



Riksantikvaren

Directorate for Cultural Heritage



**BYGGFORSK**  
Norwegian Building Research Institute

Lars Myhre

# Learning from the built heritage on the way towards a sustainable development

Some qualities of traditional building materials and construction techniques in a sustainable perspective

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(Riksantikvaren)

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## **Preface**

This paper is written for the Directorate for Cultural Heritage, to show that knowledge and experience from our built heritage can contribute to a more sustainable development in the building sector.

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Oslo, May 1996

Lars Myhre

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## Summary

To attain a sustainable development in the building sector, the consumption of energy and resources has to be notably reduced. There is a need for changed consumer behaviour patterns, where preserving becomes superior to wasting, and where the focus is on long term durability rather than on short term profit. In this context, learning from the past is fundamental. Our built heritage shows that by using traditional construction techniques and well known materials, it is possible to construct and maintain buildings in a way which will make them last for hundreds of years. In a broader perspective, the traditional construction materials and techniques are also closely linked to the historical, architectural and cultural values of buildings.

Traditional building constructions do normally not accomplish today's requirements concerning i.e. energy efficiency and indoor climate quality. However, when used in a way that accomplish today's requirements, the traditional building materials and construction techniques have important qualities which may contribute to a more sustainable development in the building sector.

In this report, some environmental and sustainable aspects of traditional construction materials and techniques are presented. It is shown that the use of traditional materials and construction techniques involves a large share of renewable materials, which is favourable in a sustainable context. Traditional construction are often simple and easy to repair, and allow easy replacement of any damaged or worn out materials. Further, it is easy to separate the building materials during demolishing of traditional constructions, which increase the reuse potential. Finally, most traditional building materials may be locally produced, reducing the transportation need, and thereby also reducing the total environmental load.

# 1 Introduction

There is an increased awareness of environmental constraints and the need for a more sustainable development in the society. The need for a sustainable development was focused in 1987 in the report of the Brundtland Commission, "Our Common Future" (WCED, 1987). There is no distinct and unanimous interpretation of the term sustainable development and a vast number of interpretations have been proposed. The main message of the Brundtland report, nevertheless, was that our generation should take on the obligation of making sure that today's consumption of resources and environmental load are not in conflict with the needs of future generations.

The present development, however, is probably in conflict with the needs of future generations. The world is experiencing an exponential growth in the use of energy and resources, and there is a notable focus on short term profit. Moreover, an environmentally unfavourable consumption pattern has developed in modern societies, where the ultimate product is newer, better, faster and bigger than the other products, and where maintenance and preservation of the existing is regarded as inferior.

A continuing growth in the consumption of energy and resources will have enormous environmental impact on the planet. Examples of environmental problems the world is challenging are global warming, depletion of the ozone layer, and acidification of forests and inland seas. Of these, the threat of global warming is probably the most complicated. Global warming is caused by large emissions of anthropogenic greenhouse gases, particularly carbon dioxide (CO<sub>2</sub>) resulting from the combustion of fossil fuels. According to the Intergovernmental Panel on Climate Change (IPCC), the anthropogenic emissions of CO<sub>2</sub> have to be reduced by more than 60% to stabilise the CO<sub>2</sub> concentration in the atmosphere on today's level (SFT, 1994). However, in contrast to most other harmful emissions, it is not possible in practice to clean the fumes for CO<sub>2</sub> when fossil fuels are combusted. Consequently, the threat of global warming can only be avoided by significantly reducing the use of fossil fuels in the world society.

The building sector is important in a sustainable context. The environmental load and the resource consumption during extraction of raw materials and production and erection of buildings are enormous. Furthermore, the use and maintenance of the existing building stock require enormous amounts of resources and energy, and produce large amounts of environmentally harmful substances which are discharged to air, water and ground. Finally, large environmental impact is connected with the handling of waste materials at the end of the building life cycle.

To attain a sustainable development in the building sector, the consumption of energy and resources has to be notably reduced. There is further a need for a changed consumer behaviour pattern, where preserving becomes superior to wasting, and where the focus is on long term durability rather than on short term profit. In this context, learning from the past is fundamental. Our built heritage shows that by using traditional construction techniques and well known materials, it is possible to construct and maintain buildings in a way which will make them last for hundreds of years. In a broader perspective, the traditional construction materials and techniques are also closely linked to the historical, architectural and cultural

value of buildings. The Norwegian Building Legislation states that these values shall be safeguarded for the future.

