

Further information  
Skanska AB  
www.skanska.com

**Contact**  
Noel Morrin,  
Senior Vice President  
Sustainability  
noel.morrin@skanska.se

## Residential Passive Housing, Sweden

### Case Study 41

#### Aspects of Sustainability

This project highlights  
the following:

##### Social Aspects

Human Resources  
Corporate Community  
Involvement  
Business Ethics  
Health and Safety

##### Environmental Aspects

Energy and Climate  
Materials  
Ecosystems  
Local Impacts

##### Economic Aspects

Project Selection  
Supply Chain  
Value Added

Skanska is designing and constructing a number of residential projects in southern Sweden that meet passive house standards and consume significantly less energy for heating than conventional buildings. The projects include newly constructed apartments and the refurbishment of existing properties with passive house techniques that provide good insight into the economic viability of passive housing.



### Project Introduction

Skanska is a passive house market leader in Sweden and is currently undertaking a series of residential projects in accordance with the Swedish passive house standard. Passive houses are buildings that do not use conventional heating and cooling systems and require very little energy for space heating. Under normal conditions the buildings are sufficiently warmed by the heat generated from human occupants, electric lighting and domestic appliances. Passive houses are typically air-tight, superinsulated, use passive solar energy and have highly efficient heat recovery ventilation systems.

Skanska has several passive house residential projects in southern Sweden that are completed or currently under construction. The Kvarteret Nornan (Nornan residential development) project

in Glumslöv, consisting of 35 rental apartments, was Skanska's first passive house project to be completed in Sweden in 2004 for the local municipality (See Sustainability case study #7). Skanska has also designed and constructed 27 single-storey apartments and 12 apartments designed for the physically disabled in Misteröd, Uddevalla, completed in December 2007 for the municipal housing company, Uddevallahem. Projects under construction include the Kvarnsjön project in Skövde with 10 family houses and Strandkanten in Gothenburg, which consists of 25 apartments that will be completed in autumn 2009. Skanska is also refurbishing 300 apartments with passive house technology in the Brogården residential development in Alingsås, which was originally constructed in the early 1970s as part of a social housing initiative. Prior to the



refurbishment, the Brogården apartments were poorly insulated, had dysfunctional ventilation systems, high energy costs and were considered unsuitable for elderly occupants due to the poor indoor environment.

Skanska is developing the Öresund Green passive house, which is designed to be used in several projects in southern Sweden. Nine Öresund Green houses are planned for construction in Bunkflostrand and one in a new eco-village in Nordanå outside Malmö, due for completion at the end of 2009. Skanska is also planning the Akterhuset project in Gothenburg with 80 passive house apartments and the Säby Vång project in Landskrona, which will include a wide range of new-design passive houses.

## Contributing Toward Sustainable Development

Skanska's passive house projects consume less energy, reduce carbon dioxide emissions and have lower operational costs than conventional buildings. The apartments and houses have high quality indoor environments and are designed to provide affordable low-energy homes. Skanska has developed solutions to exceed the Swedish passive house standards together with project partners, developed passive house knowledge within Skanska and raised awareness of energy efficient housing among concerned organisations and the general public. The projects have benefited the economy in southern Sweden by using local subcontractors and regional construction

materials, and providing passive house training to the workforce. Environmentally responsible construction materials have been used on the projects and waste recycled where possible. The next generation of Skanska's passive houses will generate on-site renewable energy and incorporate more sustainable construction features, such as green roofing.

## Social Aspects

### Project partner collaboration

The project managers of the Kv. Nornan and Misteröd projects worked with suppliers, subcontractors and Skanska technical staff throughout the project to develop innovative solutions to meet passive house standards. Two future tenants of the Kv. Nornan project were also involved in the design stage to ensure their needs and expectations of the project were met.

### Developing passive house knowledge within Skanska

The passive house technique is relatively new in Sweden and Skanska has promoted the transfer of knowledge and good practice techniques for exceeding the passive house standards between projects by encouraging dialogue and involving experienced staff on subsequent projects. The Misteröd project managers had initial meetings with the Kv. Nornan project manager regarding air-tightness techniques and the importance of issuing detailed instructions to construction workers. The Misteröd team also learnt from Kv.

