Sustainable Renewal of 1960–70's Multi-Family Dwellings




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Summary
The Norwegian research project Bærekraftig oppgradering av boligblokker or REBO is presented in this paper. This project deals with the comprehensive upgrading of multi-family dwellings which included both internal and external renovations. The focus areas of research are energy efficiency, universal design and resident involvement in the planning process. Two typical Norwegian owner occupied multi-story concrete blocks are presented to illustrate general design principles and the application of various measures. The main findings are:

- It is possible to make upgrades according to the Passive House concept economically profitable when the building mass is in poor condition and a major renovation must be undertaken. In this circumstance upgrading with Passive House components may be more lucrative – additionally; this will improve the indoor climate and comfort of the residents. Retrofitting the most urgent repairs needed, with only slightly better standards, may easily become unaffordable in the long run, and ruin the chances for more ambitious renovations in the future.

- Universal design is of great importance because it provides people greater choice in where to live. A number of actions simple or extensive can be carried out when renewing a dwelling area. Examples are installation of lifts, elimination of door sills, creation of pathway surfaces for wheeled walkers, and markings for ease of orientation. Some measures can be expensive, while others are only small expenditures. In the cases presented, actions have been taken to increase the accessibility of persons with impaired movement, while actions to increase orientation for the visually impaired were not prioritized.

- A well functioning board, and trust between the residents and the people in charge of the rehabilitation process is a requirement for success. When the residents were sufficiently informed about the rehabilitation their participation was of great value in making a success of the project. They were not necessarily a part of every decision made, but showed great confidence in the leadership of the project.

Keywords: dwellings; retrofitting; energy efficiency; design for all; resident participation

Upgrading with a focus on energy efficiency

The starting point is the application of measures to reduce energy demand, and then supply the remaining demand with an energy supply system utilising renewable energy sources. Passive energy design is in principle applicable to both low energy buildings and Passive Houses.

Fig. 2 Myhrerenga before upgrading. Photo Arkitektskap AS

Fig. 3 After upgrading. Photo SINTEF Byggforsk

Myhrerenga housing cooperative was the first apartment complex renovation in Norway which used Passive House components. Façades in need of renovation, together with complaints about draft, cold floors and poor air quality, as well as requests for larger balconies, initiated the renovation process in 2006. Since the buildings were in need of a major renovation anyway, the Norwegian State Housing Bank in cooperation with SINTEF suggested an ambitious «Passive House renovation», which was assumed to cut the net space heating demand by 80–90%. At the same time, the ambitious renovation should not be more expensive than a conventional façade renovation, expressed in figures of total monthly costs for loan, energy, maintenance and property management. After a two year long process, the cooperative decided to go for the ambitious renovation. Now, in April 2011, most of the interior work is already finished.

Upgrading with a focus on universal design

Working with universal design a broad spectre of solutions will be necessary, such as installation of lifts, avoiding long distances from parking places to the entrance door, making antiskid pathways free of steps, and installation of automatically opening entrance doors. Measures to ease the orientation for visually impaired persons are lane lines and contrasts by colours, materials, or lightening, differing one part from another. Hearing impairment, which is also common among elderly, requires the need for visual signals, such as visual fire detectors, and generally good acoustical conditions. Strategies to increase accessibility inside each flat can involve making one room out of two to enlarge the bath or bedroom, removing door sills at the front door and to the balcony, and replacing narrow doors with broader ones.

Fig. 4 Before upgrading. Photo Jarl Høva

Fig. 5 After upgrading. Photo Jarl Høva

Barkaleitet housing cooperative has implemented several smart universal design solutions; wheelchair access to the entrance doors and outside areas, and extensions with new staircases and lifts. The flats on the new top floor have meet standards for wheelchair use. However, improvements to door sills at the front doors and to the balconies have not been done. Also attention has not been given to make orientation easier for visually impaired persons.

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1. Introduction

The Norwegian research project REBO is presented in this paper. This project deals with the comprehensive upgrading of multi-family dwellings including both internal and external renovations. The aim of this project is to show how post war residential environments can be improved in

general, with a specific focus on concepts of energy efficiency, design for all (universal design) and resident participation in the planning process.

The project is funded by The Norwegian State Housing Bank. REBO has also been coupled with the Norwegian Research Centre on Zero Emission Buildings (ZEB).