In this report, some environmental and sustainable aspects of traditional construction materials and techniques are presented. It is shown that traditional materials and techniques have important qualities which may contribute to a more sustainable development in the building sector.

## 2 Description of the Norwegian building stock

The total floor area of the Norwegian building stock, agricultural buildings not included, has been estimated to be around 300 million m<sup>2</sup>. Figure 2.1 shows the building stock distributed by type of building. Roughly two-thirds of the total floor area, 200 million m<sup>2</sup>, is found in the dwelling stock. Industry buildings represent approximately 10%, trade and insurance 7%, schools 5%, health buildings 2% and office buildings 11%.

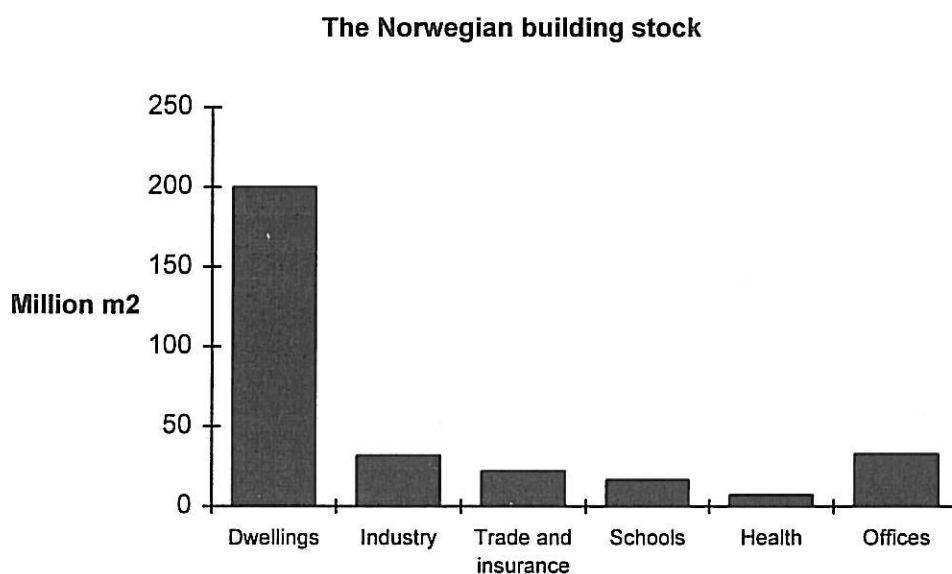


Figure 2.1  
Distribution of total floor area in the building stock by type of building (Bjørberg, 1992).

It may further be distinguished between small houses and large buildings. Traditionally, small houses have been constructed with wood as main construction material, and approximately 75% of all Norwegian dwellings are located in wooden houses. All these wooden houses may be assumed to have wooden façades.

Within the group of large buildings one may distinguish between commercial buildings, industrial buildings and large residential buildings. The statistical information on the main construction material used in large buildings in Norway is incomplete. Most large buildings constructed before 1920 may however be assumed to be brick buildings. From 1920, concrete gradually took over as the most important construction material in large buildings. Brick



buildings were traditionally rendered with pure lime mortar and thereafter painted using a lime based paint. From around 1920, it became common to add some cement to the mortar to strengthen it. From the 1920s, new paint types to be used on rendered façades were also introduced. In general, brick buildings constructed before 1920 may be assumed to have been originally rendered with pure lime mortar.

Table 2.1 shows the distribution of the dwelling stock in 1990 according to the Population and Housing Census 1990. One-family houses is the dominating house type in Norway, representing 58% of all dwellings in 1990. Dwellings in vertically and horizontally divided small houses together represented 22%, while dwellings in large houses represented the remaining 20% of the dwellings. The group of dwellings in large houses includes dwellings in blocks of flats and square buildings, and a small share of dwellings in commercial buildings.

Table 2.1 also shows the distribution of the dwelling stock in Oslo by type of house. In 1990, 14% of the entire Norwegian dwelling stock were located in Oslo. Oslo has many large residential houses. Dwellings in the group of large houses represented as much as 67% of the dwelling stock in Oslo, while one-family houses represented 11% only. In total, 47% of all dwellings in large houses in Norway were located in Oslo.

