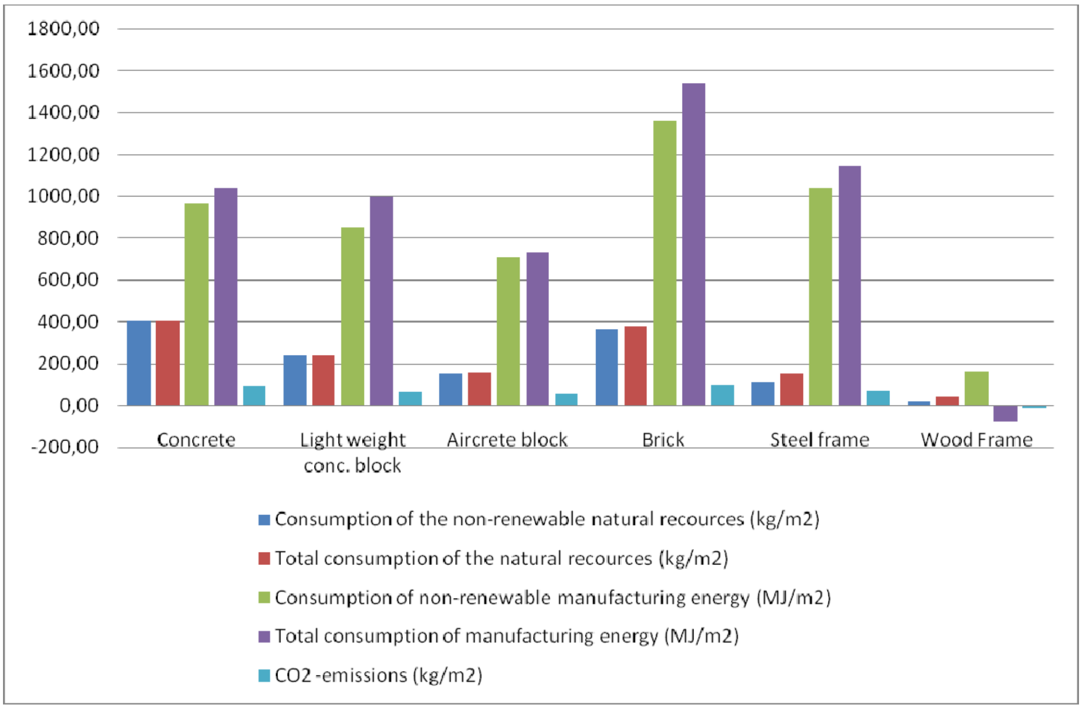
Mikko Viljakainen

10 Mar 2009

Project name

The environmental impact of construction and the manufacture of building products – will the new energy-efficiency requirements be sufficient?



Mikko Viljakainen 10 Mar 2009

TABLE OF CONTENTS

Mikko Viljakainen 10 Mar 2009

1 INTRODUCTION

It is good that energy-efficiency requirements for buildings are being tightened. It is simply bad housekeeping to squander energy, especially when there are reasonable measures to reduce consumption, even to halve it. This will likewise reduce the carbon dioxide emissions of buildings. But are the proposed measures sufficient? What else could be done to curb carbon dioxide emissions?

The significance of the entire lifecycle is often – at least in formal speeches – emphasised in the assessment of the environmental impacts of construction. However, in practice only the energy consumed during a building's use and the carbon dioxide emissions this causes are usually looked at, with the energy consumption and emissions caused by both construction and the manufacture of building products as well as by the dismantling of unused structures being ignored in equations.

Construction and the manufacture of building products account for 5% of our country's annual energy consumption and carbon dioxide emissions. No reduction targets have, at least for now, been proposed in relation to this share. Should these matters be focused on as well?

This report on the matter is not very scientific, but hopefully it will nevertheless be of interest. The aim is not to compete with more competent evaluators. The work's original sole intention was to increase my own awareness, to draw an outline of a significant issue. Having a rough feel for the facts would make it easier to define the focal points and objectives of our lobbying activities.

In the beginning, the purpose was not to publish this work or to report on it. However, discussions on the matter revealed such great interest that I decided to compile the results in an easily approachable format, which could be utilised within the industry. Later on it became evident there is a need to open the results for public discussion.The intention remains to not to use these findings against anyone; instead, the aim is to highlight an important concern, a factor that could certainly promote the use of wood in construction.

I have tried to make this report as readable and straightforward as possible. The emphasis is on the tables and diagrams presented. These are accompanied by just enough text to make the diagrams understandable. A certain amount of background knowledge is required of readers. When I in this report talk about environmental impacts, I am referring to effects on the consumption of natural resources and energyand CO_2-emissions.

Along with the translation, some amendments have taken place. They are reflected in the graphs 6, 7 and 13. However, despite the adjustments, the overall outcome remained substantially the same. Based on the feedback so far I have tried to clarify the report in some areas. I am grateful for the valuable feedback and wish to receive even more.

I hope that this report will provide a useful outline of the relevant issues and that it will help determine guidelines for wood construction lobbying activities. This is the golden egg that we are nesting.

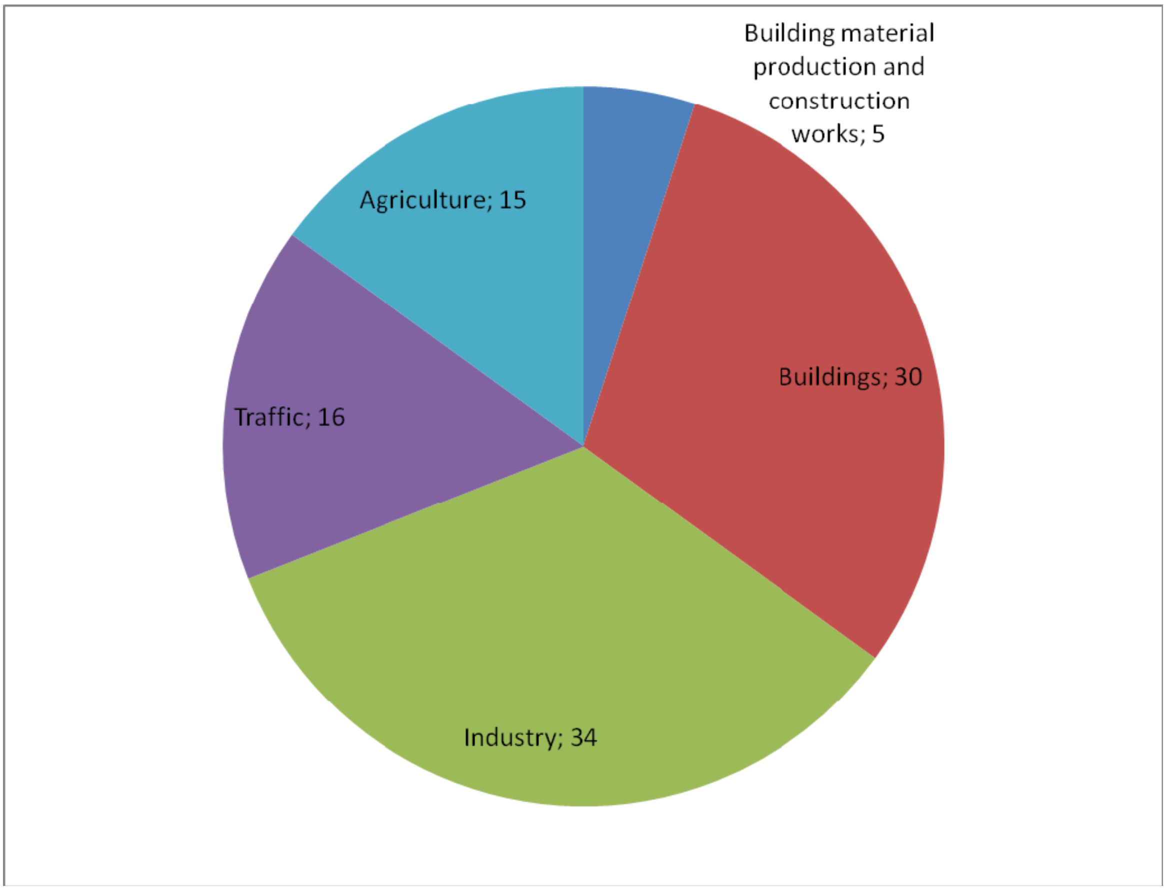
November 2008 and February 2009
Mikko Viljakainen

Mikko Viljakainen 10 Mar 2009

2 BACKGROUND

Construction and the manufacture of building products account for 5% of our country's annual energy consumption and carbon dioxide emissions. No reduction targets have, at least for now, been proposed in relation to this share.

The measures proposed for improving energy-efficiency focus on reducing the amount of energy consumed during a building's use and the carbon dioxide emissions this consumption causes. The working hypothesis of this report is that reduction targets should also be set with regard to the energy consumption and carbon dioxide emissions caused by construction and the manufacture of building products.



Graph 1 The use of buildings accounts for 39% of our country's energy consumption and 30% of carbon dioxide emissions. Pie shows breakdown of carbon dioxide emissions. (Source: Ministry of the Environment)

The new energy-efficiency requirements for buildings will come into force at the beginning of 2010. The aim of the revision is to tighten energy-efficiency regulations on new construction production in a way that will shift building practices towards low-energy construction. The background to this is formed by the European Union's central climate and energy policy commitments on emissions reductions and enhancing energy-efficiency. According to directive, the new regulations would represent a tightening of about 30-40% from current levels.

The intention with the new requirements is not to change the current structure of building regulations or the manner in which compliance to these is demonstrated; instead, changes will primarily be made to the numerical values determined in regulations.

A restructuring of building regulations and the next tightening in requirements is scheduled for implementation already in 2012, when a transition to regulation based on total energy consumption and the use of primary energy coefficients will take place. The aim is to further tighten regulations by about 20% in the same conjunction.

The goal of the new regulations is to aid in the attainment of the EU's goal to reduce carbon dioxide emissions not included in the emissions trading scheme by 16% by 2020. For Finland, this translates into a reduction of about 6 million tonnes of CO_2, of which construction would account for 1…2 million tonnes. (Source: Presentation by Erkki Laitinen at the FISE Day, 16 Oct 2008)

Although 5% of total energy consumption and carbon dioxide emissions does not sound like much, the amounts involved are nonetheless large. The energy consumed during construction and the manufacture of building products comes to a total of about 15.4 TWh and these activities cause some 4.3 million tonnes of carbon dioxide emissions. This is almost as much as the carbon dioxide emissions caused by the entire forest industry, chemical paper and pulp manufacturing included. The forest industry as a whole causes annual carbon dioxide emissions of about 5 million tonnes.

3 THE GOALS OF THIS REPORT

The aim of this comparison is to determine

- How do the environmental impacts of alternative structural solutions compare to each other?
- How does the 5% of total energy consumption and carbon dioxide emissions accounted for by construction and the manufacture of building products break down?
- What effect will the tightening of energy-efficiency requirements in 2010 have on the energy consumption and carbon dioxide emissions caused by construction and the manufacture of building products?
- How significant would a reduction in the energy consumption and carbon dioxide emissions caused by construction and the manufacture of building products be in comparison to a reduction in the energy consumption of the total building stock?

On the basis of the answers to these questions, I tried to determine whether reduction targets should also be set for the energy consumption and carbon dioxide emissions of construction and the manufacture of building products. Another matter considered was what practical measures could be used to reduce these emissions.

Another aim was to form an idea of the effectiveness of the present environmental declaration system for construction products and any development needs.

4 METHODOLOGY AND SOURCE DATA

The report compares the environmental impacts caused by building-component alternatives, which are as technically comparable as possible. The five key indicators chosen to aid in the evaluation of environmental impacts are:

- consumption of non-renewable natural resources
- total consumption of natural resources
- consumption of non-renewable manufacturing energy
- total consumption of manufacturing energy
- emissions of carbon dioxide.

The compared building components are typical exterior and interior walls, exterior cladding products, insulating materials and construction joists. At first, the calculation of the environmental impacts of building components was unit-based, i.e. it examined the effects caused by one square metre (1 m^2) of each component. To facilitate this, the weight per square metre of each component was calculated to provide the environmental impact relative to weight.

The next step was to examine the environmental effects of building components weighted by market share. Market-share weighted building-component data were also used to estimate the environmental impacts of construction activity as a whole. To be on the safe side, comparative calculations were made utilising different building components; the results yielded by these were quite similar, however.

RT Environmental Declarations, which are compiled by the Building Information Foundation, and public information disclosed by manufacturers themselves were used as sources for the comparison. The RT Environmental Declarations are based on the national methodology following the basic principles stated in the ISO standard series 14040 and 14020. The method considers also the preliminary results achieved within ISO CD 21930.The viewpoint of the comparison is thus domestic and based on uniform evaluation methods that are generally accepted within the building sector. The results would probably not be substantially different even if the study were applied overseas as well.

With respect to wood products, the evaluation takes account of the carbon dioxide and combustion energy bound in wood that has been stated in the environmental declarations. In practice, the carbon dioxide amount bound by wood that is stated in the environmental declaration has been deducted from the carbon dioxide emissions caused by the manufacture of the timber parts of a wooden structure. This gives a true representation of how the carbon bound in wood affects the carbon dioxide balance of the entire structure; in other words, it reveals how significant a carbon sink the structural component in question could be. This also leads to the conclusion that increasing the use of wood would reduce the overall emissions of the building sector. In principal, this advantage is retained only as long as wood products are not utilised as an energy source, but even in this case the carbon dioxide balance of wood products would be zero because combustion only releases the atmospheric carbon that had been bound into the wood as it grew.

The combustion energy obtained from the by-products of wood-component manufacturing and from burning wood products at the end of their lifecycle has similarly been deducted from the energy consumption associated with the manufacture of the timber components in wooden structures. This is justified because the energy contained by a wooden house can, at the end of its lifecycle, be taken into use in the form of bioenergy. Pulling down a stone, brick or steel-frame house consumes energy, as does the recycling of its constituent products. The dismantling of a wooden house also requires energy, but the wooden parts harvested from it can be utilised in the generation of energy.

The energy required in the dismantling of different types of buildings has not been compared, however, because no information is available on the matter. The comparison is probably unfavourable for wood in this respect as it is likely that pulling down a stone or steel-frame building would require more energy than the dismantling of a wooden house.