The REBO project is focused on upgrading yesterdays dwelling blocks to the standards of tomorrow by implementing universal design principles with energy efficient solutions. The overriding objective is to speed up the market penetration of sustainably renewable solutions.

We were looking for cases to study in Sweden, Denmark and Norway. It has been quite difficult to find examples that cover high level ambitions for both energy efficiency and universal design. However, we found some very interesting examples of highly ambitious projects for each of these focus areas. A few examples were found of upgrades with passive housing components, and other examples of adaptations to the principles of design for all, beyond the installation of lifts. Additionally, we found examples of upgrades to facilitate more pleasant environments and change the negative image of the building site to a positive one.

Despite this most retrofitted buildings can not reach the level of today's requirements. There are practical and economical barriers.

In most of the cases studied in REBO, retrofitting has been started because of building quality deterioration and immediate renovations have been needed. The retrofitting projects have been extended to include additional measures to upgrade the building beyond the most urgent matters.

1.1 Dwelling ownership – the Norwegian context

According to statistics in Norway for 2008, 56% of the population lives in single-unit dwellings, 23% live in semi-detached houses; row houses or other small houses, and 21% live in blocks of flats. The housing ownership structure is somewhat different in Norway compared to other European countries, where it is more common to rent a home. In Norway, nearly 80% of the households are freeholders (www.ssb.no).

14% of the freeholders own their housing unit through a housing cooperative (most housing cooperatives are blocks of flats in the cities) (www.ssb.no). «Borettslag» is the legal entity for housing cooperatives in Norway. This company is owned by those who live in the cooperative, the shareholders. Each share gives the resident the right to live in the cooperative, in a particular apartment (or house) and the shareholder is free to sell her/his part. The cooperative statute can give internal first preference and owns the buildings and the property. The highest authority in the cooperative is the annual meeting for shareholders that elects the board responsible for daily operations. Some cooperatives are members of a housing association, which again are members of the Norwegian Federation of Co-operative Housing Associations.

It is often challenging to obtain the residents agreement to carry out a renewal of large housing cooperatives. In order to implement a renewal plan in a housing cooperative, a decision by a two-thirds majority vote of the general meeting is required. In Norway there are many examples of how difficult it is to achieve consensus on maintenance and renewal projects. Even if the investments are well grounded economically, the fear of increased association fees often stops the process and leads to building degradation in the long run.

2. Project objectives and methods

The overriding goal of the project is to contribute to accelerate the market penetration for the sustainable upgrading of buildings. The aims are to:

- Highlight measures for obtaining very low energy standards, by reducing energy demand and implementing renewable energy sources

- Highlight measures for improving accessibility for the mobility impaired person, and other improvements according to universal design
- Analyse the significance of resident participation, and how it influences the renewal process.

Work on the project started with literature studies; resulting in a knowledge status report on environmentally friendly retrofitting measures, plus an overview of soon to be implemented regulations for building upgrades. We looked at different levels of standards that might be applied to future requirements.

Analysis of state of the art case buildings followed next, involving project participants from various disciplines such as architects, civil engineers and social scientists. From the very start an advisory board, representing the building industry, owners and authorities, has been involved in the project. Workshops were arranged to raise research questions and discuss findings.

The qualitative case studies rely on multiple sources of evidence [2]: Interviews with employees, board members, chairmen, residents and architects. In addition, site inspections and studies of correspondence between different actors in the rehabilitation processes were conducted. The results from the case studies can be generalized through analytical generalization, meaning that the findings from one study can be used as a guide to what might occur in other situations [3]. Far from being typical, a case might be selected on the grounds that it provides a contrast to the norm. In this way, knowledge that is not found anywhere else might be revealed, and influencing factors might be more easily seen than in an average case [4]. Both case studies presented are renewal projects with a special focus on residents' needs. Thus the case studies must be classified as extreme cases in different ways (see information about the case studies in the next section). A typical or average case is often not the richest in information; extreme cases often reveal more knowledge [5].

In the time being we are at the starting point of developing strategies and concepts to be implemented in pilot buildings.

3. Intended impact of the REBO project

Pilot projects and their successors are very likely to initiate a chain-effect that will result in a growing number of replication projects within few years.

Best practice examples and pilot projects have proven to be indispensable for the further development of building practices. Without good examples to proof that the next steps for tightening the performance requirements are possible at reasonable additional costs, the building industry tends to deny that the market is ready.