Nornan's initial problems with the ventilation systems and the manufacturers data sheets were carefully analysed before selecting the most appropriate system. Many of the key members of the Misteröd team have since been involved in the development of subsequent Skanska passive house projects. Projects such as Strandkanten have benefited from the involvement of experienced personnel and the Öresund Green passive house design built on the experience of previous projects by including improved roof insulation and an insulated roofing frame to reduce the risk of damp.

### Raising awareness of energy efficient housing

Kv. Nornan and Misteröd have acted as demonstration projects for the passive house technique and have featured in local and national media and specialist construction journals. Architects and construction specialists from all over the world visited Kv. Nornan as part of a sustainability conference in southern Sweden and in 2006 the UK Minister for Housing visited the project during an educational tour of passive houses around Europe to investigate what could be learned from a British perspective. The Misteröd project held study days and a demonstration apartment was open to public organisations, companies, members of the public and other Skanska business units to raise awareness of the passive house technique. Uddevallahem has distributed information regarding passive houses among Misteröd residents and the project raised awareness of passive house techniques among local subcontractors during construction. The Brogården passive house renovation project held public education days and the project was visited by the Swedish Prime Minister and the Swedish king in 2008 to consider the potential for renovating more energy inefficient buildings in Sweden with the passive house technique. Brogården is also home to the West Götalands Passive House Centre, which is managed by the IVL Swedish Environmental Research Institute and works to promote energy efficient buildings in the region.

### High quality indoor environments

Passive houses have comfortable indoor environments with a constant temperature throughout the year, good indoor air quality, access to natural light and sound proofed walls. Passive houses are superinsulated to maintain a relatively constant temperature even when the building is unoccupied during cold weather. Each passive house apartment has its own fresh air ventilation system, which ensures good air circulation in all

rooms, compared to a conventional Swedish apartment that only has ventilation in the bathroom and kitchen. Low-VOC and non-toxic materials are also used in the apartments to ensure good indoor air quality. Marmoleum flooring made from organic and hypoallergenic materials was used for the Misteröd project, together with paints that met the EU flower eco-label sustainable production standards and the Swedish Asthma and



Allergy association's criteria. Other low-VOC materials included a water based tile sealant, non-toxic floor glue and wooden window frames.

The buildings typically have large south facing windows and are open planned to ensure that natural light penetrates the apartments. Noise disturbance is reduced by low frequency ventilation systems and soundproofed walls that exceed the Swedish category B sound standards, which is higher than legal requirements. The risk of damp damage is minimised by ensuring long drying out periods and mechanical drying.

### Constructing flexible and long-life buildings

Skanska's passive houses are designed to be flexible to meet the needs of different households now and in the future. The apartments are open planned and have no wall heating elements or pipes, which allows residents more freedom to arrange furniture how they want. The later projects have added protection against moisture damage, such as the Öresund Green project with an insulated roof frame. Steel beams instead of wooden supports were used on the Strandkanten project, which is by the coast and more susceptible to moisture damage.





## **Sustainable urban planning**

All Skanska's passive housing projects in southern Sweden are on the edge of villages or small cities and are relatively close to amenities and bus services. The larger projects form new self-contained urban districts, such as the planned Öresund Green Nordanå project, which is part of an eco-village development. Säby Vång is also designed to create a new city area just north of Landskrona, which is within cycling distance of the city, has good bus services and includes a mix of different housing types and amenities. Many of the projects are designed to be family houses, such as the Misteröd development, with safe, child-friendly surroundings.

As part of the Brogården refurbishment project, the neighbourhood is being improved for residents by making the area more child-friendly, creating communal meeting places and improving access to shops and amenities.

## **Economic Aspects**

### **Local subcontractors**

Many of the subcontractors for the passive house projects are from the local area, such as the electricity and ventilation subcontractors on the Misteröd and Strandkanten projects. Skanska has an established network of preferred subcontractors in the area and has developed a resource base with technical knowledge of passive house development from previous Skanska projects.

### **Regional construction materials**

Construction materials are sourced locally where possible, such as wood and domestic appliances for the houses and apartments. Some materials were sourced regionally from southern Sweden, such as

the insulation, and other materials were sourced from northern Sweden, such as highly insulated windows and doors.

### **Vocational training**

Skanska has provided training and detailed instructions for the workforce and subcontractors on the passive house techniques, such as the important requirements for air-tightness. Students from Chalmers University in Gothenburg were involved in the Misteröd new build and Brogården renovation projects as part of their dissertation work investigating construction cost comparisons and the production aspects of passive house techniques.