For the sake of comparison, the calculations were also made in a way that did not count the combustion energy obtained from the by-products of wood product manufacture and from the products themselves at the end of their lifecycle or the carbon dioxide bound by wood products in wood's favour. However, even these calculations produced a result that was very much in line with the one presented here: the market-share weighted share of wood building components in the overall environmental impact of the building sector is very small relative to competing products. For the sake of clarity, the calculations of the report have been presented in just one manner.

The calculations do not take into consideration the amount of energy used in the transport of construction products from the factory to the building site because this has not been included in the environmental declarations either. The transporting of raw materials to the factory has, on the other hand, been considered in the environmental declarations. Comparisons of transport energy consumption would probably not yield any great differences once the analysis reaches the construction-site stage. All materials have to be transported to the construction site. Furthermore, the material-loss figures presented do not contain differences of a magnitude that would result in substantial transport-cost differences. In this respect, the comparison is unfavourable for wooden building components as the moulds of concrete structures that are cast on-site, for example, cause dismantling waste, which has to be transported away from the site as well.

The comparison is, naturally, only indicative because no comprehensive source of information on the environmental impacts of entire building components is available. Further uncertainty is added by the relative technical equivalency of the different components, a matter on which it is always possible to disagree. A corresponding study of building maintenance technology is also necessary. But then, the assumption is that this would be largely the same with respect to the different alternatives.

Mikko Viljakainen 10 Mar 2009

5 FINDINGS

5.1 ENVIRONMENTAL IMPACTS OF THE MANUFACTURE OF BUILDING COMPONENTS

5.1.1 Exterior walls

The compared exterior wall structures were typical sandwich, Leca (lightweight expanded clay aggregate) blocks, Aircrete and red brick walls as well as steel-frame and timber-frame walls. The structural specifications were chosen in as simplified a manner as possible, so that in the brick wall, for example, both the exterior and interior shell were made of the same bricks, the steel-frame wall was clad with sheet metal and the timber-frame wall was clad with wood. The wall structures and their respective weights per square metre are presented in greater detail below:

Sandwich module (372 kg/m^2)
- Exterior shell 77 mm concrete
- Rock wool insulation 165 mm
- Interior shell 80 mm concrete

Leca block walls (230 kg/m^2)
- Insulation blocks 300 mm
- Mortar 5 kg/block
- Reinforcement steel 4m/m^2

Aircrete wall (211 kg/m^2)
- Aircrete block 375 mm
- Mortar 14 kg/m^2

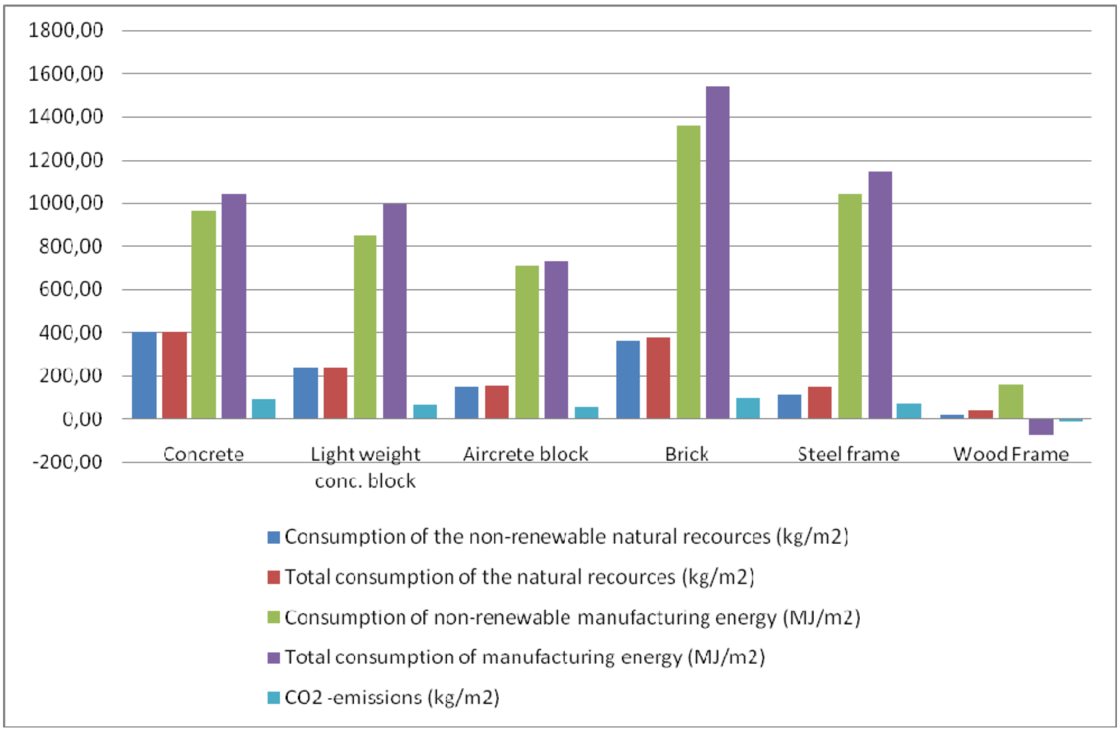
Brick wall (284 kg/m^2)
- Red brick 85 mm
- Mineral wool 175 mm
- Red brick 85 mm

Steel-frame wall (83 kg/m^2)
- External cladding sheet-metal cassette
- Windbreak, gypsum board 9 mm
- Thermal frame 200 mm
- Rock wool 200 mm
- Gypsum board 13 mm

Timber-frame wall (40 kg/m^2)
- External cladding 28 mm + battens
- Windbreak, porous fibreboard 25 mm
- Wooden frame 48 mm x 172 mm
- Insulation (ecowool) 175 mm
- Gypsum board 13 mm

Mikko Viljakainen 10 Mar 2009

Fillers and surface plasters were not taken into consideration for masonry structures. A sandwich module also requires some type of interior filler, which has not been included in the calculations. The steel- and timber-frame wall figures do not take into consideration any interior gypsum board fillers. Surface treatment is not included in any of the wall types.



Graph 2 Environmental impacts of technically equivalent non-bearing exterior walls in 2007

The greatest amount of natural resources per square metre is consumed by exterior concrete sandwich walls. Exterior brick walls consume almost as much. Weighty structures consume a lot of natural resources. The natural resource consumption of these as well as of other masonry structures is almost entirely made up of non-renewables.

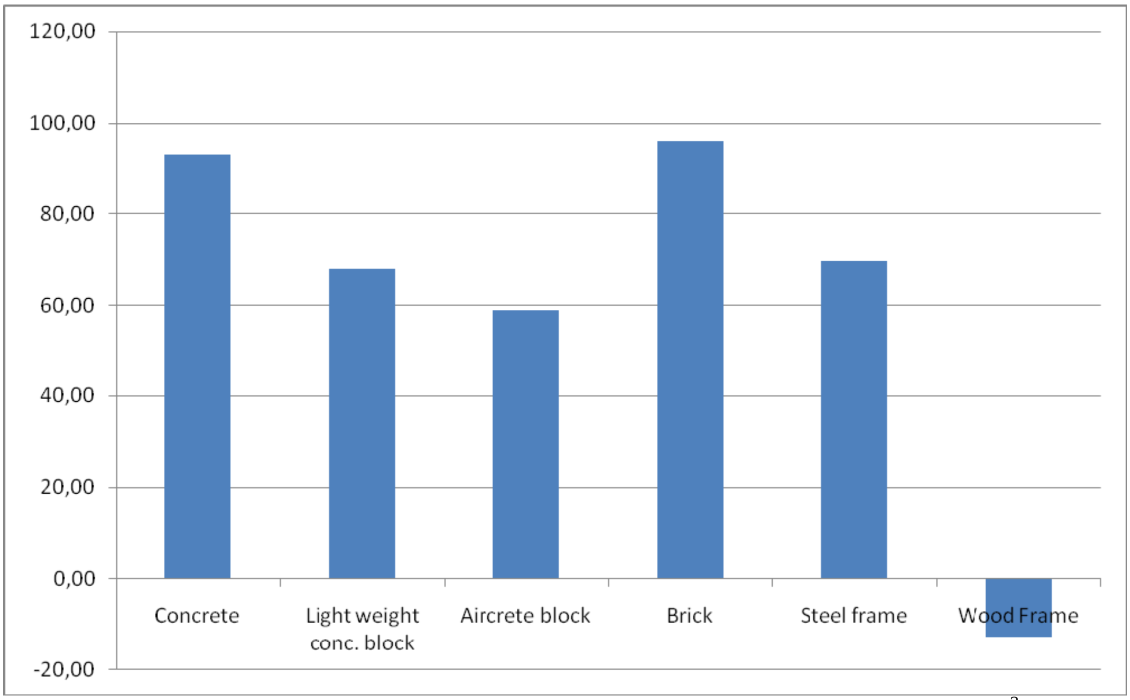
What was curious was that the making of a 211-kg Aircrete wall only consumed 155 kg of natural resources. This is one of the oddities contained in the environmental declarations. In the case of steel, for example, recycled steel is not counted into natural resource consumption at all. The environmental declaration for Aircrete does not indicate what constitutes the “dark matter” that is missing from the totality.

Another anomaly related to Aircrete is its weight. The environmental declaration states that the specific weight of Aircrete is 400 kg/m^3, but the weight noted for Aircrete blocks is different. Using the figure noted for blocks indicates that a square metre of exterior wall would require 195 kg of blocks, but if calculations are based on the specific weight, the weight of the blocks required for one square metre of exterior wall is just 150 kg. This represents a difference of 30%.

As a light-weight structure, a timber-frame wall consumes very little natural resources in comparison to the other exterior wall alternatives and this consumption focuses heavily on renewables.

Brick walls take the top spot in energy consumption. Steel-frame, sandwich, Leca and Aircrete walls also require a considerable amount of energy – and most of this comes from non-renewable sources. Even though the making of a timber-frame wall also requires non-renewable energy, the amount of energy generated from wood products in conjunction with manufacture and at the end of their lifecycle is enough to make the energy balance of a timber-frame wall negative. In other words, more energy can be extracted from a wall than is required to make it. This is true also of the carbon dioxide emissions of timber-frame walls. A wooden wall is a carbon sink.

The carbon dioxide emissions caused by different exterior wall types range from the -12.66 kg bound by a timber-frame wall to almost 96 kg for brick walls. Although products, such as gypsum board, whose manufacture produces carbon dioxide emissions are also used in the making of timber-frame wall structures, the carbon dioxide bound by its wooden components is sufficient to compensate for this negative impact when the structure is examined as a totality. Relative to weight, steel-frame walls cause the greatest amount of carbon dioxide emissions (84 % of own weight).

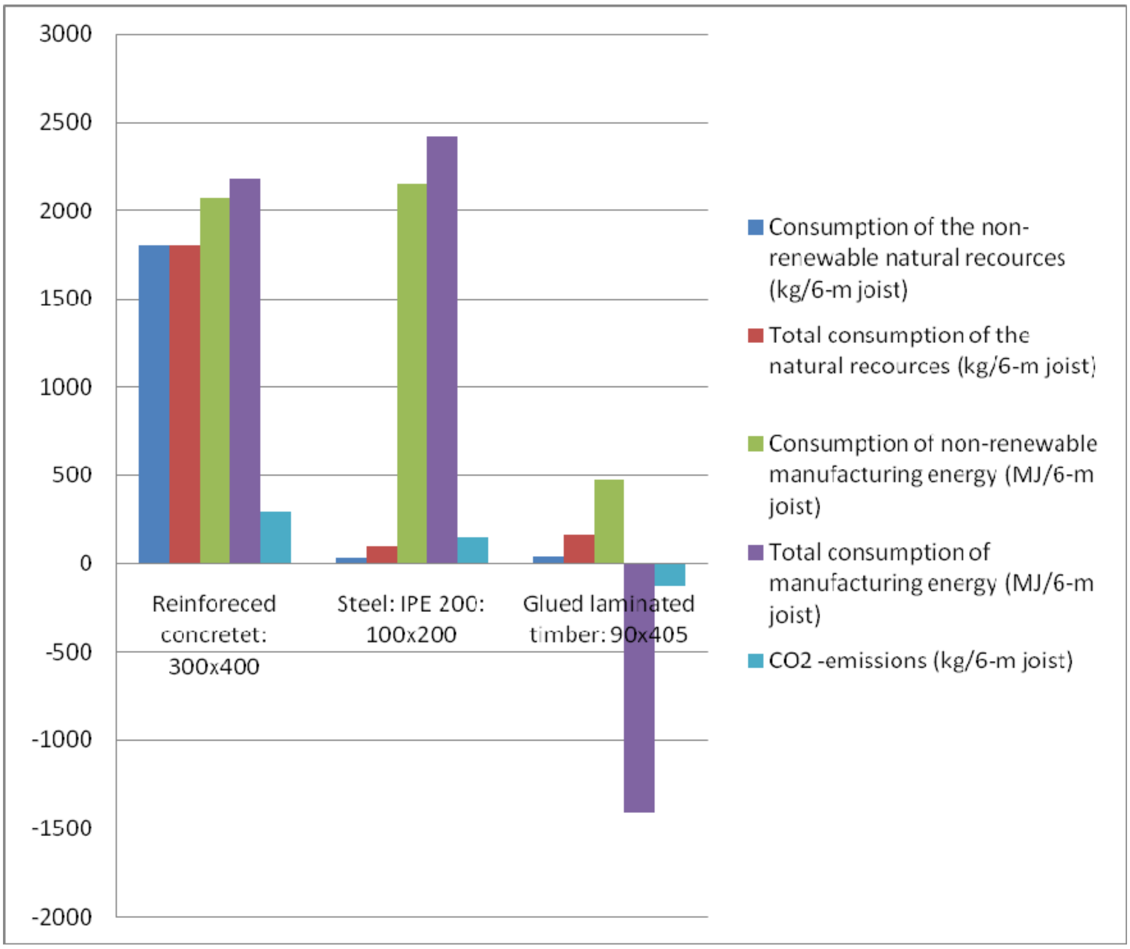


Graph 3 Carbon dioxide emissions caused by the manufacture of exterior walls (kg/m^2)

5.1.2 Joists

The comparison included technically equivalent glulam, steel and reinforced concrete joists. The length of the joists was 6 m, the fire endurance rating was R30 and the load was 3kN/m. The compared joists were:

- R30 glulam: 90x405, weight 94 kg/6m
- Steel: IPE 200: 100x200, weight 134 kg/6m
- Reinforced concrete: 300x400, weight 1,728 kg/6m