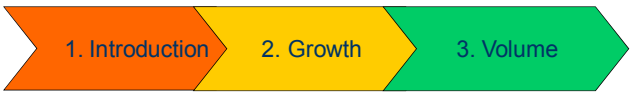

Fig. 1 Three main phases in sustainable building [1]

Regarding sustainable renewal of post war dwelling blocks, we are still in the introduction phase. The overriding objective of the project is to create a solid foundation for the growth phase.

By demonstrating that high ambitions regarding energy efficiency and universal design are achievable within an affordable cost frame, pilot projects support the faster introduction of these concepts into mainstream use. By including information about how to deal with these topics in the design, and with quality control at the commissioning, pilot projects can accelerate the market penetration.

4. Requirements in building code

In Norway the principle is that new building regulations apply to existing buildings only when the purpose or use of the building is changed, or when retrofitting by the municipal authorities is

considered to be so extensive that the building is fundamentally renewed (main reconstruction). In addition, the new regulations are applied when the retrofitting or changes result in the renewal of parts of the building. In practice, limits on the application of new regulations have been generous in the municipalities. Most retrofitting projects are not included in the concept of main reconstructions.

4.1 Energy efficiency

Usually, no energy requirements are stated at all (e.g. the pilot project Myhrerenga was not a «main reconstruction»). Even the alternative – to state energy requirements for the renewed parts of the building – is seldom used. Additionally, the local authority can give special permission, if it is impossible to adapt the building to new regulations by affordable costs. In the case of renovation measures which are not subject to approval, there are no minimum requirements applied to the renovated building elements.

4.2 Universal design

In the new Planning and Building Act universal design is emphasized through an objects clause. The act and the regulations followed are meant to secure universal design in new buildings, constructions and outdoor area. As in the Anti-Discrimination and Accessibility Act (2009), universal design concerns only public buildings and outdoor areas. Only claims of accessibility are regarded for these dwellings.

5. Design principles for energy efficiency

In aiming to reduce the consumption of energy in new buildings, a five step strategy for passive energy design was developed within the project *'Cost effective low energy buildings'* [6], which was finished in 2006:

1. Reducing heat losses
2. Reducing electricity consumption
3. Utilising solar energy
4. Controlling and displaying energy use
5. Supplying rest of the energy demand with renewable energy sources

In other words: The starting point is the application of energy efficient measures to reduce energy demand, and then supply the remaining demand with an energy supply system utilising renewable energy sources. Passive energy design is in principle applicable to both low energy buildings and Passive Houses, but the Passive House concept includes particular requirements, defined by Passive House Institute in Germany or specific standards in other countries.

The German definition is as follows: «A Passive House is a building, for which thermal comfort can be achieved solely by post-heating or post-cooling of the fresh air mass, which is required to achieve sufficient indoor air quality conditions (…).» (www.passiv.de). The Norwegian standard NS 3700 is not based on such a functional definition. Nevertheless, the main requirement according to both standards is that energy demand for heating or cooling does not exceed 15 kWh/m² per year. To ensure this, the following measures are crucial:

- Building envelope with U-values maximum 0.15 W/(m²K), avoiding thermal bridges
- Airtight building envelope, measured air leakages not more than 0.6 h^{-1}
- Windows with total U-value maximum 0.8 W/(m²K), including frame
- Balanced ventilation with highly efficient heat recovery

In addition, domestic hot water generation, the distribution system and household electricity should be very efficient, and solar collectors, heat pumps or other measures to reduce CO_2 emissions, should be used.

In the case of refurbishment, it is often impossible to achieve Passive House standards in a cost efficient way. Still, the above-mentioned measures and concepts can be used. This can be called renovation according to Passive House concepts or principles, or renovation with Passive House components.

5.1 Example of upgrading with a focus on energy efficiency – Myhrerenga borettslag

Myhrerenga housing cooperative is situated 15 km north-east of Oslo, in Skedsmokorset, and consists of 7 similar blocks, erected in 1968–1970, three storeys high with 24 apartments in each block, in total 168 dwelling units. Myhrerenga was the first apartment complex renovation in Norway which used Passive House components.