### **Financial savings due to energy efficiency**

Passive houses have lower operating costs than conventional buildings due to the reduced energy consumption for heating and cooling and enable occupants to make significant financial savings throughout the life span of the building. Skanska's passive houses consume around a third less energy in total than a conventional apartment or house.

The refurbished Brogården apartments consume almost 60 percent less energy in total than prior to the redevelopment. All the apartments in the project are equipped with individual water and electricity meters, which enable residents to monitor and control their resource consumption and make further financial savings. The residents of Brogården paid a flat fee for electricity and heating prior to the refurbishment so had no incentive to reduce energy consumption.

### **Providing affordable low-energy homes**

Passive houses typically cost slightly more than conventional buildings to build, although Skanska's



aim is to design and construct high quality, low-energy homes that are as affordable as conventional homes. The Misteröd project cost approximately 2 percent more to construct than if conventional techniques had been used, and the average annual rent for a Kv. Nornan apartment in 2008 was 930 Swedish kronor / m<sup>2</sup> (US\$ 130/m<sup>2</sup>), which compared favourably with conventional apartments in the area. The Brogården renovation project cost between 20 and 30 percent more than a conventional renovation would have cost.

## Environmental Aspects

### Energy efficient housing

Skanska's passive houses consume between 30 and 40 percent less energy in total than a conventional apartment or house. The total annual energy consumption of one of the Misteröd apartments has been measured at 59 kWh/m<sup>2</sup>, excluding electricity for household appliances.

The Brogården renovation project will reduce the total energy consumption from 216 kWh/m<sup>2</sup> to 92 kWh/m<sup>2</sup>. Skanska's passive houses are superinsulated, airtight, have efficient ventilation systems and sun shading. The walls have minimal cold bridges and are insulated with around 480 mm of polystyrene and mineral wool, and have a u-value of between 0.11 and 0.095 W/m<sup>2</sup>K, compared to a conventional Swedish building with a u-value of around 0.22 W/m<sup>2</sup>K. The roof has between 400 and 550 mm of insulation, which is 100 to 200 mm more than a conventional building. The foundations have 350 mm of insulation and a u-value of less than 0.09 W/m<sup>2</sup>K in the new build projects and 140 mm of insulation was added to the existing foundations of the Brogården

apartments to provide a u-value of 0.2 W/m<sup>2</sup>K.

Insulated doors and xenon gas-filled triple glazed windows with u-values of 0.9 W/m<sup>2</sup>K or lower have been used. Windows with less than 1.2 W/m<sup>2</sup>K are considered to be energy efficient in Sweden.

Skanska's passive houses are made airtight with plastic sheeting and the Misteröd and Kv. Nornan projects exceeded the Swedish passive house airtightness standard of 0.3 l/sm<sup>2</sup>. Kv. Nornan set a new Swedish record of 0.1 l/sm<sup>2</sup>, for air-tightness compared to a conventional apartment with an air-tightness of approximately 0.8 l/sm<sup>2</sup>. The buildings are equipped with balanced heat recovery systems, which recover at least 85 percent of the energy from outgoing air. The systems can also provide additional heating when required. All south-facing windows on the projects have roof overhangs to avoid over warming in summer but to allow passive solar heating in winter when the sun is at a lower angle.

### Reducing carbon dioxide emissions

Carbon dioxide emission calculations for the Misteröd project (not adjusted to local energy generation) estimated that 11.4 kg of carbon dioxide are produced annually per m<sup>2</sup> for heating from bought electricity, which is approximately 40 percent less than a conventional Swedish building. Passive houses contribute to Sweden's EU target of reducing carbon dioxide emission by 17 percent between 2005 and 2020.

### Renewable energy

Skanska promotes the supply of renewable energy from energy companies and is developing techniques for on-site renewable energy generation. The first Öresund Green house will include a small-scale wind turbine for producing electricity and a solar water heating system, which will meet around 50 percent of the house's requirements for hot water. The use of co-owned sun panel installations is being investigated for the Säby Vång project.

## Learning From Good Practice

Skanska is refining its passive house techniques in southern Sweden by sharing knowledge, promoting internal competence and developing a network of specialist partners. Increased energy costs and environmental consciousness are expected to lead to greater interest in low-energy housing in the future and Skanska has established itself as a passive house market leader in the region.