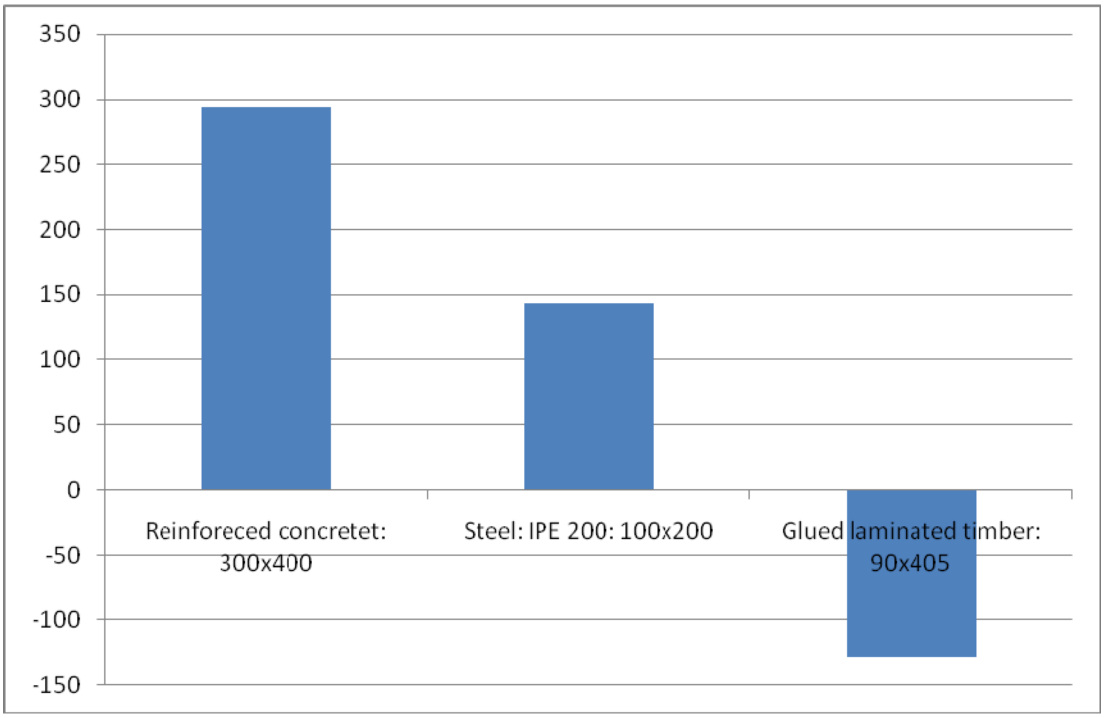
Graph 4 Environmental impacts of construction joists – joist span 6 metres, 3kN/m, R30

Weighty reinforced concrete joists consume the largest amount of natural resources. The anomaly mentioned in the foregoing is repeated in the case of steel. A 134-kg steel joist is created using 97 kg of natural resources. This is explained by the practice of omitting recycled steel entirely from the natural resource consumption figures in the environmental declaration of steel.

Renewables account for a large share of the natural resource consumption of glulam joists. A total of 123 kg is used to make a joist that weighs 94 kg. The excess portion is utilised as energy, which, when added to the combustion energy of the glulam, shows in the energy balance of glulam. The manufacture of a glulam joist produces renewable energy, as does the joist itself when it is utilised as an energy source at the end of its lifecycle. The greatest amount of manufacturing energy is consumed in the making of steel joists. The manufacture of reinforced concrete joists consumes almost as much energy. In both cases, non-renewables account for the greater share in consumption.

The greatest amount of carbon dioxide emissions is caused by reinforced concrete joists (293 kg/joist), followed by steel joists (143 kg/joist). A glulam joist stores 129 kg of carbon dioxide for the duration of its lifecycle.

Mikko Viljakainen 10 Mar 2009



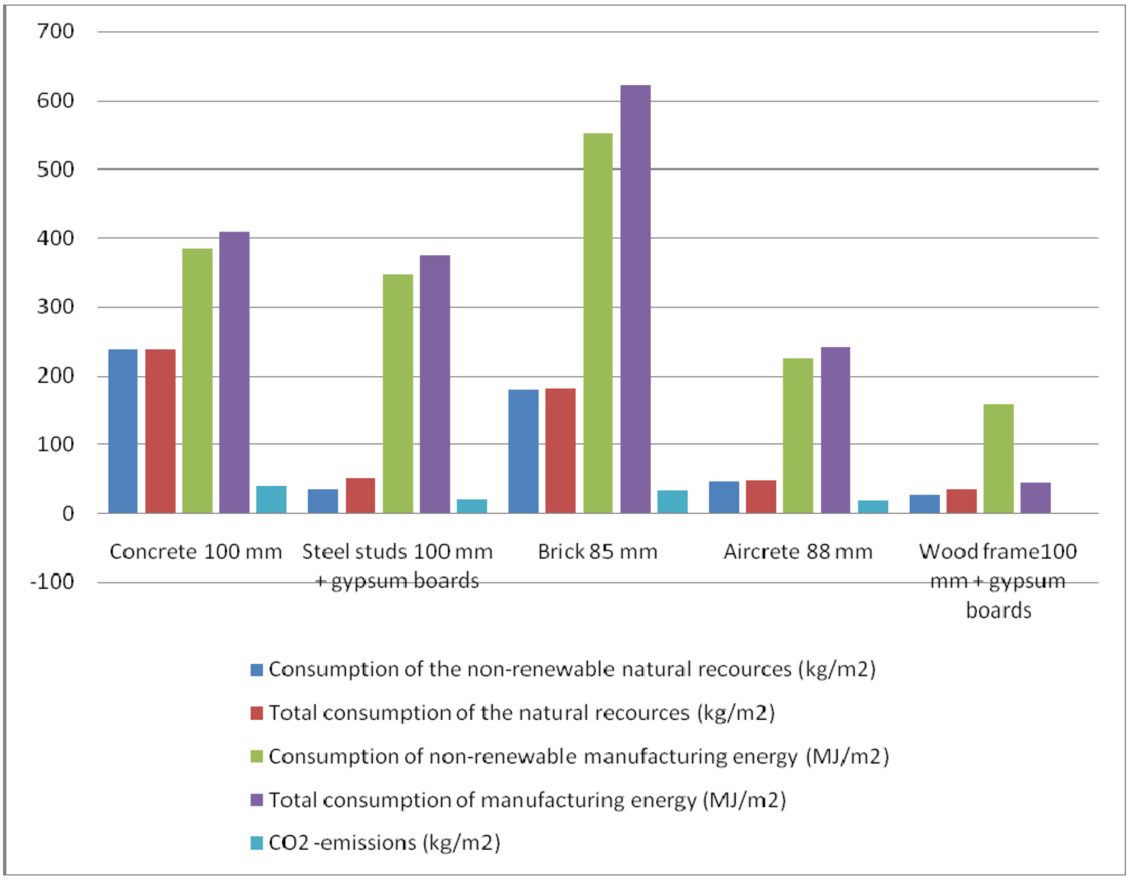
Graph 5 Carbon dioxide emissions of joist manufacture (kg/6-m joist)

5.1.3 Interior walls

The most commonly used interior wall types were compared. The figures for masonry structures do not take fillers or surface plasters into account. Concrete modules also require some kind of filler materials, but these have not been included in the figures. For their part, the steel- and timber-frame wall figures do not include the necessary gypsum board fillers. Surface treatment was excluded from the figures for all wall types. The compared wall structures and their weights per square metre are:

- Concrete wall 100 mm, weight 240 kg/m^2
- Sand-lime brick wall 85 mm, weight 138 kg/m^2
- Aircrete wall 88 mm, weight 70 kg/m^2
- Steel-frame wall, weight 35 kg/m^2
  - Gypsum board 13 mm
  - Sheet-metal frame 100 mm, k 400
  - Gypsum board 13 mm
- Timber-frame wall, weight 29 kg/m^2
  - Gypsum board 13 mm
  - Timber frame 100 mm, k 400
  - Gypsum board 13 mm

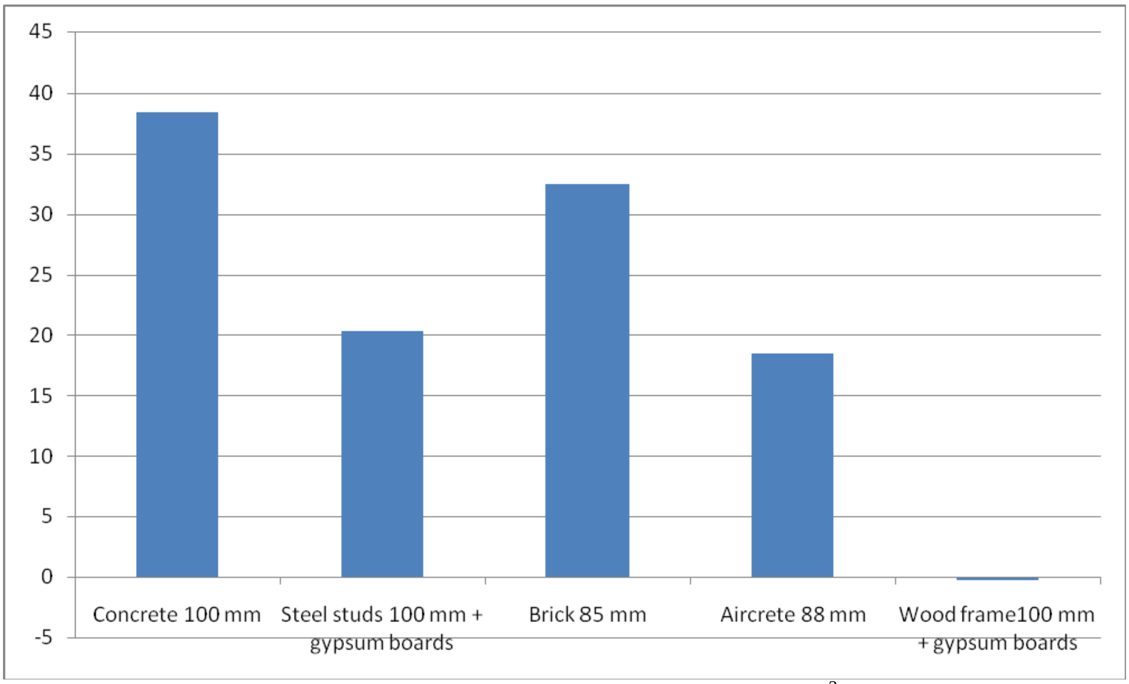
Mikko Viljakainen 10 Mar 2009



Graph 6 Environmental impacts of different interior wall solutions

The natural resource consumption follows a similar pattern to the earlier comparisons. The greatest amount of natural materials is consumed by masonry structures, in which consumption focuses on non-renewables. A concrete wall consumes almost seven times the amount of natural resources that are needed for a timber-frame wall.

Timber- and steel-frame walls distinguish themselves with respect to their consumption of natural resources. The differences between these two are created by the frame structure, as the walls are otherwise identical. The manufacture of a steel-frame wall consumes 31% more natural resources than the making of a timber-frame wall. Its manufacture consumes almost 9 times the energy than the timber-frame wall.



Graph 7 Carbon dioxide emissions of interior wall manufacture (kg/m^2)

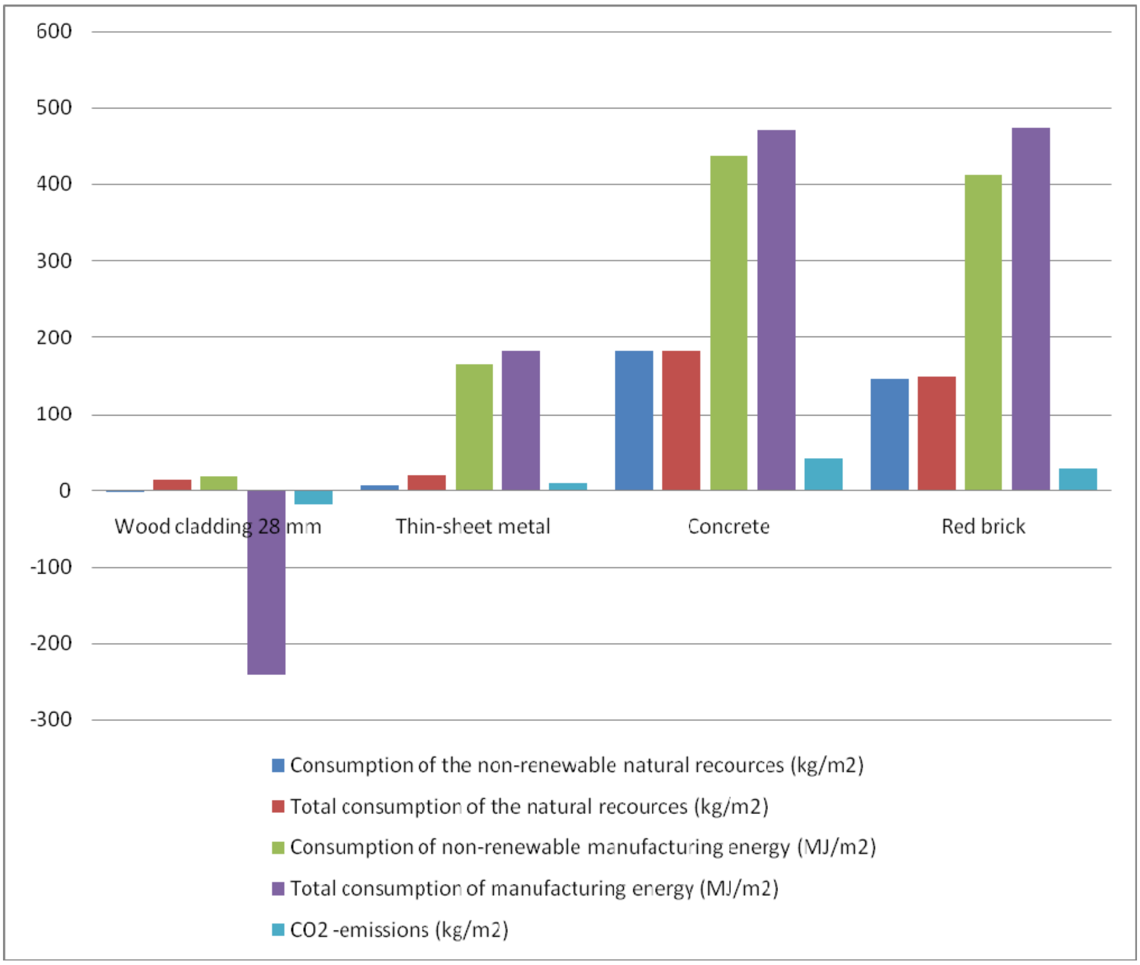
The largest carbon dioxide emissions are caused by concrete (38 kg/m^2) and sand-lime brick (32 kg/m^2) walls. These are followed by steel-frame (20 kg/m^2) and Aircrete (18 kg/m^2) walls. Conversely to this, timber-frame store some 8,7 kg/m^2 of carbon dioxide but that is almost neutralised because of gypsum boads in the wall.

