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Energy Renovation and CO_2 Reduction Project

This case describes a private-home renovation project completely outside the application area of the MUST design method (Bødker, et al. 2004; 2011, Bratteteig et al., 2012). The case demonstrates how MUST's four principles can be situated in design projects that do not focus on IT. The project was not conducted as an IT-design project and did not specifically follow the phases or use any IT-related techniques and tools from the MUST method. The MUST principles were, however, an explicit concern during the project, as represented by one key designer, the owner, who is also a coauthor of this chapter.

Global climate changes caused by burning fossil fuels have led to a general concern about our society's energy consumption. A large part of energy consumption is due to heating and cooling the buildings we live and work in. The Nordic Council of Ministers established, as part of a joint Nordic vision to prepare for future independence from fossil fuels, the Nordic Energy Municipality initiative. This initiative focuses on sustainable energy, green growth, and energy-related climate work in the Nordic countries. The aim of the initiative was to recognize, in particular, municipalities that make an extraordinary effort to implement innovative energy and CO_2-reducing projects. The Danish municipality of Albertslund was, in 2011, named the Nordic Energy Municipality, based on the "Albertslund-concept of energy-effective renovation of houses" (Nordic Energy Municipality 2012).

The majority of the housing stock in Albertslund was built between 1968 and 1972, before the energy crises of the seventies. The municipality aimed for an overall 25 percent reduction in CO_2 emissions by energy renovation of the housing stock. Nine demonstration projects were completed to develop new standardized energy solutions in 2011 and 2012. These projects renovated energy-consuming houses build in the sixties and seventies into CO_2-friendly houses, meeting the new standards for low-energy houses (the so-called Building Regulation BR2015 standard).

One of the demonstration projects was a privately owned town house built in 1971. The project comprised the following features (see fig. 4.1):

- Exterior insulation of roof and walls mounted as a new shell on existing facades.
- Solar panels ensuring self-sufficiency in electricity.
- Electrical-grid-powered roof windows with rain sensors.
- Electricity-powered exterior awning blinds providing more daylight and fresh air while also preventing overheating during summertime.
- Air ventilation with heat recovery to maximize indoor climate as the renovation made the house completely airtight.
- Wireless centrally controlled heating thermostats allowing daytime and nighttime temperature drop when the occupants are away or asleep.
- Rainwater filter, draining rainwater from the roof back to the ground instead of to the sewer system to accommodate the increased flooding risks resulting from climate change.

Coherent Vision

The MUST principle of coherent visions for change includes a metaphor of sustainability that in the project became a key success factor regarding the economy.

At the many public meetings where the architects presented their ideas, the residents repeatedly mentioned their concerns regarding the economy of the project. All houses in Albertslund are heated by a large district heating plant providing some of the cheapest heating costs in Denmark. Although the houses are poorly insulated and drafty, they are therefore relatively cheap to warm up. The architects and energy consultant were enthusiastic about the project and aimed for an ambitious energy renovation. This challenged a reasonable cost-benefit result that is sensible for a privately owned house. The resulting prototype house was to be designed as a standard solution to inspire future renovations throughout the neighborhood. However, no one could be forced to renovate his or her house; the owner of a private property solely decides on this investment. Thus a sustainable solution was contingent on being economically viable.