Fig. 2 Myhrerenga before upgrading. Photo Arkitektskap AS

Fig. 3 After upgrading. Photo SINTEF Byggforsk

Façades in need of renovation, together with complaints about draft, cold floors and poor air quality, as well as requests for larger balconies, initiated the renovation process in 2006. Since the buildings were in need of a major renovation anyway, the Norwegian State Housing Bank in cooperation with SINTEF suggested an ambitious «Passive House renovation», which was assumed to reduce the overall demand of delivered energy from about 275–300 to 80 kWh/m² per year, and to cut the net space heating demand by 80–90% to about 25 kWh/m² per year. At the same time, the ambitious renovation should not be more expensive than a conventional façade renovation, expressed in figures of total monthly costs for loan, energy, maintenance and property management. After a two year long process, the cooperative decided to go forward with the ambitious renovation. Now, in April 2011, most of the interior work is already finished.

To reduce heat losses, the following measures have been applied: New insulation and cladding on exterior walls and below the ground floor, in-blow insulation in the attic, window replacements (passive house windows and «almost» passive house doors), simplified insulation on staircases and outer cellar walls, new balconies with studs placed on the outside of the insulation layer, and installation of a ventilation system with a heat recovery of 79%. During the first air leakage test an air change rate of 0.64 h^{-1} was reached, very near Passive House requirements.

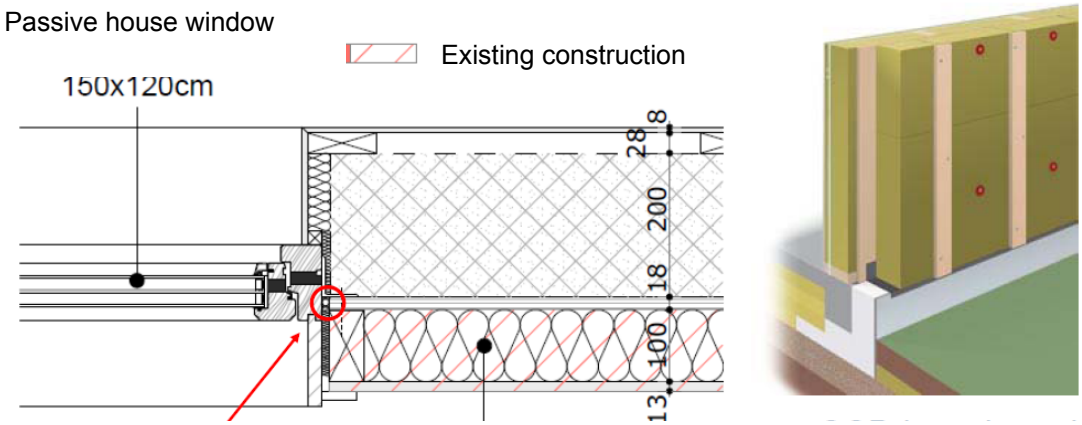

Fig. 4. New façade with 20 cm insulation and vapour permeable OSB on the outside of the existing 10 cm stud wall. Adhesive tape between new Passive House window frame and OSB. Illustration: Arkitektskap AS, and Rockwool AS.

To utilise solar energy, 44 solar collectors were installed on the roof top of the block located nearest to the heating plant. The solar collectors are dimensioned to cover 10% of the heat demand.

To supply the rest of the energy demand with renewable energy sources, three air-to-water heat pumps are dimensioned to cover 60% of the heat demand.

5.1.1 Residents' evaluation

Some of the residents have been interviewed about their evaluation of the renewal. They are very pleased with the results. They are impressed by the new look of the building blocks, and happy with the extended balconies. They are pleased with the indoor climate and temperature also after the first winter.

5.1.2 Economy

The extra cost of the energy measures is calculated to be covered by the reduction in energy costs, even without subsidies. The total monthly cost will be 300–400 NOK lower than with a conventional façade renovation, equivalent to 40–50 Euros per apartment. Without subsidies, the cost advantage would be about 200 NOK. Calculated with an ordinary bank loan instead of a loan from the State Housing Bank, the monthly cost for the ambitious renovation would be on the same level as a conventional façade renovation.

6. Measures for improving accessibility and orientation

In working with universal design a broad spectre of solutions will be necessary to meet the increasing elderly population in the coming years. Installation of lifts is an example of measures to increase accessibility. Other measures to improve accessibility for persons with impaired movement are pathways free of steps from parking places to the front door, tool sheds and rubbish chutes, while long distance designs have to be avoided. The surface is of importance in how easy or hard it is to use a wheeled walker, a pram or a wheelchair. A surface that is antiskid can prevent accidents from falling. For persons with reduced muscle strength an automatically opening entrance door is of great help, and persons with movement restrictions can be totally dependent on a lift to visit or live in a block.