Table 2.1  
The dwelling stock in Norway and Oslo by type of house. Based on the Population and Housing Census 1990 (Statistics Norway, 1992).

Type of house	Norway		Oslo		
	Number of dwellings	%	Number of dwellings	%	As % of all dwellings within the group in Norway
Total	1 751 405	100%	244 434	100%	14%
One-family houses	1 018 142	58%	27 971	11%	3%
Divided small houses	380 020	22%	51 780	21%	14%
Large houses	353 243	20%	164 682	67%	47%

The total area of wooden and lime rendered façades in the Norwegian residential sector can be estimated to be 178 million m<sup>2</sup> and 1.9 million m<sup>2</sup>, respectively (see Appendix). The area of these façades is thus significant, and obviously it is of large importance to maintain the façades in a sustainable way.

### **3 Sustainable construction and maintenance of buildings**

Our built heritage shows that by using traditional materials and construction techniques, it is possible to construct and maintain buildings in a way which will make them last for hundreds of years. The traditional materials and construction techniques therefore seem to have qualities which are important to make use of in current and future building activities.

However, the traditional building constructions do normally not accomplish today's requirements concerning i.e. energy efficiency and indoor climate quality. Therefore, traditional materials and construction techniques have to be used in a way which accomplish today's requirements.

In the following, some qualities of traditional materials and construction techniques are presented on the basis of a sustainable perspective. It is focused on the advantages of the traditional materials and construction techniques, and the potential and limitations of these materials and techniques with respect to future trends.

#### **3.1 Consumption of resources**

The consumption of resources has to be reduced to attain a sustainable development in the building sector. The consumption of resources is however large during production of many traditional building constructions. Examples are log houses requiring thick logs to attain a adequate thermal insulation performance, and traditional solid brickwork requiring considerably more bricks than modern slim brickwork. Still, as presented in the following, the traditional building materials and construction techniques have important qualities which contribute to reduce the overall consumption of resources.

##### **3.1.1 Increased use of renewable resources**

Paint is used on façades to protect against climatic deterioration, and for decorative and architectural reasons to increase the status of the buildings. The paint coat is exposed to rough climatic loads, and it is meant to deteriorate and act as a sacrificial layer in the protection of the underlying surfaces. Thus, the deterioration of the paint coat is included in the natural life cycle of building components.

The binding materials used in composition paint and linseed oil paint, which both are traditional paint types, come from renewable sources. Cellulose paste or rye or wheat flour are used as binding material in composition paint, while oil from the seeds of the flax plant is used in linseed oil paint. In modern acrylic based paints, in contrast, the binding material is a petroleum product from a non-renewable source. The use of traditional paints based on renewable resources, is therefore beneficial in a sustainable context.

However, when considering the use of renewable resources like rye and wheat flour, it has to be remembered that fossil fuels normally are consumed during ploughing of land, fertilising, harvesting and transportation. The use of rye and wheat as binding material in paint may therefore also involve some consumption of non-renewable resources.

### **3.1.2 Improved durability of building products**

It is important to improve the durability of buildings and building components to increase the life span. Increased life span of building components will reduce the number of times the components must be replaced during the life span of the building. Consequently, this will significantly contribute to reduce the total resource and energy consumption.

However, many aspects influence the life span of building components, and not all of them are related to the durability against climatic and mechanical exposure. It may be distinguished between technical aspects, functional aspects, economical aspects and aesthetic aspects. For kitchen fitting ups, as an example, functional aspects and the inhabitants desire for something "trendy" are as important as the technical durability of the product. For external façades, however, the durability against climatic exposure is of dominant importance since it influences both the technical and aesthetic life spans.

The durability of traditional building materials and traditional construction techniques is demonstrated by all the old buildings being in good condition today. Many buildings being 100 years or more still have original windows, original lime rendering or original wooden cladding. The reason for this superior durability is both proper maintenance and the use of excellent building materials and construction techniques.

The introduction of new "maintenance-free" materials and new construction techniques has been disastrous for many old buildings. Especially the use of modern paint types on old lime rendered façades has commonly resulted in severe damage to the façades. One reason for this is that modern paints are too vapour tight and do not allow moisture in the wall to dry out between rainy periods. In contrast, the lime paint originally used, is far more vapour open.

