Nordic guide to sustainable materials

WP 4: Guide to sustainable materials

Author: Rambøll on behalf of GBCF
Reference group: NGBC, SGBC, GBCF and IGBC

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CONCEPTS AND ABBREVIATIONS

BIM	Building information model: model can be used e.g. for life cycle analysis, energy efficiency modelling, material need calculations.
CEN TC 350 (Sustainability of construction works)	CEN/TC350 is responsible for the development of horizontal standardized methods for the assessment of the sustainability aspects of new and existing construction works (buildings and civil engineering works), including horizontal core rules for the development of environmental product declaration of construction products (EPD).
EN15978	Standard instructions for assessing the environmental performance in the CEN TC 350 sustainability of construction works standard family
EN 15804	Standard instructions for Environmental Product Declaration content in the CEN TC 350 sustainability of construction works standard family
“Cradle-to-grave”	The review begins with the gathering of raw materials from the earth to create the product and ends at the point when all materials are returned to the earth.
Environmental certification schemes for buildings (LEED, BREEAM)	LEED (Leadership in Energy and Environmental Design) is a certification scheme for different buildings and construction projects from US. BREEAM is the BRE Environmental Assessment Method, certification scheme for different buildings and construction projects from Great Britain.
EPD	Environmental product declaration is an independently verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of products
LCA	Life cycle assessment is a “cradle-to-grave” approach for assessing product environmental measures. LCA includes an inventory of relevant energy and material inputs and their environmental releases.
LCC	Life-cycle costing or LCC is a tool which evaluates the costs of an asset throughout its life-cycle.
Life cycle	The series of stages through which a product passes from the beginning of its production raw material harvesting until its disabling to landfill
Material efficiency	Material efficiency is natural resource use minimization by using products and services that reduce the raw material use and environmental harms during the product life cycle.
REACH	REACH abbreviation comes from Registration, Evaluation, Authorisation and Restriction of Chemicals. REACH is a regulation that entered into force on 1st June 2007 to help in the identification of chemical origin and product chain traceability.
Service life	The time that the product is expected to serve the used that it is designed for.

Sustainability	Sustainability means that issues are done in environmentally responsible way. Sustainable development is globally and locally organized social development that should secure future generations the same conditions than today. That also means that environment, human and economy is taken into consideration in the decision making. The UN Brundtland Commission's report (1987) defined sustainable development as "development which meets the needs of current generations without compromising the ability of future generations to meet their own needs".

FOREWORD

The project Nordic Guide to Sustainable Materials, financed by Nordic Built, has been a cooperation between the Green Building Councils in Finland, Iceland, Sweden and Norway. We started this project because there has been a need for predictable criteria and lack of common agreement of sustainability in existing tools and environmental labels.

The project has resulted in different reports and guidelines;
WP1: State-of-the-art, is a report with updated overview of the regulations and running activities both in the Nordic countries and Europe within this field.

WP 2: The criteria, is a report that defines functional criteria for sustainable building products and describe the background for the different specifications.

WP 3: Survey results – Knowledge and demand of EPD, summarizes the results from a survey done in each of the four countries among both Building owners and Producers and providers

WP 4: Guide to Sustainable materials - this report, discusses sustainable materials both on a building, material and product level. This report also gives a overview of the whole project and include summaries from the other work packages.

The project also has produced three guidelines:

- **Why do we need a EPD** – a brochure that explain what an EPD is and why building owners should ask for it
- **Guidelines for sustainable materials** – with advices for both the building design, choice of materials and choice of building products
- **Guidelines for procurement –** which goes more into details of how to use the criteria defined in the projects in procurements

In addition to these outputs, the project has been an important experience of how important it is to collaborate within the Nordic countries. We all have a concern about sustainable materials, but have a lot to learn from each other. We also hope our project can raise the knowledge within the building sector in the whole Europe.

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Trine Dyrstad Pettersen, Norwegian project manager

Jonny Hellman, Swedish project manager

Sigríður Björk Jónsdóttir and Helga Bjarnadottir, Icelandic project managers

Jessica Karhu, Finnish project manager

Katharina Th. Bramslev, NGBC, Nordic project manager

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1. INTRODUCTION

1.1 Goal of this guide

The goal has been to tackle three important challenges for the transition to more sustainable materials:

- agreement on a common set of functional criteria for sustainable materials
- sufficient Environmental Product Declarations (EPD) for Nordic products to enable manufacturers to get credit from their development of sustainable products and
- simplification of the procurement, planning and construction process for sustainable materials

The project will also provide practical guidelines for building owners who require the use of sustainable building materials and will be applicable for all types of building and rehabilitation projects.