For visually impaired persons contrasts are of great importance; by colour or by contrasts in materials, surfaces or lightening, making one part different from another. Contrasts at the front of each step on the stairs, at the glazed door and the handrail make it easier for the visually impaired to orientate. This is also the case for signboards with contrasts and lane line.

Hearing impairment, which is also common among elderly, requires the need for visual signals, such as fire detectors with flashing lights, and generally good acoustical conditions.

Strategies to increase accessibility inside each flat can involve making one room out of two to enlarge the bath or bedroom. It is also relevant to remove door sills inside each flat, at the front door and to the balcony, and to replace narrow doors with broader ones.

6.1 Example of upgrading with a focus on universal design – Barkaleitet borettslag

Barkaleitet housing cooperative is situated outside the city of Bergen. Built in 1977 with 180 flats, and renewed in 2010. The number of flats has been expanded to 215.

This housing cooperative has implemented several smart universal design solutions; disability access to the front door and outside areas, lifts dimensioned for stretchers, and a new staircase in the extension. The flats on the top floor meet standards for wheelchair use. However, improvements to door sills at the front door and to the balconies have not been done. Also attention has not been given to make orientation easier for visually impaired persons.

Fig. 5 Before upgrading. Photo Jarl Høva

Fig. 6 After upgrading. Photo Jarl Høva

Fig. 7 Before upgrading - Plan ground floor

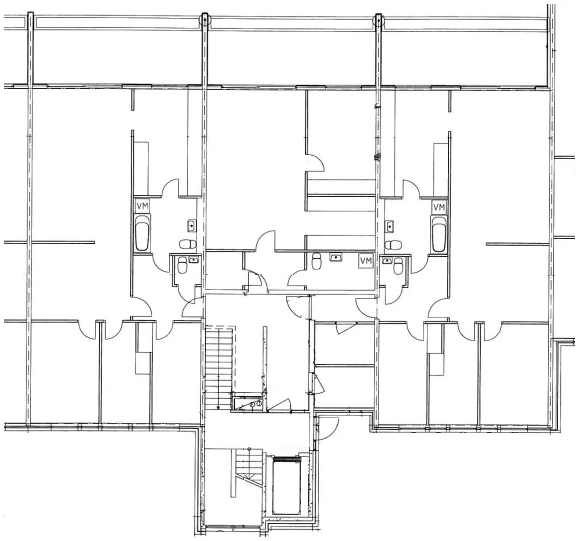

Fig. 8 After upgrading

6.1.1 Economy

The upgrades at Barkaleitet show that universal design can be financed through the extension of a building or construction of new buildings on the premises. There was a strong desire among the housing board and the elderly residents to see lifts installed and to incorporate several universal design solutions for the surrounding area. In total, the upgrades cost 240 million NOK, of which 8 million NOK was allocated for the installation of 15 lifts. The sales of the new apartments on the top floor gave the housing cooperative a capital income of 100 million NOK.

7. Concluding remarks

Normally, a holistic approach is not common in renovation projects, which prohibits the synergetic effects between different solutions. Thus, the synergy of energy efficiency, accessibility and other improvements is not utilized. At Barkaleitet the goal was to improve both energy efficiency and accessibility, yet, they did not use (and did not discuss at all) the full potential of Passive House components. On the other hand, at Myhrerenga universal design was not a consideration before the Housing Bank specifically requested the incorporation of these design principles.

Both building constraints and ownership can be barriers, especially for universal design. Our two Swedish cases (not described specifically in this paper) demonstrate that it is easier to carry out ambitious projects in blocks of rented flats. At Brogården in Alingsås near Gothenburg the municipal housing association renovated in accordance to the Passive House concept in addition to increasing the accessibility of a large number of apartments. New floor plans with two accessible,

medium-sized apartments, instead of three smaller flats, made it possible to install lifts. Such a fundamental restructuring is not usually realistic in owner-occupied dwellings.

At Stilledal, a Danish case in Copenhagen with rental flats, they also established new floor plans incorporating larger apartments. Prefabricated façade elements were used to enlarge kitchens and living rooms without moving the tenants. However, the entire potential of prefabrication was not completely utilized in any of the cases.