### **3.1.3 Increased reuse and recycling**

Reuse and recycling of materials significantly contribute to reduce the total consumption of raw materials required to produce buildings and building components. The built heritage offers many excellent examples on how particular building materials, building components and whole buildings can be reused. The main reason for this is the simplicity of many traditional constructions. Few types of building materials were used in the constructions, and the materials were jointed without using glue or nails.

One example on how traditional construction techniques enable reuse of building materials is masonry brick with lime mortar. Lime mortar do not have the same strength, especially not the adhesive strength, as modern cement based mortars. Consequently, it is a lot easier to separate the bricks during demolition when lime mortars have been used, enabling reuse of the bricks in a new building.

One example on how building components and whole buildings can be reused is the large number of log houses that have been dismantled and re-erected in Norway. The simple load-bearing wall constructions, consisting of logs only, makes it easy to dismantle the house and transport the logs to a new site for re-erection. Modern light timber framed constructions, in contrast, are more complicated to dismantle and re-erect, but may in some cases be moved in one piece or in large units.

### **3.1.4 Increased reparability**

The simple constructions used, also prolonged the life span of the traditional constructions since they were easier to repair and maintain. Damage caused by any failure is normally also smaller for traditional constructions than for most modern constructions. A traditional construction can for instance easily dry out if a leak occurs, while leaks in modern constructions often result in extensive repair works since the moisture often is trapped between vapour tight layers.

Similarly, it is often more easy to replace materials in traditional constructions than in modern construction. The simplicity of many traditional constructions improves the reparability, and the materials for replacement are readily available.

## **3.2 Pollution**

Many of the environmental problems the world is challenging, are energy related. Especially the combustion of fossil fuels has severe environmental consequences. Examples of such problems are global warming and acidification of forests and inland seas.

The transportation distance is crucial in an environmental assessment of building materials since the volume and weight of the materials are large. Local production of building materials is therefore preferable since it reduces the transportation distances and hence the associated energy consumption and emissions to air.

Traditionally, building materials were locally produced. Today, building materials are more often centrally produced in large factories, increasing the total need for transportation. The use of locally produced construction materials in traditional constructions is therefore favourable from an environmental point of view since it reduces the transportation need.

## **3.4 Potential and limitations to the use of traditional materials and construction techniques**

Traditional materials and construction techniques have important qualities that will contribute to a more sustainable development in the building sector. Examples of such qualities are the use of well known construction techniques and the use of renewable materials. Further, the simplicity of many traditional constructions make them easier to repair and maintain. It is also generally easier to dismantle traditional constructions, as compared to most modern constructions. Consequently, it is easier to replace damaged or worn out materials in traditional constructions, as well as it is easier to reuse the building materials when the building is demolished. Finally, the traditional materials are well adapted for local production, which will reduce the transportation need. Based on this, it is obvious that traditional materials and construction techniques have qualities that should be applied in current building construction.

However, the applicability of traditional building materials and construction techniques in modern constructing have some important limitations. Examples of such limitations are the

limited thermal insulation performance of traditional walls and window constructions, and the generally lower durability of traditional paints as compared to modern paints. It should also be noted that many traditional paints contained environmentally harmful substances (i.e. lead compounds,) to increase the durability, and that these substances should not be used any more. Finally, it could be argued that traditional materials are more expensive and that the traditional construction techniques are more time consuming as compared to the modern alternatives.

The fact that traditional materials and construction techniques often are more expensive, however, is very much caused by the limited use of traditional materials and construction techniques in current building practice. More widespread use will surely contribute to reduce the overall time consumption and costs, and thus improve the competitiveness of the traditional materials and construction techniques.

There is also an increased focus on economic instruments according to the "Polluter-Pays-Principle" in environmental policy making, and there is a growing attention around "green" taxation. In "green" taxation, increased tax is levied for environmentally harmful products, while reduced tax is levied for the environmentally more favourable products. A result of the implementation of "green" taxation is that reduced tax is levied on services and labour, and increased tax on environmentally harmful products and consumption of exhaustible resources.

Because labour costs have been rather high, there has been a pressure on reducing the time consumption during the construction phase. Many of the traditional construction techniques have been labour intensive, and thus expensive. Therefore, industrially produced materials and components have been introduced, reducing the overall labour costs, but not necessarily the material consumption and transportation costs.