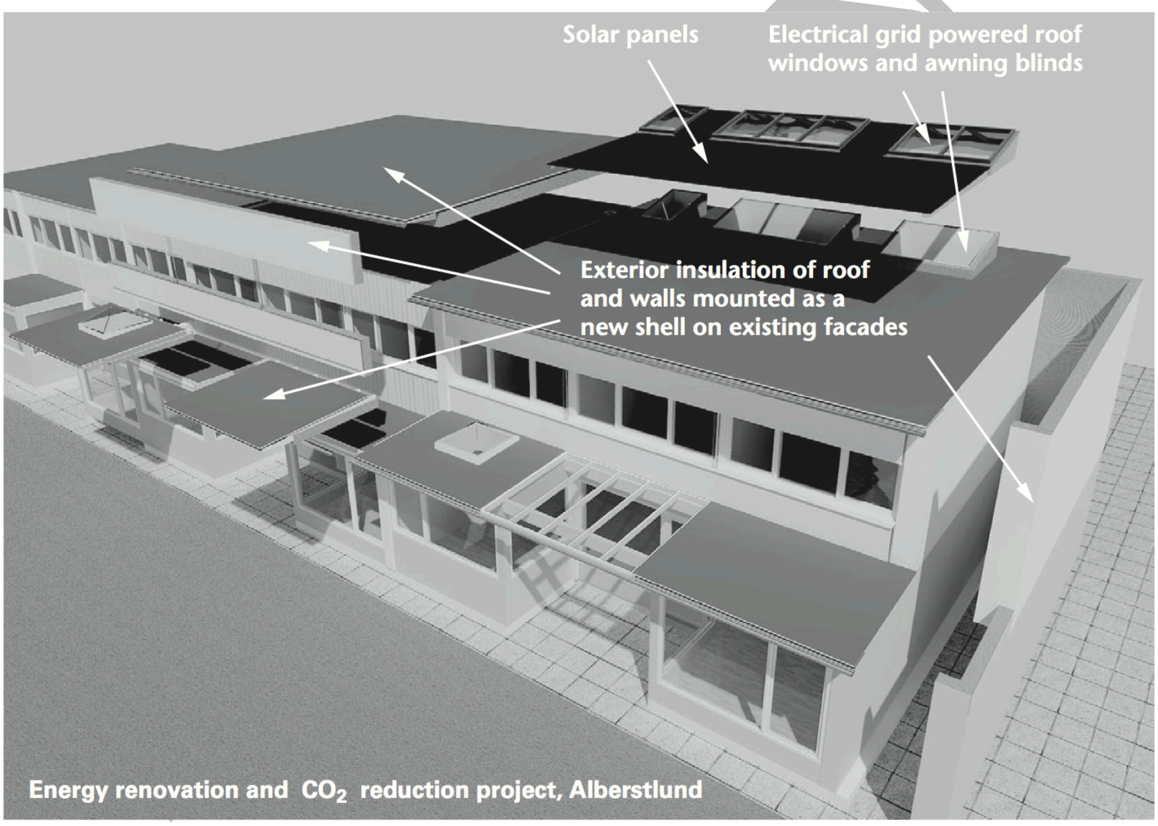

Figure 4.1 Model of the demonstration project made by Martin Rubow, Architect MAA, and Carl Galster, Architect MAA.

The contractors' bid on the first detailed design proposal turned out to be too expensive and would have resulted in a considerable mortgage increase even when taking the lower heating costs into account. The project was then profoundly redesigned, cutting all high-expense and low-energy-saving ideas, including dropping insulating the footing below ground level, aligning windows and doors with the new shell, and so on. Moreover, during the actual project, many new ideas were developed regarding how to further minimize costs, including blowing insulation granulate into prefabricated shells rather than attaching insulation batting and plastering a shell onto these afterward. The result is a renovation where the energy cost savings almost balance the investment. And taking the additional improved environmental, comfort-related, and aesthetic elements of the project into account, the investment is broadly assessed as both beneficial and attractive.

The balance between technology, organization, and qualifications, which is also included in the principle of coherent visions, was not explicitly addressed in the project. This might have been relevant, as the involved technologies do have consequences regarding organization and qualifications:

- Organizational consequences include, for example, behavioral change to airing, heat adjustment, and aligning electricity use with solar panels production.
- New qualifications are required to configure and use the advanced systems controlling ventilation, heating, and electrical windows and blinds. The user manual for the windows and blinds is, for example, ninety-eight pages long and written in a highly technical language.

Genuine User Participation

The MUST principle of genuine user participation, its political argument regarding the user's right to influence a design, and its related theory of mutual learning processes were realized during the renovation project in relation to the design of the roof construction of the house.

The architects' design ideas, drawings, and increasingly detailed plans of the project had been presented and discussed at several meetings with local authorities and at town hall meetings where the neighborhood residents were invited. The town houses are regulated by a restrictive district plan to maintain a uniform appearance, including a detailed list of the colors to be used for the buildings, style and size of windows, fences, extensions, and so on. The renovation had to be balanced in such a way that one renovated house among the others in a row did not look too different from the existing houses.

Any design that would differ too much from the existing regulations would require an alteration of the district plan, and this involves a complicated and time-consuming procedure, hearings among the local residents, and ultimately a new bill to be passed by the city council. Discussions involving the district plan usually spur great public interest; this plan imposes many constraints that the residents need to be aware of when they maintain and change their houses.

Perhaps the most distinct feature of the architects' design ideas was to construct the new insulated roof with a large overhang (fig. 4.2). This overhang was intended to protect the facade and windows and to minimize solar radiation that caused the houses to overheat during summertime.

As a final step before the renovation could be initiated, the design had to be approved by the municipality's agency for construction work. The agency judged that all design ideas could pass through an exemption except the roof overhang, which would require an alteration of the district plan that the agency would not recommend to the city council. Therefore the agency asked the architects to redesign the project without a roof overhang.

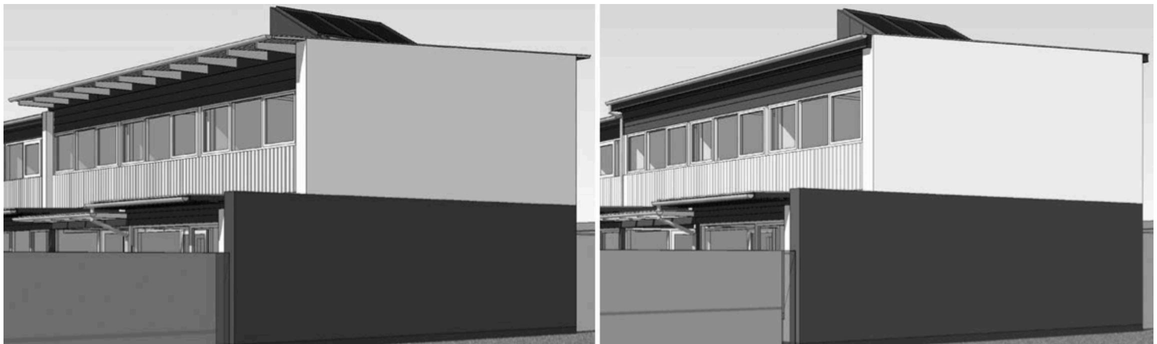

Figure 4.2 Design with roof overhang (left) and without (right). Model by Martin Rubow, Architect MAA, and Carl Galster, Architect MAA.