5.1.4 Exterior cladding

The most common exterior cladding solutions (wood, brick, concrete and steel) were compared. Coating materials were not considered in this comparison because they are not presented in the environmental declarations. The figures for wooden facades take account of the timber battens to which the facade cladding is attached. The figures for brick facades do not, however, take account of the necessary mortar or steel binding.

- Wood cladding 28 mm, weight 12.4 kg/m^2
- Thin-sheet steel 1.5 mm, weight 9.8 kg/m^2
- Concrete 77 mm, weight 168 kg/m^2
- Red brick 85 mm, weight 125 kg/m^2

Mikko Viljakainen 10 Mar 2009



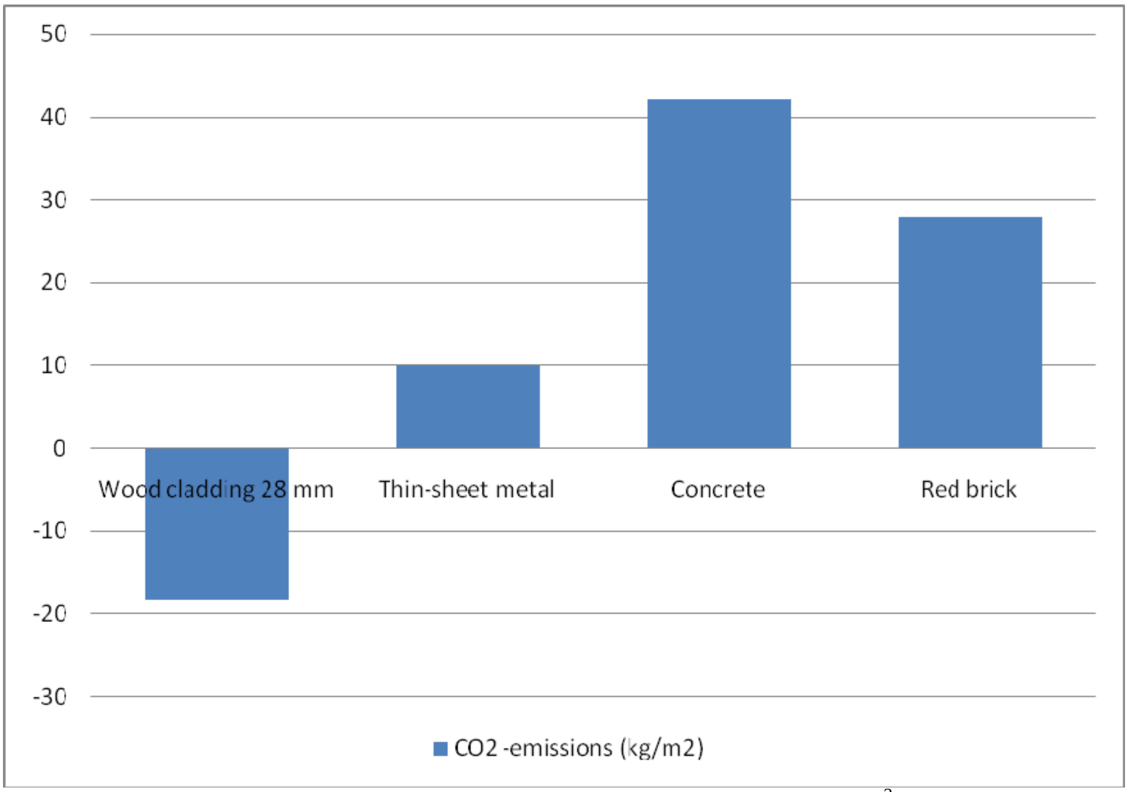
Graph 8 Environmental impacts of most common facade cladding solutions

The pattern seen in the foregoing is repeated here. Weighty concrete and brick cladding consumes a lot of natural resources, and consumption is almost entirely focused on non-renewables. As ultra-light structures, the natural resource consumption of wooden and steel exterior cladding solutions is considerably smaller than that needed for masonry structures. In the case of wood products, this consumption is almost completely made up of renewables.

Concrete and brick exterior cladding solutions are also in a league of their own with respect to energy consumption. Their manufacture requires over two times as much energy as steel exterior cladding does. The energy extracted from the by-products of wood products manufacture as well as from the product itself at the end of its lifecycle give wooden exterior cladding solutions a negative energy balance. In the final analysis, as much energy is recovered from wooden exterior cladding as is required to manufacture steel exterior cladding. In fact, a more detailed comparison would probably be even more favourable for wood products because this examination does not take account of the energy needed for dismantling and reuse.

The pattern is similar for carbon dioxide emissions. The biggest emissions are caused by concrete (42 kg/m^2), the second-largest by brick (28 kg/m^2) and the third-largest by steel (10kg/m^2) exterior cladding solutions. Wooden exterior cladding stores 19 kg/m^2 of carbon dioxide.

Mikko Viljakainen 10 Mar 2009



Graph 9 Carbon dioxide emissions of exterior cladding manufacture (kg/m^2)

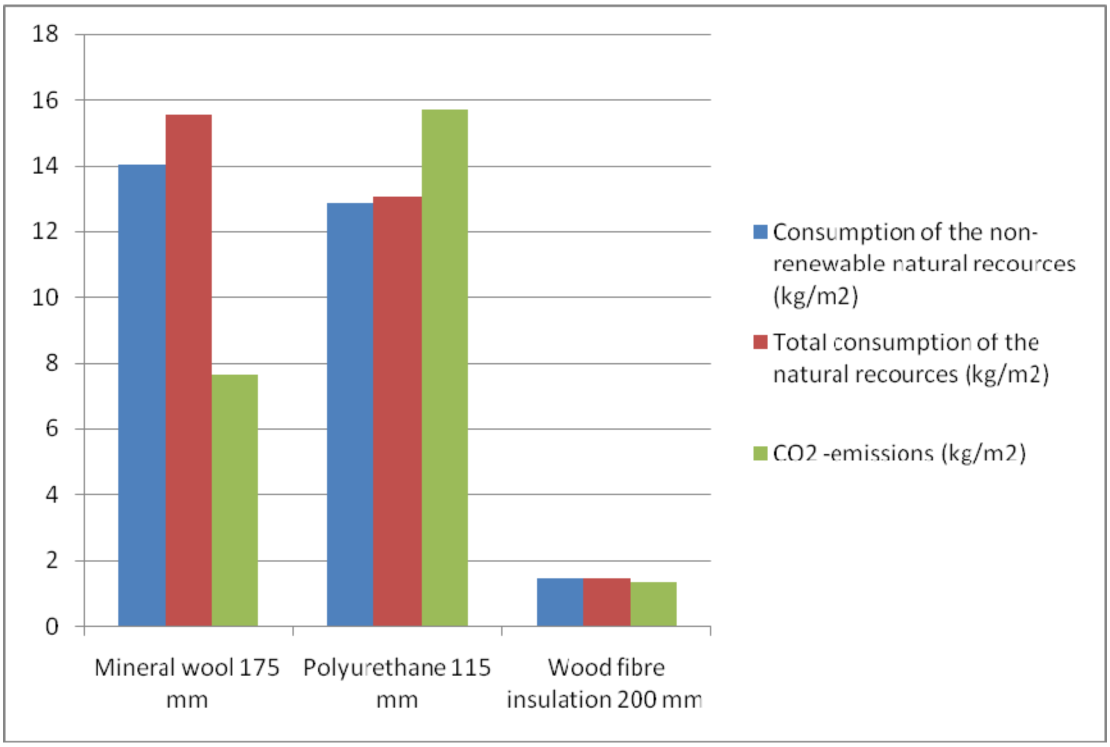
5.1.5 Insulation materials

Tightening energy-efficiency demands will increase the consumption of insulation materials substantially. This is why I wanted to examine the environmental impacts of the manufacture of insulation material alternatives in this comparison. The most common materials, mineral wool, polyurethane and wood-fibre insulation, were compared. The impact per square metre was calculated using insulation thicknesses stipulated in the energy-efficiency requirements in force in 2007. The thicknesses and weights used for the calculations were:

- Mineral wool 175 mm, weight 7.9 kg/m^2
- Polyurethane 115 mm, weight 4 kg/m^2
- Wood-fibre insulation 200 mm, weight 7 kg/m^2

The greatest amount of natural resources is consumed by mineral wool, with polyurethane consuming almost as much. This consumption focuses on non-renewables. Polyurethane is the biggest consumer of manufacturing energy, however. Compared to the other examined materials, wood-fibre insulation consumes little natural resources and energy. As was the case with the data presented earlier on steel, the environmental declaration of wood-fibre insulation does not take into account the principal raw material extracted through recycling, i.e. recycled paper. But then, it, too, is based completely on a renewable natural resource, wood, and is primarily manufactured with renewable energy, which is generated from the by-product flows of pulp-making.

Mikko Viljakainen 10 Mar 2009



Graph 10 Natural resource consumption and carbon dioxide emissions of the manufacture of insulation materials per square metre of wall

Graph 11 Energy consumption of the manufacture of insulation materials per square metre of wall

Mikko Viljakainen 10 Mar 2009

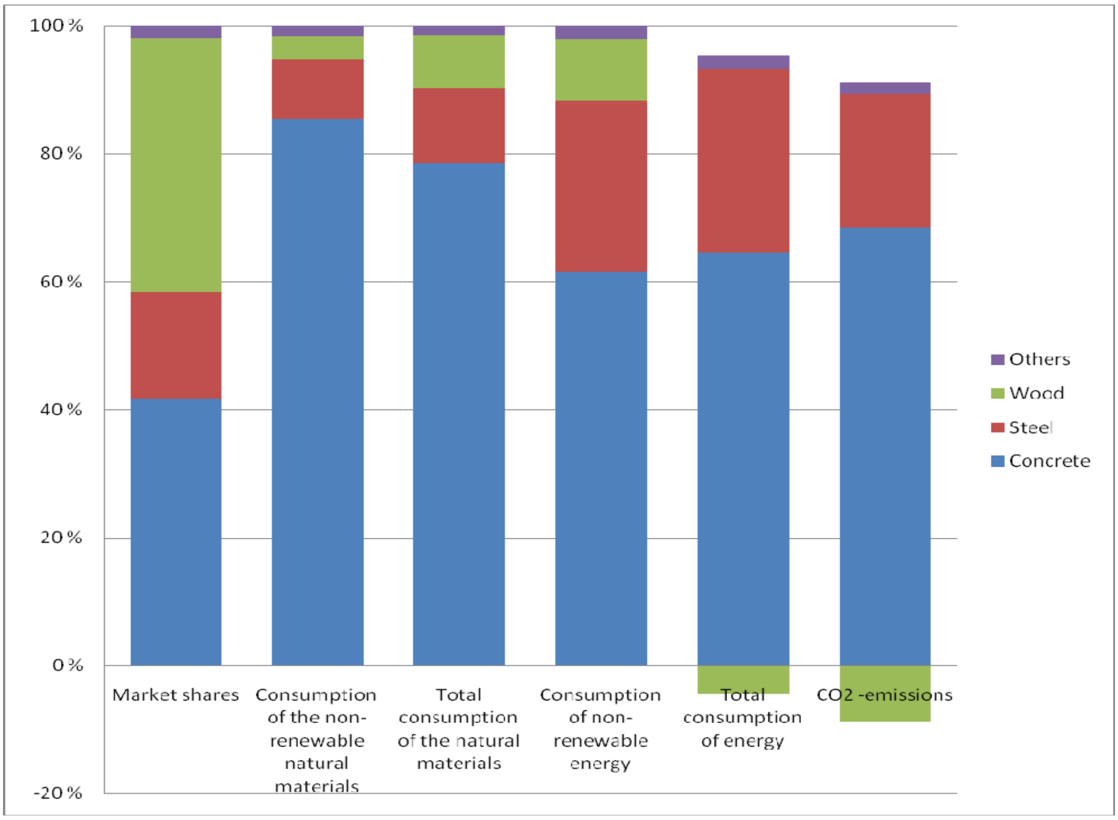
5.2 CAUSES OF CONSTRUCTION-RELATED NEGATIVE ENVIRONMENTAL IMPACTS IN 2007

This chapter examines the causes of the negative environmental impacts of construction and the manufacture of building products – in other words, how does the 5% share in the nation's energy consumption and carbon dioxide emissions that was mentioned in the initial information of this report break down. As has been stated in the foregoing, construction and the manufacture of building products consume about 15.4 TWh of energy and cause some 4.3 million tonnes of carbon dioxide emissions. These emissions are almost equal to the aggregate carbon dioxide emissions of the entire forest sector, which stand at about 5 million tonnes.

The indicators used for the calculations were the exterior and interior wall structures as well as the exterior cladding solutions that were compared earlier. Joists and insulation materials were not examined because they, being made up of a single material, would probably have presented an unrealistic picture of the issue. The environmental impacts of the chosen structures were weighted according to actual market share.

