.

3. Conclusions

The second semester in Sustainable Architecture was tailored to cope with the interdisciplinary challenges in connection with this task. The structure of the course was changed so that monodisciplinary theoretical input could be given in the beginning of the semester. Then, the design project was introduced as a problem that catalyzes the solution finding process and improves the 'evidence base'. At the end a relatively simple design project worked as the starting point to explore building physics and construction related problems and put them into context with social and societal questions. Energy design in that respect worked as the symbiotic parameter that connects the different issues and helped to not get lost in the multidisciplinary ditch of priorities.

List of seminars that help to create an 'evidence base':

- Building physics /building envelope
- Ventilation and building services
- Daylight
- Passive house
- Solar energy
- Building simulation
- Conservation
- Life cycle analysis
- Zero waste and behavior

How can the results of this research by design exercise be used for other projects? What became obvious is that the ambitions of a project are an important factor. They not only define the success of the project in terms of measurable CO2 emission reductions but also predefine sets of solutions that are applicable. Therefore, a solution depends on the scope of the research and the goal settings at the beginning.

This can be illustrated in three levels of frameworks to explore the possibilities inherent in the projects as shown in Figure 5.

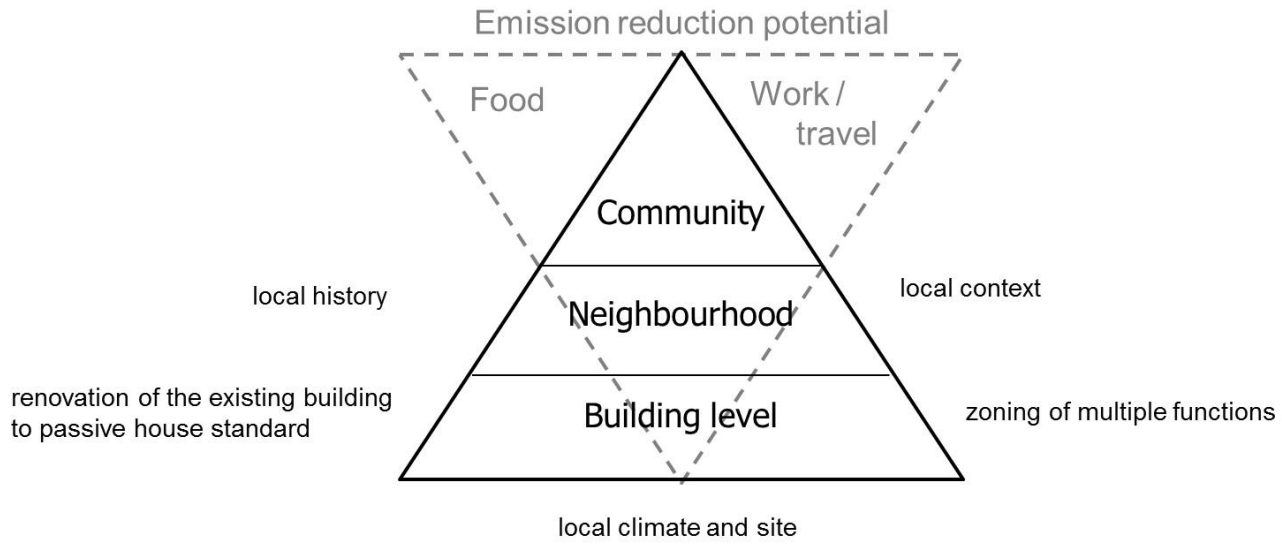

Figure 5. Levels of framework with total emission reduction potential

Finally, recommendations for further design work should focus on the following:

1. Renovation of the existing building to passive house standard: This means that the building is insulated to reduce heat losses. The heating demand is not completely reduced to zero but so far reduced that a simplified heating system is sufficient.

2. Zoning of multiple functions according to usability, local climate and site: Climate and site related specifications are those that should be fully integrated with usability aspects resulting in a zoning that takes energy and heat loss into account.

3. A meaningful connection to local history, context and community: This part of the design work links the regenerative aspects of energy and usability in the context of the history and usefulness on a communal level.

However, the total CO2 emissions depend on community level on influences from other sources, such as work and preferences, travel and commuting pattern as well as user pattern of the building (temperature levels, operation hours) that have a major influence on emission reduction potential. This has to be taken into consideration when trying to reduce emissions in the built environment. Regenerative design should take these aspects into account and find an architecture that reduces the total emissions of society.

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Conflict of Interest

The authors declare no conflict of interest.

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