A shift towards "green" taxation will probably be economically beneficial for the labour intensive traditional construction techniques since the labour costs are reduced. This may ultimately lead to increased use of traditional materials and construction techniques in building construction?

## **4 Conclusions**

Traditional building constructions do normally not accomplish today's requirements concerning i.e. energy efficiency and indoor climate quality. However, when used in a way which accomplish today's requirements, the traditional building materials and construction techniques have important qualities which may contribute to a more sustainable development in the building sector.

The use of traditional materials and construction techniques involves a large share of renewable materials, which is favourable in a sustainable context. Traditional construction are often simple and easy to repair, and allow easy replacement of any damaged or worn out materials. Further, it is easy to separate the building materials during demolishing of traditional constructions, which increase the reuse potential. Finally, most traditional building materials may be locally produced, reducing the transportation need, and thereby also reducing the total environmental load.

## References

Bjørberg S., (written personal communication) "Oppgraderingsbehov for bygningsmassen, Versjon 2", Norway, 1992 (in Norwegian).

Statistics Norway, "Folke- og boligtelling 1990. Hele landet", Norway's Official Statistics, Norway, 1992 (in Norwegian).

Statens forurensningstilsyn (SFT), "Forurensning i Norge 1994", TA-1079/1994, Norway, 1994 (in Norwegian).

World Commission on Environment and Development (the Brundtland Commission), "Our Common Future", Oxford University Press, UK, 1987.

# Appendix

## Estimated total façade area in the dwelling stock

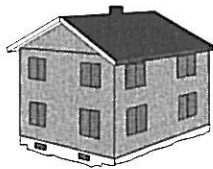
The total façade area of the wooden houses in Norway may be estimated using a stereotype of house approach as shown in Figure A.1.

Figure A.1

Division of the Norwegian dwelling stock into twelve representative groups of houses, and description of the stereotype of house defined for each group. Source: Myhre (1995).

### One-family houses

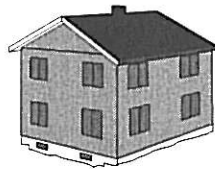
Before 1956



383 857 dwellings

Two storey detached one-family house.

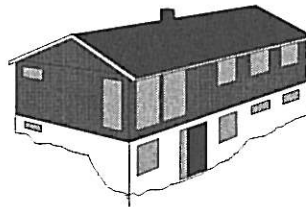
1956 to 1970



235 199 dwellings

Two storey detached one-family house.

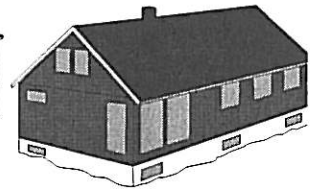
1971 to 1980



214 632 dwellings

Detached one-family house. Basement house.

1981 to 1990

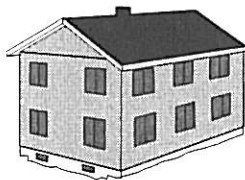


184 454 dwellings

1½ storey detached one-family house.

### Divided small houses

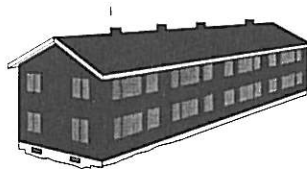
Before 1956



120 980 dwellings

Two storey, horizontally divided two-family house. Two dwellings per house.

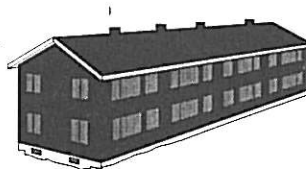
1956 to 1970



94 250 dwellings

Two storey building in row. Four dwellings per house.

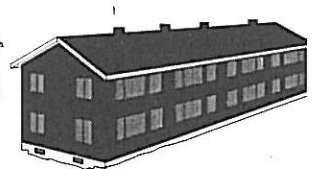
1971 to 1980



87 088 dwellings

Two storey building in row. Four dwellings per house.

1981 to 1990

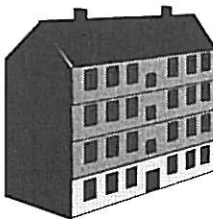


77 702 dwellings

Two storey building in row. Four dwellings per house.