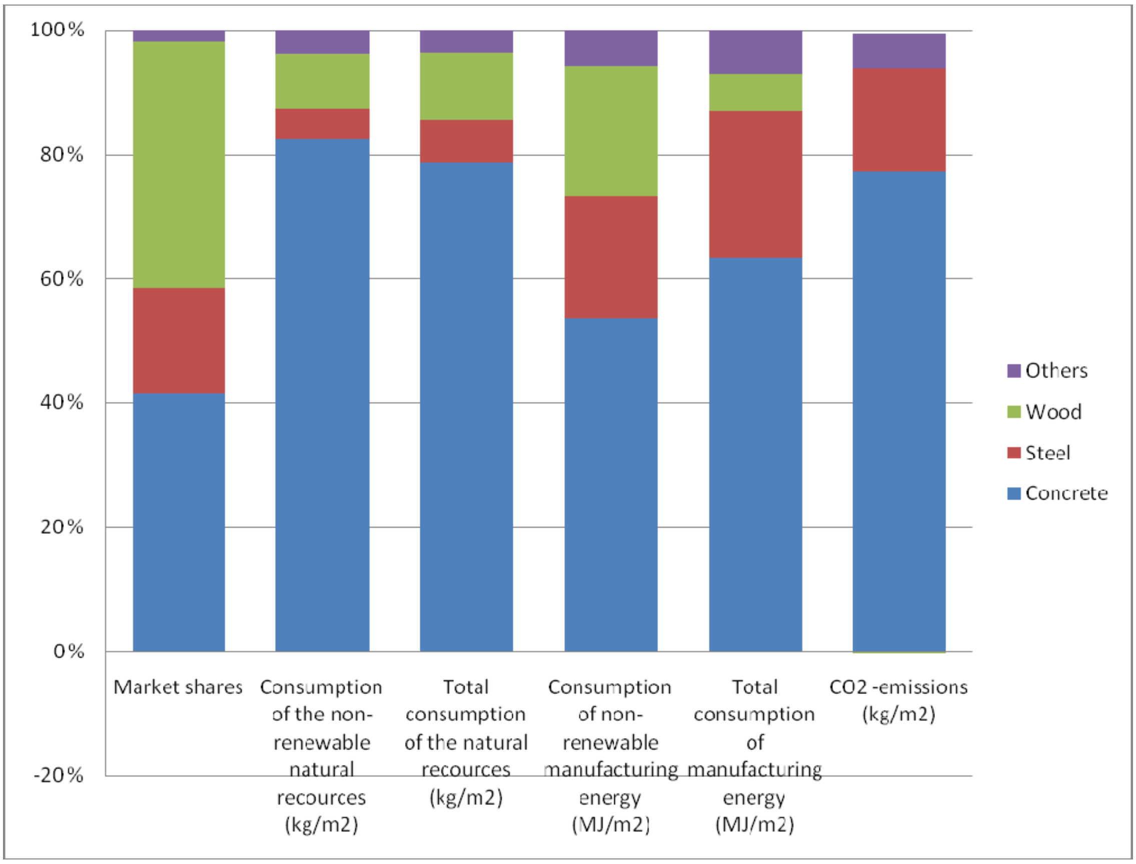
5.2.1 Exterior and interior wall structures as indicators

The environmental impacts of different exterior and interior wall structures were weighted according to their share of the framing construction market. Concrete, steel and wood structures were chosen for analysis. Other structures were taken into consideration as the mean value of the remainder, which was weighted according to the aggregate market share of these structures.



Graph 12 Causes of construction-related negative environmental impacts in 2007 – exterior wall structures as indicators

Mikko Viljakainen 10 Mar 2009



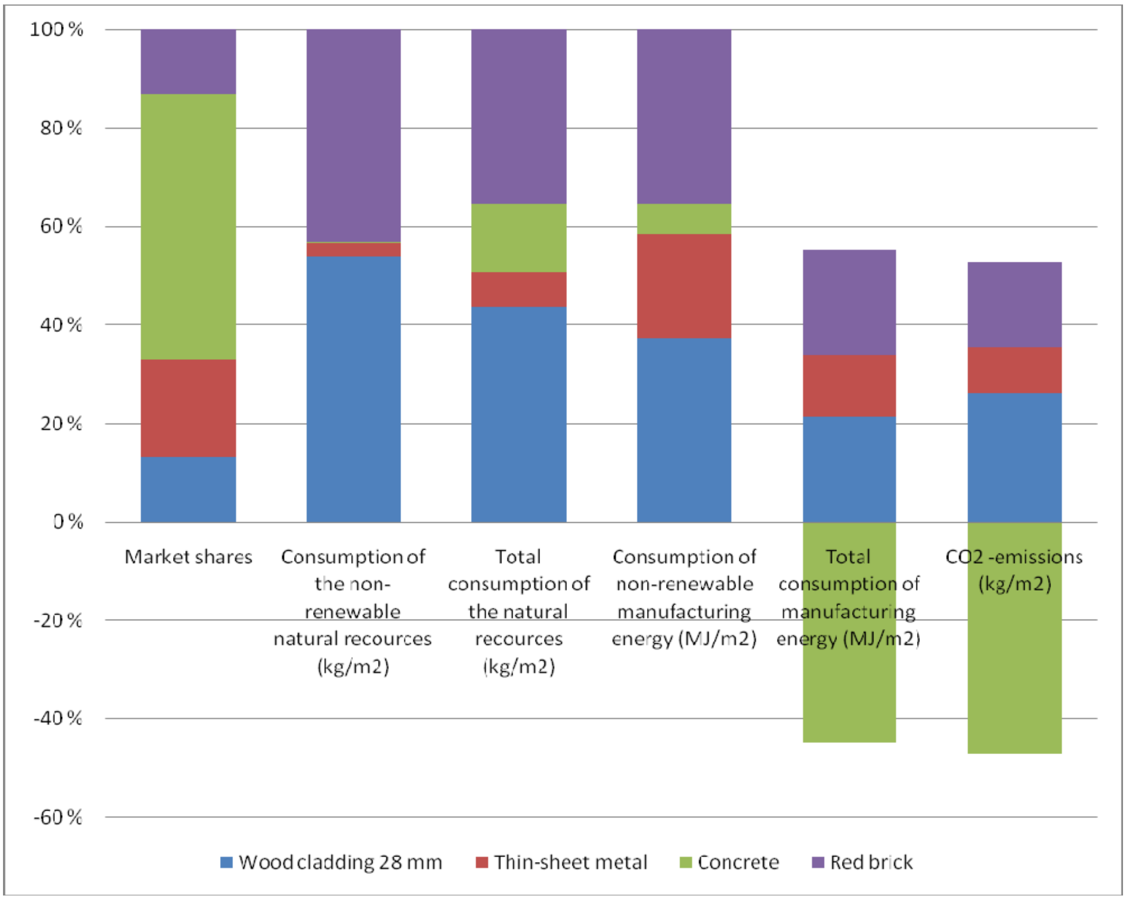
Graph 13 Causes of construction-related negative environmental impacts in 2007 – interior wall structures as indicators

Analyses of both exterior and interior wall structures provide very similar results. Even though timber and concrete structures have an almost equal share of the market, the great majority of the negative environmental impacts of construction and the manufacture of building products are caused by concrete structures. Wooden structures account for a very small share of the total consumption of natural resources and energy. The total energy consumption of the exterior walls is actually negative; in other words, the amount of energy extracted from the by-product flows of manufacture and the wood products themselves at the end of their lifecycle is larger than the amount required to build a wooden house. The greater part of carbon dioxide emissions is also caused by concrete structures. It is possible to reduce overall carbon dioxide emissions by increasing the use of wood. Wooden houses act as carbon dioxide stores throughout their use, in addition to which increasing the use of wood would reduce the emissions caused by other materials.

Mikko Viljakainen 10 Mar 2009

5.2.2 Exterior cladding as an indicator

The environmental impacts were weighted according to the market shares of different exterior cladding solutions. Wood, brick, concrete and thin-sheet steel exterior cladding solutions were included in the comparison.



Graph 14 Causes of construction-related negative environmental impacts in 2007 – exterior cladding as an indicator

In spite of their large market share (49%), wood exterior cladding solutions account for only a small portion of negative environmental impacts. As was the case in the examination of exterior and interior walls, the carbon dioxide emissions and total manufacturing energy consumption of wood exterior cladding solutions are clearly in negative territory. Despite their small market share, brick and concrete solutions cause the greater part of the negative environmental impacts of exterior cladding manufacture.

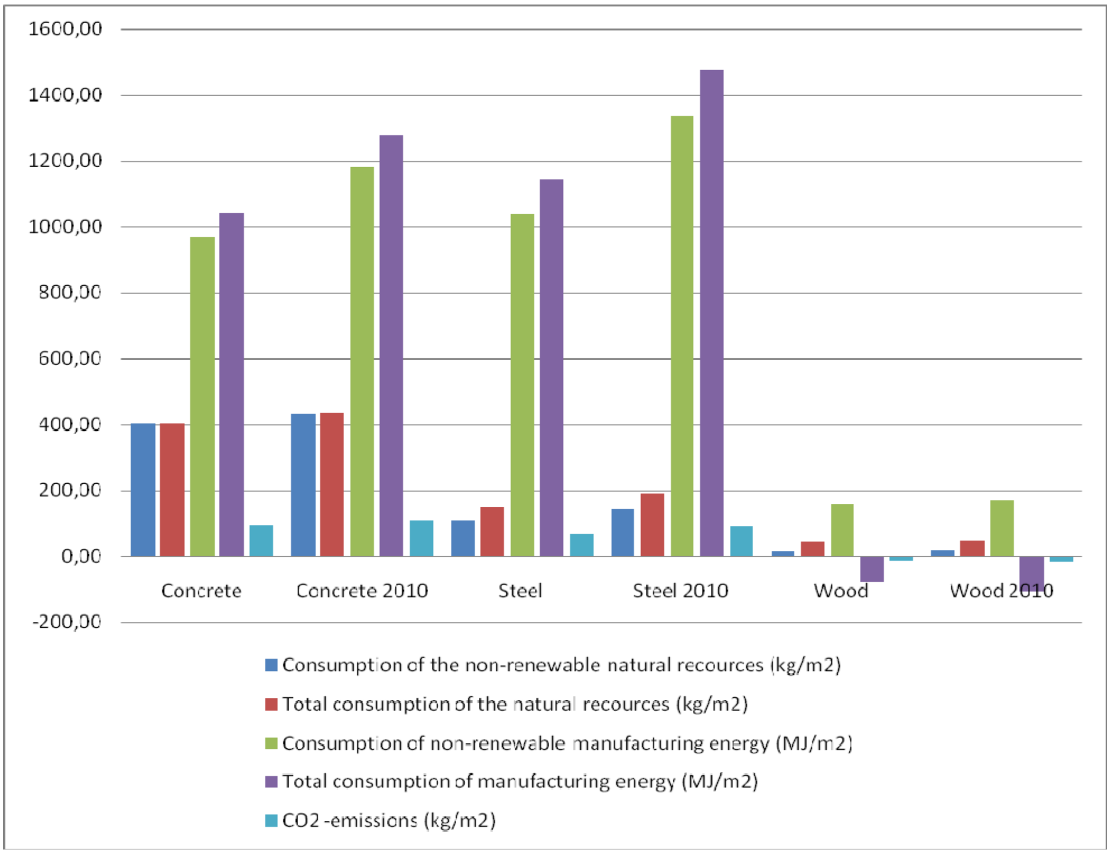
Mikko Viljakainen 10 Mar 2009

5.3 HOW WILL THE NEW ENERGY-EFFICIENCY REQUIREMENTS AFFECT THE NEGATIVE ENVIRONMENTAL IMPACTS OF CONSTRUCTION AND THE MANUFACTURE OF BUILDING PRODUCTS?

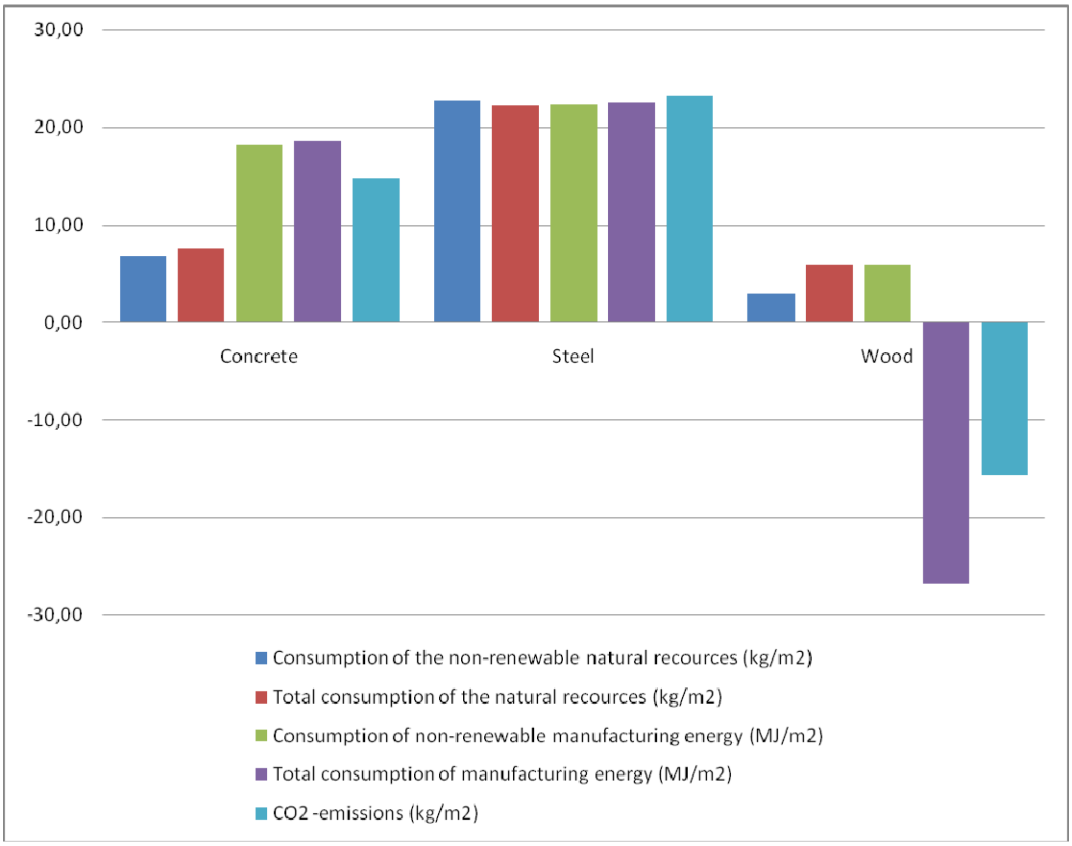
This chapter examines how the new energy-efficiency requirements, which come into force in 2010, will affect the negative environmental impacts caused by construction and the manufacture of building products. The indicators used for this examination were exterior walls and their changes. The changes necessitated by the new requirements focus on the exterior shells of buildings.