The new design (roof without overhang) was discussed by the executive committee of the homeowners' association. The committee was extremely disappointed that the municipality had declined the former design. They objected to the decision, but the agency dismissed their protest. Then the committee brought the new design proposal to the neighborhood's annual general meeting. At the meeting, a motion was carried unanimously requiring the committee to insist on the original design solution. This public pressure forced the municipality's agency to acknowledge and initiate a change to the district plan to allow for an approval of the original design, including the large roof overhang.

The local democratic process and mutual learning involved in the participation of residents (users) and professionals (architects and local-authority experts) required that the residents learn about the design options of the project and that the professionals learn about a core interest of the residents. This interest was not driven by the designers' functional arguments for the roof overhang. Rather, it was the residents' interest in the aesthetic change—that the roof overhang actually represented a major change of the district plan. If a homeowner is to invest a considerable sum of money in renovating his house, he wants it to be visible that he has actually done so. The roof overhang was one of the most distinct changes indicating a modern and newly renovated house.

Firsthand Experience

In the MUST method, the principle of firsthand experience is originally intended for using ethnographically inspired techniques to access concrete experiences of work practices before the introduction of new technologies, as well as experiences of using early prototypes before full-scale implementation. In this project, the principle was applied with the latter intention in mind only.

Experiencing the newly renovated house proved to have a vital impact regarding the assessment of the different solutions and the dissemination of the renovation to other households (see also the next section, on the anchoring principle). There is a qualitative difference between looking at different models of the house (e.g., figs. 4.1 and 4.2) and considering calculations on energy savings versus entering and experiencing a full-size prototype house.

Hundreds of neighbors and other interested parties have visited the house at open-house arrangements. An immediate impression was meeting a house that looked like a newly built house (due to the new roof and new facades) and experiencing a highly perceptible change of the inflow of light inside the house (due to the new large roof windows). This considerable aesthetic improvement had no voice in the many discussions at public meetings held during the years before the project. Along with the owners' communicated experiences of an improved indoor climate without cold walls, drafts, and overheating on sunny days, and with constant fresh air and less dust without airing several times a day, experiencing the renovations firsthand will most likely provide many neighbors with the decisive motivating factor for making the investment.

Anchoring Visions

The MUST principle of anchoring visions includes attempting to gain wider support by openly presenting design ideas and proposals and testing critical assumptions and hypotheses (see e.g. Simonsen, 2007). In the renovation project, the anchoring principle was specifically concerned with achieving a sustainable solution that would be both attractive and economically viable to households in the neighborhood, motivating them to invest in ambitious energy renovation.

The design strategy included completing the renovation while the house's occupants continued to live there. The insulation was done from outside, encasing the existing walls and roof with a new shell including 200 to 300 millimeters of insulation. The project was designed in modules (each with a separate energy-savings calculation) to be completed in separate phases and at levels of ambition concurrent with the owner's desires and economic capability; a household could, for example, start with a new insulated roof (when the roof needed maintenance anyway) and then later insulate the walls.

One major design approach to minimize costs was to attach the new insulated roof on top of the existing roof, thereby also closing the ventilation of the existing roof. This necessitated many technical considerations to ensure that the new vapor barrier would not later cause moisture and mold. Albertslund is widely known for a major construction scandal in the 1970s, when many of the prefabricated constructions with flat roofs (a new construction approach at the time) resulted in severe and costly moisture and mold damage. Construction experts approved the final solution, but many residents were concerned about whether it would actually work out. To test the hypotheses underlying the roof solution, wireless readable humidity sensors were placed in the roof construction. In this way, the validity of the roof construction solution and possible risks of moisture damage could be monitored.

After the renovation was completed, a number of logging devices (measuring district heating consumption, room temperatures, electricity consumption and production, ventilation volume, etc.) were installed to test the assumed energy reduction and cost savings related to different technologies implemented in the project. The data from these loggings aim at measuring the solar panel electricity production compared to the concurrent electricity consumption, efficiency of the ventilation with heat recovery versus traditional ventilation, savings resulting from daytime and nighttime temperature drop regulation, and so on. Consequently the calculated (assumed) savings can be supplemented by actual values measured from each different energy solution.

The principle of anchoring visions was of great relevance in the renovation project to establish support and motivation for the residents to invest in energy and CO_2 reduction in their private households. This was approached by taking the residents' economic concerns seriously, testing and documenting economic and technical assumptions and hypotheses, and implementing a full-size demonstration project where aesthetic, economic, technical, and indoor climate aspects could be experienced and evaluated.

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