### Large houses

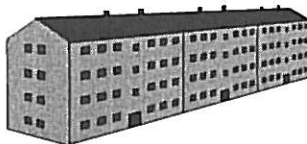
Before 1956



141 868 dwellings

Four storey square building. Eight dwellings per house.

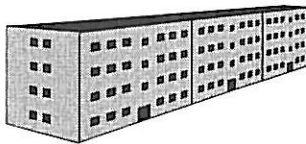
1956 to 1970



107 048 dwellings

Four storey detached block of flats. Three entrances and 24 dwellings per house.

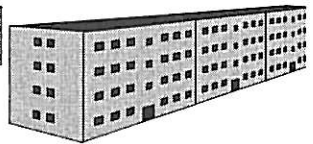
1971 to 1980



72 459 dwellings

Four storey detached block of flats. Three entrances and 24 dwellings per house.

1981 to 1990



31 868 dwellings

Four storey detached block of flats. Three entrances and 24 dwellings per house.

The total Norwegian dwelling stock per 1990 is divided into three main groups according to type of house, and four sub groups according to year of construction. The three main groups are one-family houses, divided small houses and large houses. The four sub groups are houses constructed before 1956, between 1956 and 1970, between 1971 and 1980, and between 1981 and 1990. Based on statistical data, a stereotype of house is defined for each of the twelve groups, assumed to be representative for all the houses within the group. All one-family houses and small divided houses are defined having wood as the main construction material, while all large houses are assumed having brick or concrete as the main construction material. Based on the defined stereotype of houses, it is possible to aggregate information estimated for single houses on to the level of the entire dwelling stock.

## A.1 Estimated total area of wooden façades in the Norwegian dwelling stock

Table A.1 shows the calculated net façade area of the stereotypes of houses defined for one-family houses and divided small houses. By multiplying the areas with the number of houses each stereotype is representative for, the entire façade area of the Norwegian wooden housing stock may be estimated to be 178 million m<sup>2</sup>. Of this, as much as 36% are found in one-family houses constructed before 1956.

Table A.1  
Estimated total area of wooden façades in the Norwegian residential sector in 1990, based on the defined stereotypes of houses shown in Figure A.1.

	Unit	One-family houses				Divided small houses			
		Before 1956	1956-1970	1971-1980	1981-1990	Before 1956	1956-1970	1971-1980	1981-1990
Width	m	7.5	7.5	7.6	7.6	7.5	7.1	7.1	7.1
Length	m	8.1	7.9	11.7	12.1	12.3	28.4	28.4	28.4
Height per storey	m	2.8	2.7	2.6	2.6	2.8	2.6	2.6	2.6
Number of storeys	no.	2	2	1	1	2	2	2	2
Total façade area	m <sup>2</sup>	191	183	117	123	242	387	387	386.8
Window area	m <sup>2</sup>	24	18	13	20	37	61	61	61
Net façade area	m <sup>2</sup>	167	165	104	103	205	326	326	326
Number of houses		383 857	235 199	214 632	184 454	60 490	23 563	21 772	19 423
Total net façade area	Mill. m <sup>2</sup>	64.0	38.8	22.3	19.0	12.4	7.7	7.1	6.3
<b>Total</b>	<b>Mill. m<sup>2</sup></b>	<b>177.5</b>							



## **A.2 Estimated total area of lime rendered façades in the Norwegian dwelling stock**

As for the wooden façades, the total area of lime rendered façades in the residential sector may be estimated using the stereotype of house approach. As a simplification, all large residential houses constructed before 1921 are assumed constructed with bricks. These buildings are also assumed originally being rendered with pure lime mortar. A square building containing eight dwellings was defined as stereotype of house for dwellings in large houses, constructed before 1956 (see Figure A.1). The net façade area (not included windows) of this stereotype of house is estimated to be 324 m<sup>2</sup>.

Assuming that the defined stereotype of house is representative for all large residential houses constructed before 1921, the total façade area of these lime rendered houses can be estimated as 1.1 million m<sup>2</sup> in Oslo and 1.9 million m<sup>2</sup> in the whole of Norway.

### **References**

Myhre L., "Some Environmental and Economic Aspects of Energy Saving Measures in Houses", Doctoral thesis, University of Trondheim, The Norwegian Institute of Technology, NTH 1995:120, Norway, 1995.