5.3.1 Effects on the building-component level

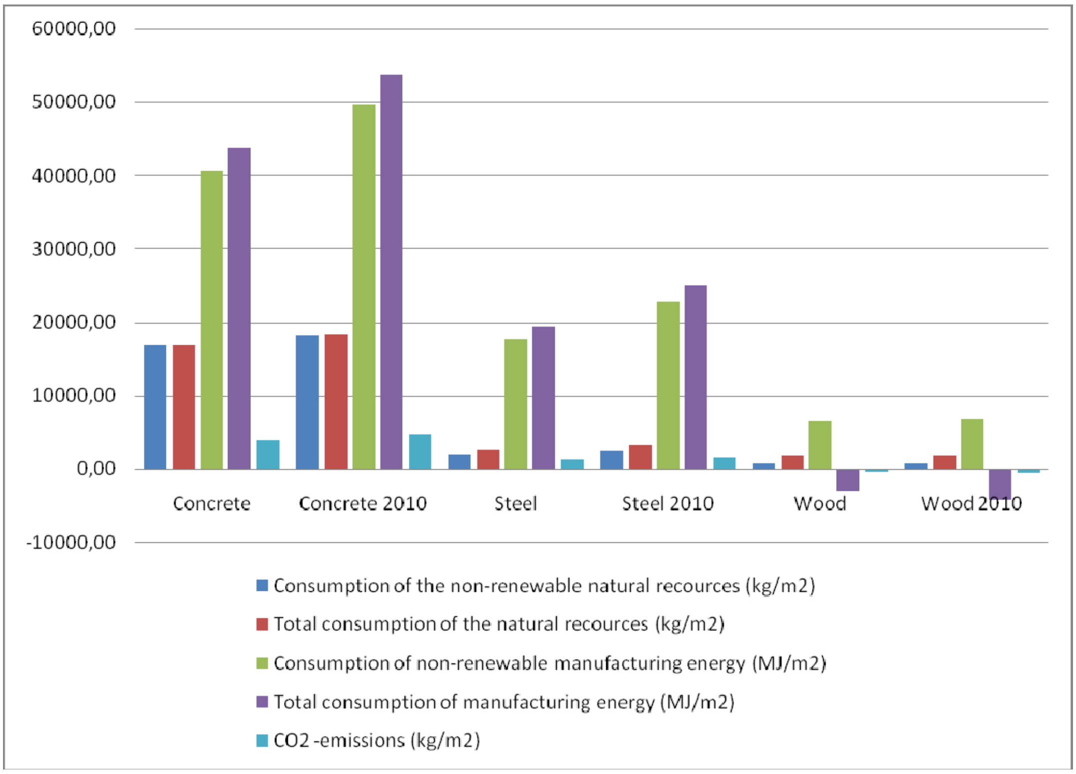
The new regulations will require builders to increase the amount and effectiveness of thermal insulation in the exterior shells of buildings. This will have slightly different practical implications for various structural solutions. The amount of concrete required for a concrete sandwich structure, for example, will not change, but a thicker layer of insulation will have to be placed in between the two cover sheets. The calculations do not take the changes required of the steel couplers that hold the two concrete layers together into account. Increasing the thickness of the insulation layer will probably also increase the amount of material required for the shell in the case of steel- and timber-frame walls, however. This has been taken into account in the calculations.



Graph 15 Environmental impact per square metre of concrete, steel- and timber-frame exterior wall in 2007 and after new regulations take effect in 2010.



Graph 16 Effect of coming energy-efficiency requirements on the environmental impacts of concrete, steel- and timber-frame exterior walls, %.



Graph 17 Effects of coming requirements adjusted according to market share.

The new energy-efficiency requirements will increase the environmental impacts of steel-frame exterior walls the most. The compared environmental impacts of steel-framed solutions will rise by about 23%.

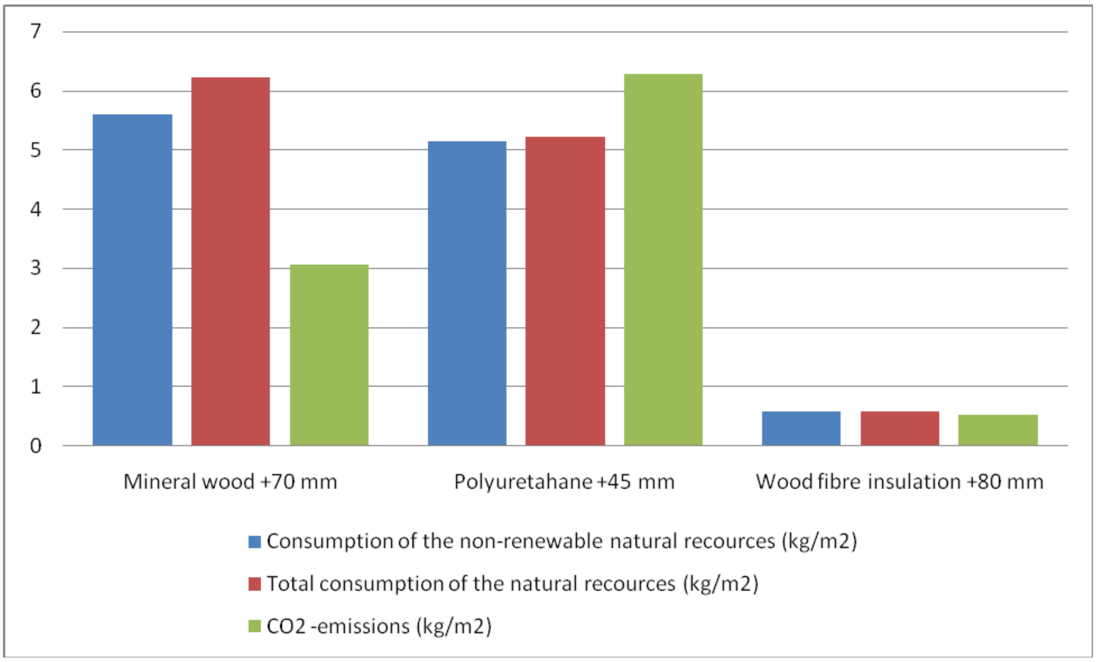
In the case of concrete, the increased environmental impacts are due solely to the larger amount of thermal insulation required. It should be noted, however, that when weighted according to market share, concrete structures account for the overwhelmingly largest increase in environmental impacts.

The effects on natural resource consumption growth in the timber-frame wall category are small, at about 5%. The effect of the new energy-efficiency requirements on the energy balance and carbon dioxide emissions of wooden structures is inverse to their impact on the other structures included in the comparison. The new regulations will translate into an increase of about 15% to the carbon sink of wood-structured exterior walls and an increase of more than 25% to the energy that can be extracted from the structure.

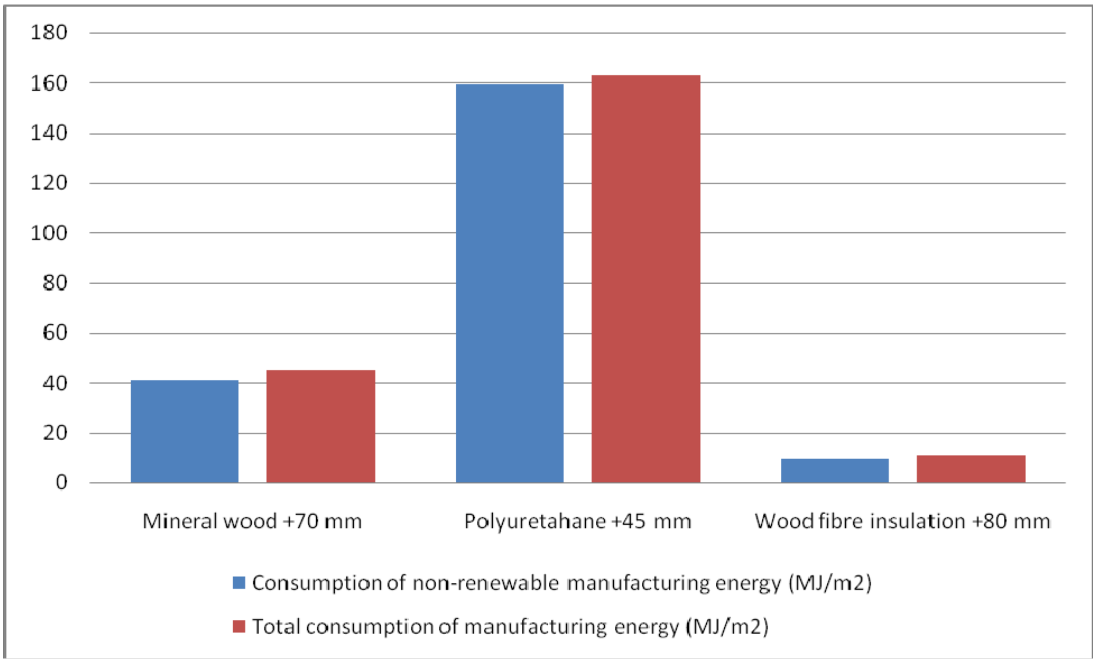
5.3.2 Thermal insulation – building renovations

It is of interest, especially with regard to building renovations and the additional insulation carried out in conjunction with these projects, to examine the effects that various additional insulation alternatives have on the environmental impact of construction and the manufacture of building products.

The same insulation materials that were examined in the foregoing were included in the comparison. The thickness required to increase the thermal insulation of exterior walls by 40% was calculated for these materials.



Graph 18 Improving thermal insulation by 40% - effects on the natural resource consumption and carbon dioxide emissions of various insulation materials.



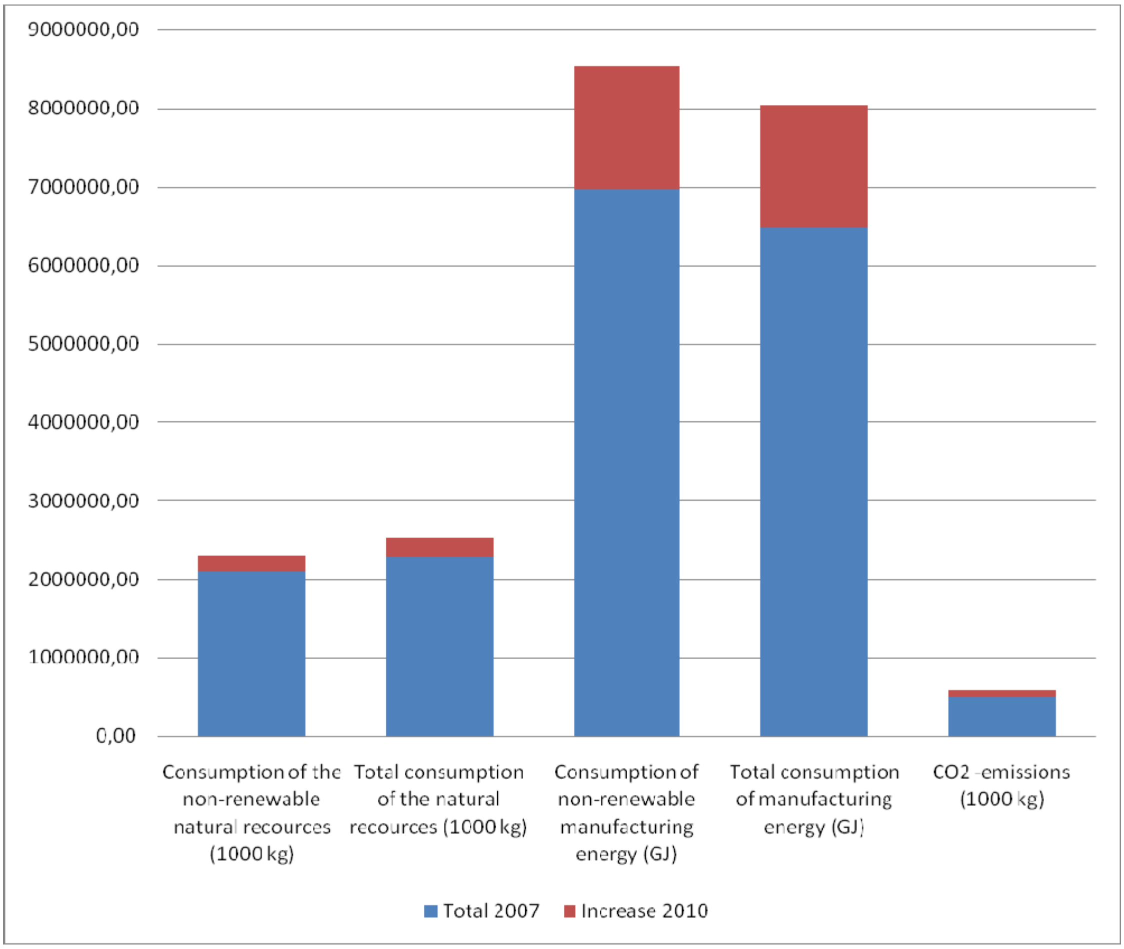
Graph 19 Improving thermal insulation by 40% - effects on the manufacturing energy requirements of various insulation materials.

An examination of environmental impacts alone indicated that wood-fibre would be the best choice for additional insulation. On the other hand, building renovators may come across situations in which the thinness of the insulation, for example, is the decisive factor. The comparison revealed that a polyurethane layer achieves the same insulating effect as mineral wool or wood-fibre insulation layer that is twice as thick.