With regard to sustainable results in the long term, it is crucial to see the interconnection between different challenges and measures. In existing buildings, there is often no need to realize a major renovation incorporating many measures all at once. Various building components have different life-expectancies and can deteriorate in varying degrees. It is therefore important to develop a plan so that measures taken can be seen in a larger context and carried out in the correct order, more effectively.

7.1 Energy efficiency

Existing buildings can have many constraints which make it difficult to fill the gaps between the original standards and the requirements according to new building codes or Passive House principles, especially if the building or façade is historically listed. Instead of giving permission to drop the requirements, requirements should be developed on several levels to ensure that buildings, which for various reasons can not fulfil the intended level of requirements, can be covered by the next level.

In the case of step by step renovations, where only a few building components are affected at one time, it can be very challenging, and often expensive, to achieve technically good solutions with low thermal bridges and high air tightness. Step-by-step upgrading of individual building components needs to take into account that many energy saving measures depend on each other.

In most renovation projects there is room for improvement. For example, if a façade is in need of a major renovation there are nearly no additional costs for increased insulation thickness. On the other hand, to add further insulation at a latter date would not be affordable under any circumstances. In general, when it is time for a building component to be renewed the additional effort for a qualitatively better implementation would be relatively small. It is therefore an important principle to connect an ambitious upgrading initiative to any required rehabilitation [7].

Upgrading according to the Passive House concept can be economic profitable when the building mass is in poor condition and a major renovation has to be done. Other opportunities can take advantage of wishes for modern façade designs, requirements for larger balconies and so on. Upgrading with Passive House components may then be most lucrative, compared with conventional renovation or renewal measures. Additionally, the indoor climate and comfort for residents will be improved. Retrofitting where only the most urgent repairs are done, with slightly improved standards, may easily become unprofitable in the long run, and ruin the chances for ambitious renovations in the future.

7.2 Universal design

Between 2 and 9 percent of the houses built before the year of 1990, are accessible to wheelchair users, while the percent increases to 24 percent of houses built after 1990. It has been presumed that 26 percent of all housing cooperatives that have an accessible front door and access to the most important rooms at the entry level are not totally accessibility inside, but have the potential for total accessibility with simple solutions [8]. An inquiry made by NBBL (The Norwegian Federation of Co-operative Housing Associations) identifies few solutions other than the installation of lifts in existing buildings. One reason for this is that housing cooperatives are mostly involved in the upgrading of common public areas inside and outside of the buildings [9].

Focusing on solutions that work with universal design and accessibility and account for the increasing amount of elderly, has to be central in the years to come. Elderly often have problems

with seeing, hearing and/or mobility, which makes it especially import to prioritize the possibilities for their participation in social life and to improve the personal management of their daily life.

At Barkaleitet the housing cooperative had to build new staircases because the former were too narrow to install a lift and make space for parking wheeled walkers, etc. It was necessary to build staircases outside the dwelling structures. At Myhrerenga only the entrance area, car parking and walkways were made accessible, and orientation measures were only taken on the exterior.

Both cases have made efforts to improve accessibility for people with impaired movement; Barkaleitet more so than Myhrerenga. None have provided indoor solutions to improve conditions for the visually impaired, which are actions that are simple and of great importance to this special needs group. At Myhrerenga they discussed it, but finally all proposed work inside the staircases was dropped in order to save money.

7.3 Resident participation

A well functioning board and trust between residents and the leaders responsible for the upgrading process, seems to be essential to the success of the renewal process. At Myhrerenga residents had great confidence in their consultants. The fact that, according to the Passive House concept, the upgrading cost less than traditional practices, and proper communication with residents, accounted for the majority of ambitious upgrading proposals undertaken. The experience of Barkaleitet, where the leader of the board was greatly respected among the residents and facilitated resident participation, has proven a particularly good example. It has exemplified the importance of these relationships, he was seen as 'one of them', he had close contact with the residents and was deeply trusted. The relationships between project stakeholders have proven to be of particular importance and great value. The residents felt sufficiently informed about the upgrading process and while they were not necessarily a part of every project decision they showed great confidence towards the leaders of the project.

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More information in Norwegian: http://www.sintef.no/projectweb/rebo/

8.1 Acknowledgements

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