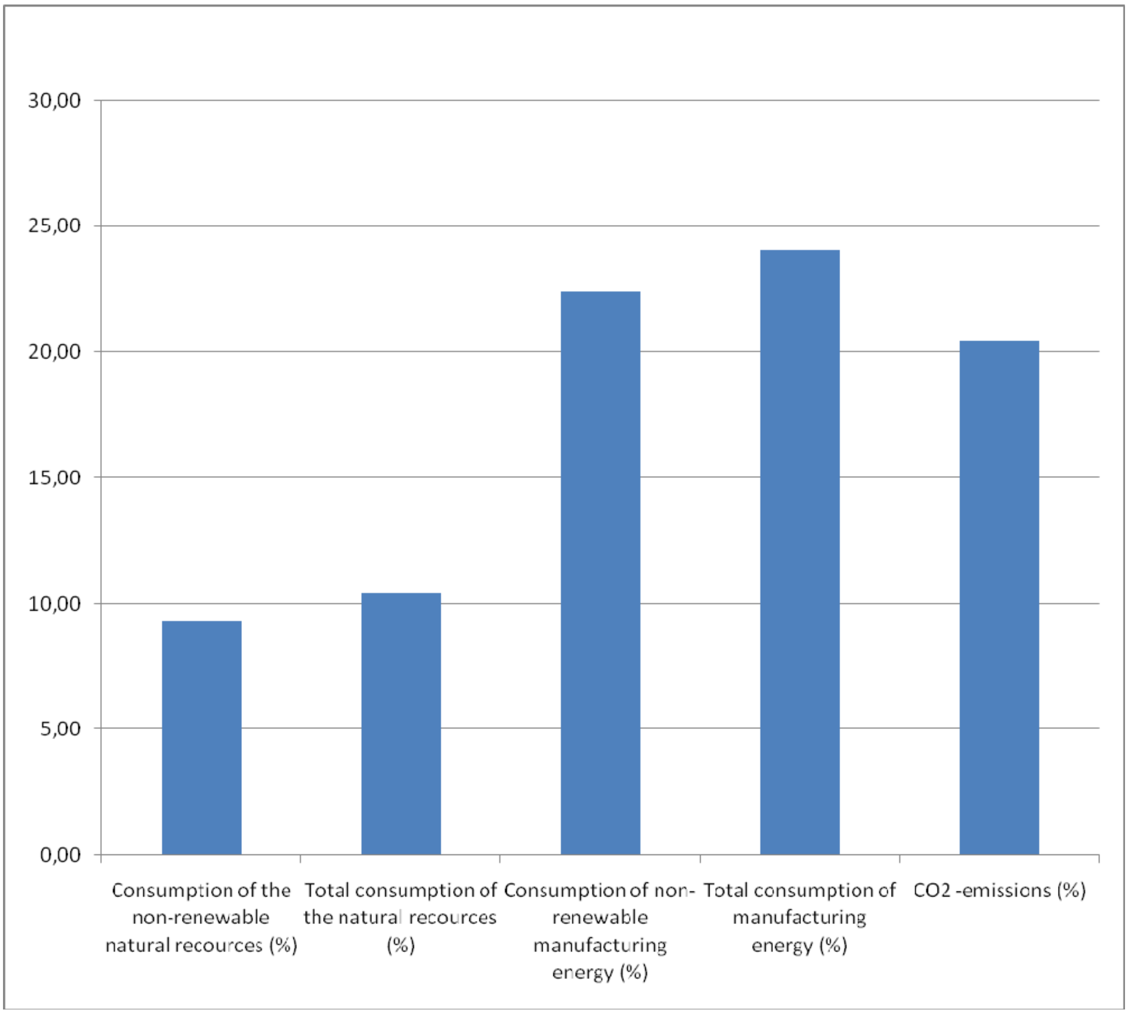
5.3.3 Overall effects

Exterior wall data were again used as an indicator of the effects of the new energy-efficiency requirements on the overall environmental impacts of all construction activity by adjusting the data according to market share. The impacts were multiplied with the number of exterior wall square metres built; this figure was 10,782,000 m^2 in 2007. Changes were examined in the form of absolute numbers and percentages. Finally, exterior wall structures' share of overall building was estimated in order to form a rough idea of how the effects of the new energy-efficiency requirements on the carbon dioxide emissions caused by construction and the manufacture of building products would range.

Mikko Viljakainen 10 Mar 2009



Graph 20 Increase caused by tightening energy-efficiency requirements in 2010 – exterior walls as indicators



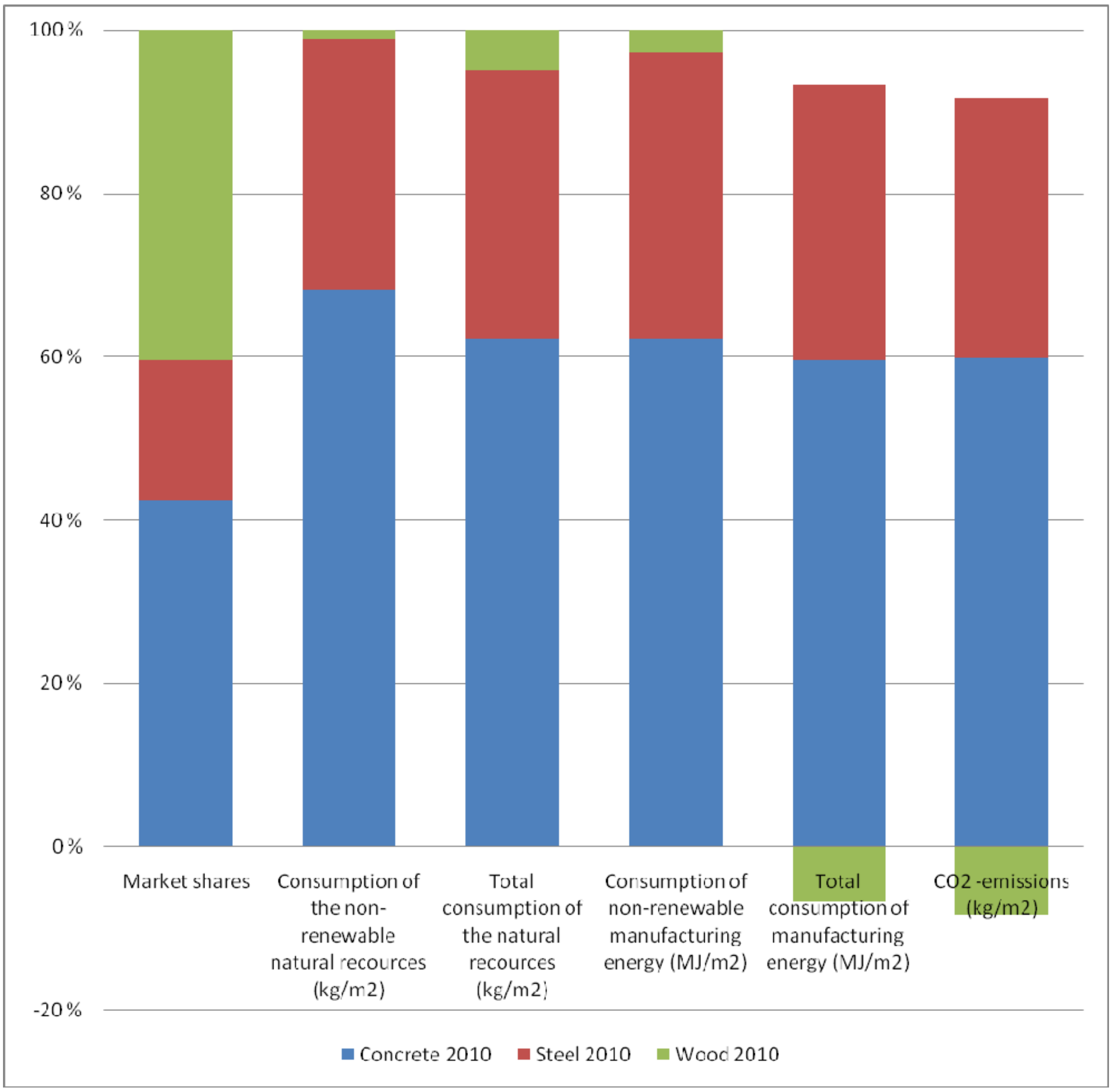
Graph 21 Effects (%) of tightening energy-efficiency requirements in 2010 – current market shares indicate that carbon dioxide emissions could increase by as much as 0.3 - 0.45 million tonnes.

The calculations show that, because of the new energy-efficiency requirements, construction and the manufacture of building products will consume about 10% more natural resources, 20-25% more energy and cause around 20% more carbon dioxide emissions.

An assessment of exterior walls' share in overall building activity, taking into account that the new energy-efficiency regulations will impose similar changes also on ceiling and floor structures as well as on windows and doors, came to the finding that the new requirements will cause an increase of about 0.3-0.45 million tonnes to the carbon dioxide emissions of construction and the manufacture of building products.

Mikko Viljakainen 10 Mar 2009

5.3.4 How do the changes break down?



Graph 22 Breakdown of the negative environmental impacts caused by tightening energy-efficiency requirements

An examination of how the aforementioned increase in environmental impacts breaks down reveals once again that the great majority (about 60%) of growth is caused by concrete structures. Steel structures also account for a large portion of the overall increase in environmental impacts when viewed in relation to their market share. The impacts of wooden structures are quite trivial in spite of their large market share. The impact of wooden structures on overall energy consumption and carbon dioxide emissions is actually inverse.

5.4 EFFECT OF NEW ENERGY-EFFICIENCY REGULATIONS ON CARBON DIOXIDE EMISSIONS

This chapter examines how the future improvements to the energy-efficiency of buildings as well as reductions in the energy consumption of construction and the manufacture of building products would affect carbon dioxide emissions. The period under review is 2010-2020.

5.4.1 How improving the energy-efficiency of buildings affects carbon dioxide emissions

The assumed annual rate of renewal of the building stock has been set at 1.5% for this examination. However, the proportion of newbuild houses in the overall building stock is forecast to be lower than this, about 1%, during the period under review. On the other hand, when building renovations and the energy-efficiency enhancements carried out in association with them are taken into account, a 1.5% rate of renewal might prove a fairly good estimate.

On the basis of the presented proposal and available advance information, the assumed improvement in energy-use efficiency from 2010 was set at 40% for 2010 and 2011, and at 20% more from 2012 onwards. A further assumption is that the building stock will not grow during the period under review.

This indicates that the carbon dioxide emissions of the building stock will reduce by 0.154 million tonnes annually in 2010-11 and by 0.193 million tonnes annually from 2012 onwards. In 2020, the building stock would therefore create 2.04 million tonnes of carbon dioxide emissions less than in 2010.

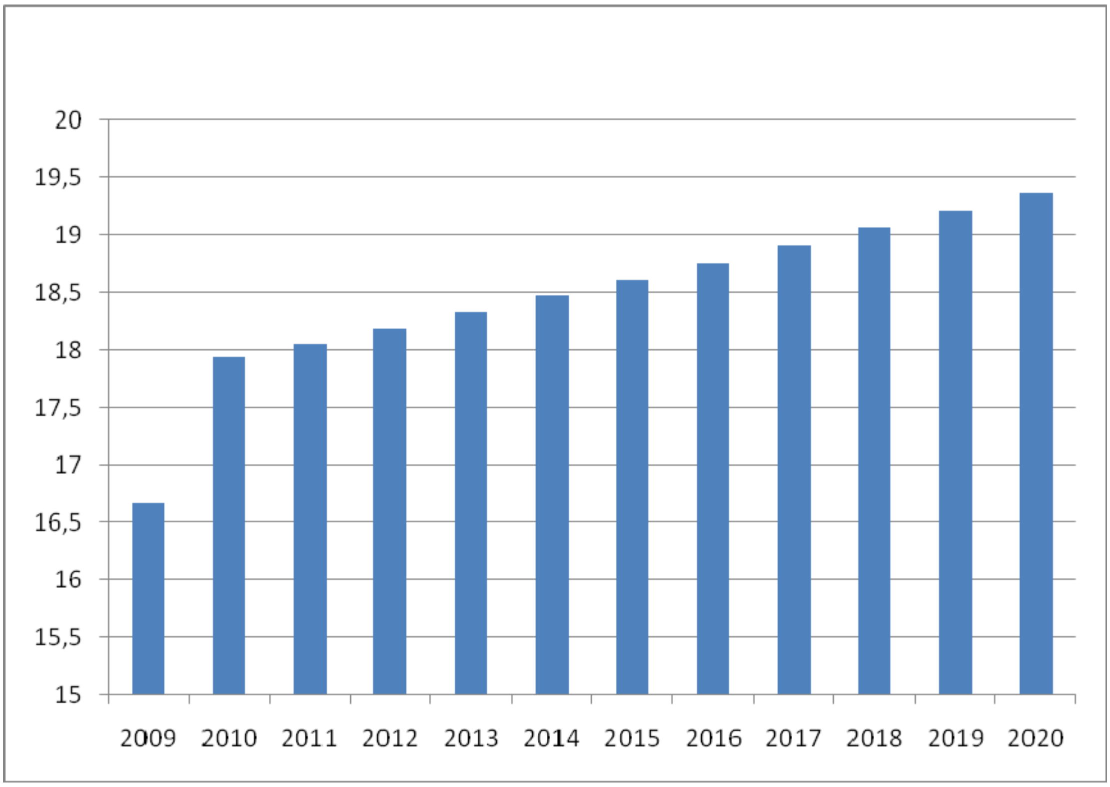
In spite of the improvement to the energy-efficiency of new buildings, overall carbon dioxide emissions will at first rise because the new energy-efficiency requirements will probably lead to an increase of 0.3 (- 0.45) million tonnes in the carbon dioxide emissions caused by construction and the manufacture of building products. Savings will begin to accumulate only in the third (or fourth) year following the revision. But even when this is taken into consideration, the building stock would produce 1.74 million tonnes of carbon dioxide less in 2020 than in 2010 – this indicates that the proposed tightening in the energy-efficiency requirements of buildings have been scaled correctly with respect to the designated objective.

5.4.2 Carbon dioxide emissions of construction and the manufacture of building products in the overall emissions caused by the energy consumption of buildings

Energy-consumption observers quite often mention the 10/90 rule. This refers to the idea that the energy consumption and carbon dioxide emissions that occur during a building’s use account for about 90% of the overall figures, while around 10% occur during construction.

The rule does not hold up to precise calculations, however. Even at present, construction and the manufacture of building products account for 12.82% of the energy consumption and 16.67% of the carbon dioxide emissions created during use, and these figures do not include the energy consumed during the dismantling and recycling of building components.

Mikko Viljakainen 10 Mar 2009



Graph 23 Ratio of carbon dioxide emissions of construction and the manufacture of building products to emissions occurring during the use of buildings, 2009 - 2020

Furthermore, when the amount of energy consumed during use is reduced, the portion of total emissions accounted for by construction and the manufacture of building products will increase further. The currently proposed targets would increase the portion of total carbon dioxide emissions accounted for by construction and the manufacture of building products to 19.4% in 2020. This share increases further when it is taken into consideration that tightening energy-efficiency requirements will lead to an increase in the emissions caused by construction and the manufacture of building products. Once the stock of buildings has been fully renewed to compliance with the currently proposed requirements, the carbon dioxide emissions of construction and the manufacture of building products will represent no less than 35% of the emissions occurring during use (4.5 million tonnes : 12.68 million tonnes).

5.4.3 Opportunities to reduce carbon dioxide emissions in construction and the manufacture of building products

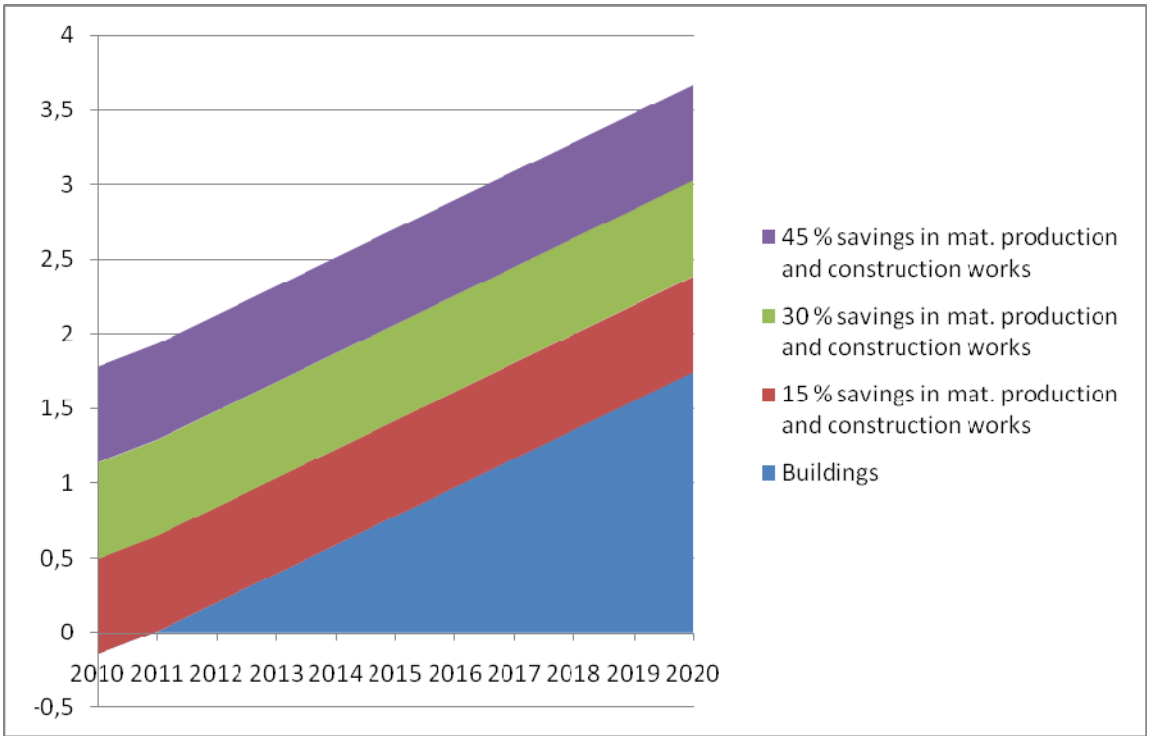
There are two principal ways with which to reduce the carbon dioxide emissions caused by construction and the manufacture of building products:

1 Reduce emissions associated with products that cause heavy environmental burdens by developing manufacturing technologies, which cause fewer emissions, and/or by making use of renewable energy during manufacture.
2 Shift the focal point of construction towards products that cause fewer emissions.

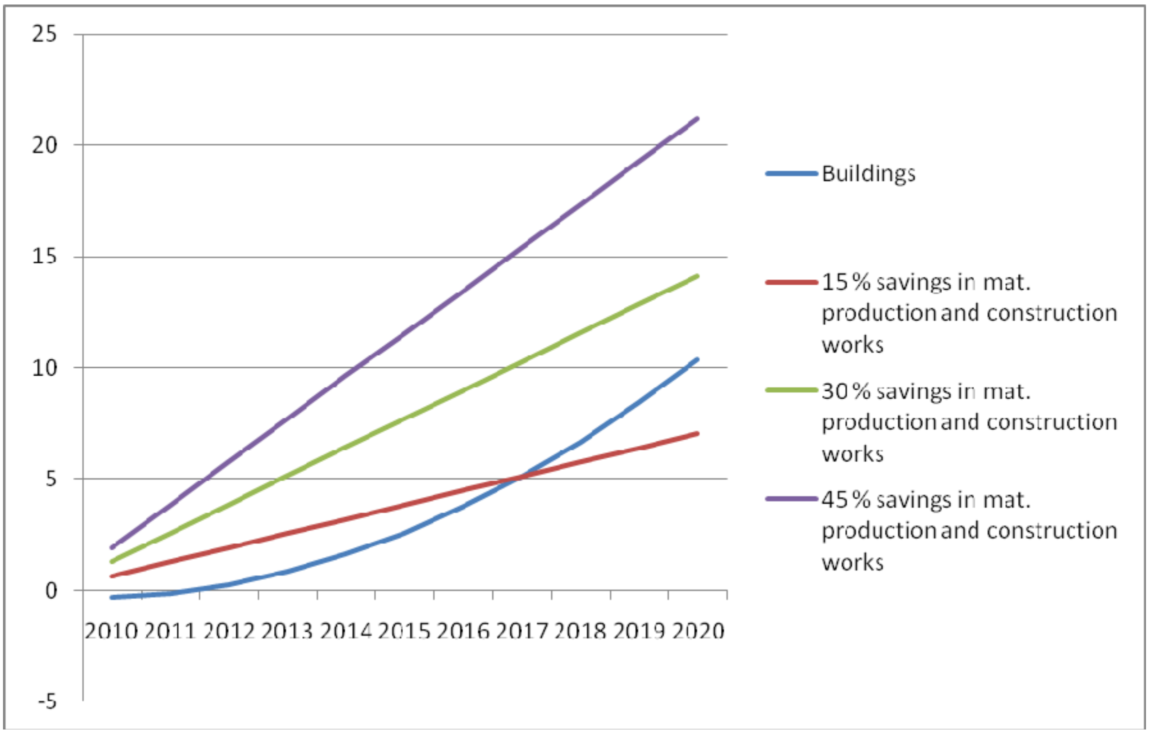
In practice, both ways should be taken advantage of because it is probably not possible to construct all buildings with only low-emission materials. However, on the building-component level, all structures should be examined carefully and high-emission products replaced with goods that cause fewer emissions as often as is feasible. This need not even be visible to the users of a building, unless it is considered desirable. Even now, it would be possible to increase significantly the use of wood products in light-weight interior and exterior wall structures and the ceiling structures of hall-like buildings without there being any visible effects for the users of these buildings.

The following graphs represent estimates of how enhancing the energy-efficiency of buildings as well as of construction and the manufacture of building products would affect carbon dioxide emissions. The assumed reductions used for different scenarios of enhancing the energy-efficiency of construction and the manufacture of building materials are 15%, 30% and 45%. This would translate into annual carbon dioxide emissions reductions of

- 15% –> 0.642 million CO_2 tonne reduction from 2010 level
- 30% –> 1.284 million CO_2 tonne reduction from 2010 level
- 45% –> 1.926 million CO_2 tonne reduction from 2010 level



Graph 24 Annual carbon dioxide emissions reductions of the new energy-efficiency regulations compared to alternative 15%, 30% and 45% reduction scenarios in construction and the manufacture of building products (Mt CO_2)



Graph 25 Cumulative reductions in carbon dioxide emissions of the new energy-efficiency regulations compared to alternative 15%, 30% and 45% reduction scenarios in construction and the manufacture of building products (Mt CO_2)

Reducing the energy consumed during construction and the manufacture of building products would result in significantly reduced annual carbon dioxide emissions. Cutting the emissions caused by construction and the manufacture of building products by just a quarter would result in greater emissions reductions by 2020 than the proposed improvement to the energy-efficiency of buildings. Furthermore, these effects would be rapid. Changing newbuild production into low-energy buildings reduces consumption by just 0.18% per year if the building stock does not grow and the rate of renewal is roughly 1.5%. In practice, however, the rate of renewal will be slower than this, about 1% annually.

Mikko Viljakainen 10 Mar 2009

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

6.1.1 Proposed tightening of energy-efficiency requirements a good start

The future energy-efficiency targets for buildings that are supposed to come into force at the beginning of 2010 have been scaled appropriately in relation to climate objectives. Once they are realised, our national building stock will, according to the calculations presented in this report, produce about 1.74 million tonnes of carbon dioxide less in 2020 than in 2010. The grounds given for improving energy-efficiency need not be so complicated, however, as it is quite simply economically prudent not to waste energy.

The natural resources and energy consumed by construction and the manufacture of building materials as well as the carbon dioxide emissions these produce should be given greater attention than before. Cutting the emissions caused by construction and the manufacture of building materials by a just a quarter would achieve greater emissions reductions by 2020 than the currently proposed improvement to the energy-efficiency of buildings. Furthermore, the effects of this would be rapid.

As the thermal energy consumption of the building stock becomes more efficient, the significance of construction and the manufacture of building materials will become even more emphasised. Once the stock of buildings has been renewed completely to compliance with the regulations now being proposed, the carbon dioxide emissions caused by construction and the manufacture of building materials will be equal to as much as 35% of the emissions occurring during use.

The best way to reduce the environmental impacts caused by construction and the manufacture of building materials would be to increase the use of wood in construction whenever possible. This should be accompanied with efforts to reduce the environmental impacts caused by the manufacture of concrete, bricks and other masonry-type materials as well as of steel.

6.1.2 The environmental properties of wood are second to none

The environmental impact of wood construction is considerably lighter than that of competing materials, even when the emissions and energy consumption caused by the manufacture of gypsum board, for example, are taken into account in the calculations for wooden structures. In addition, wooden structures consume only a very small amount of non-renewable natural resources. In fact, the effect of wood construction on energy consumption and the carbon dioxide balance is actually negative. Increasing the use of wood would transform buildings into carbon sinks.

Wood accounts for just 5% of the overall natural resource and energy consumption caused by construction and the manufacture of building materials, even though about 40% of all building frame structures are made with wood.

Concrete, on the other hand, has a market share of about 43%, but it accounts for around 80% of the environmental impacts of construction. Brick exterior cladding solutions have only a 12%

share of the market, but still they cause around a third of the environmental impacts attributable to all exterior cladding.

6.1.3 Observations on environmental declarations

The RT environmental declarations form a good foundation for comparisons. The uniform declarations present a good and comparable picture of the environmental impacts of different products. There is no data on the how much these declarations are used.

An RT environmental declaration has not been compiled for all products, however. Bricks, for example, are not included. Wood products like particleboard and laminated veneer lumber are also not included. In order for the system to be functional, it should be made comprehensive.

Product-specific data should be complemented with environmental declarations on different types of structures as well. These would enable planners to routinely make environmental comparisons of buildings during the early planning stages. Calculating the environmental properties of entire buildings is too complicated and slow and it requires special expertise if data is only available on the product level; in practice, this means that such analyses won't be performed. Inevitably, one gets the impression that this is the purpose of the entire system.

The environmental declarations also contain some inconsistencies. The specific weights presented for Aircrete, for example, are radically different from the numbers given by the manufacturer of these products. Calculating the weight of Aircrete structures with the presented specific weight values gives lighter results than are disclosed by manufacturers. The difference is 30%, which has a significant effect on the environmental balance of the product. The calculations of this report relied on the actual weights disclosed for the products and not their specific weights. Steel products, for their part, take no account of recycled steel, giving rise to the impression that a kilo of steel is made with 834 grams of raw material. This also applies to ecowool thermal insulation products, the figures for which take no account of recycled paper.

The manufacturer websites of products, which are not included in the RT environmental declarations, contain varying amounts of relevant information. Unfortunately, this data is presented in partially differing ways (as is the case with bricks, for example) from the uniform environmental declarations. Deviations from commonly-agreed standards and inconsistencies give rise to the impression that the data is intended to distract users.

6.2 RECOMMENDED FOLLOW-UP MEASURES

On the basis of this report, I recommend the following measures:

- The setting of reduction targets for the carbon dioxide emissions caused by construction and the manufacture of building materials and requiring building planners to evaluate the environmental impacts of construction in the planning stage (State authorities)
- The drafting of environmental declarations for different types of structures (construction industry, building product manufacturers and the Building Information Foundation)
- Making the curtailing of the emissions caused by construction and the manufacture of building materials a focal point in lobbying on the EU level especially (wood products industry)
- Commissioning of a similar report for the EU level from a credible research institution (CEI-Bois, EU Commission)

7 IN CLOSING

It is no doubt easy to shrug off the findings of this report by saying that they are incompetent. I myself believe, however, that the matter will not be substantially affected even by quite drastic alterations to the calculations. I made several mistakes when performing the calculations – *inter alia* because of the inconsistent way in which different manufacturers disclose data on their products – which I then had to adjust and correct. Even so, whether calculated correctly or incorrectly, the overall outcome remained substantially the same. In other words, even if the findings aren't 100% correct, they nevertheless provide an accurate representation of the big picture.

Doubts may also focus on the fact that my viewpoint for the calculations was purely domestic. However, I believe that, if replicated on the European level, the calculations would be even more dramatically advantageous for wood because its share in overall building is considerably larger in Finland than in many other European countries. It would therefore be easy to discover substantially more opportunities for increasing the use of wood in building in these countries.

Debate may also be spurred by the fact that these calculations count the combustion energy extracted from the by-product flows of wood product manufacture and from the products themselves at the end of their lifecycle as well as the carbon dioxide that wood binds favourably for wood structures. There are good grounds for this practice, however, and performing the comparative calculations in another way did not result in a substantially different outcome in this matter. Furthermore, these phenomena are based on the laws of nature that cannot be altered, not even by the competition's intensive lobbying efforts. Wood can be used in the generation of energy and wood is a carbon sink.

The assessments do not adopt a very strong stance on whether the natural-resource consumption of the manufacture of specific building products is based on renewables or non-renewables. They merely state that the manufacture of materials other than wood is primarily based on the exploitation of non-renewable natural resources. This should also be examined more closely because construction is one of the most significant, if not the most significant, consumers of natural resources. If primary production grows by just 5% annually, many key non-renewable natural resources will be used up completely during the next 50 years. Long-term global economic growth cannot therefore be based on constant growth in their consumption. Whether we want it or not, the use of wood will have to increase from the present also in construction. We are dealing with a global challenge and those who will solve it operate in a global market. It would thus be sensible to learn to use wood before we are forced to do so.

None of the abovementioned matters means a thing, however, if attention is not also paid to the development of wood-based building solutions, the competitiveness of these products and to increasing competence in both the wood products industry and especially the construction sector.