The Green Building Councils in Norway, Sweden, Finland and Iceland are all partners in the project. Each country's respective GBC consists of members from the whole value chain and these members are invited to join the project. The project consists of five work packages. Work package 1 is written by the Swedish Green Building Council, gives a short overview of regulations in this field and existing commonly used tools and criteria in each country. The state-of-the art-report summarizes the results and the report comprises important input for our Nordic efforts to identify common functional criteria for sustainable materials.

The Norwegian Green Building Council has been in charge of work package 2 and is responsible for this report. There has been close collaboration between all of the partners in obtaining information from all four countries.
This guide is based on the results of the Nordic Sustainable Materials -project, funded by Nordic Built in 2014- 2015. The guide answers to the project goals but also aims to motivate the use of sustainable materials and building products.

The objective of this guide is to clarify the relevance of building materials and products while evaluating the sustainability of our built environment. The building materials and products can have different environmental effects depending on their use in the building. Therefore, for evaluating materials´ sustainability, it is important to recognize their intended function in the building and estimated serving time.

This guide aims to give common Nordic guidelines on how to evaluate and communicate the sustainability of building materials. This guide emphasises that all evaluating processes should be based on common EU –standards and policies in order to achieve comparable results. Other goal of this guide is to encourage organisations to set targets that are more strict than the general level in order to reach ambitious and significant changes to current situation in Nordic countries.

In addition to the discussion concerning the energy consumption of our built environment we are starting to understand that the embodied energy in the constructions and building products has a significant role regarding the carbon footprint of the construction sector. Material efficiency and recycling/recycled materials have significant potentials for the construction sector and we should support new innovations in that field. Customers are more and more conscious of hazardous materials in building materials and demand of non-hazardous living environment is rising. We are spending most of our life indoors, thus the healthy indoor climate is crucial element of sustainable buildings.

This guide provides practical guidelines for building owners in order to support the demand of sustainable building materials and gives instructions for the tendering process. It also offers advice to planners and designers on how to consider recycling and material efficiency within the design process.

1.1.1 Definition

The objective of this step-by-step guideline is to help the building owner, his project team and the contractor to make decisions that reduce the negative environmental impact from building materials. The building materials and products can have different environmental effects depending on their use in the building.

1.1.2 Three levels in this guide

This guideline deals with materials in three levels. The first level Building design covers form and structure of the building, reuse of building components and design for reuse. The second level Choice of material covers life cycle analyses and reuse of materials together with environmental impact during service life. The third level Choice of building products covers functional criteria of a product group and individual product declaration

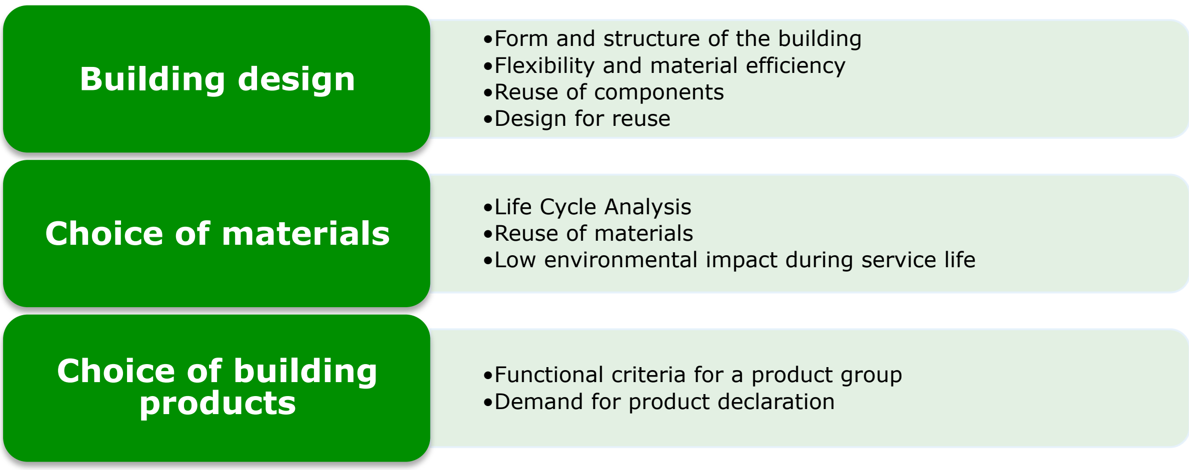


Figure 0.Three levels of material sustainability.

1.1.3 Four indicators with three different ambition levels

Greenhouse gas emissions, material resources, hazardous substances and indoor air emissions are the four indicators describe the sustainability of building materials. The ambitions are split into three levels: Best Nordic practice, high ambitious and good ambitious. For each indicator and chosen ambition level it is defined criteria that the most used building materials have to fulfill.

1.2 State-Of-Art /Sweden/ WP1

There is overriding European legislation covering this area. The laws have been implemented but the interpretation among the Nordic countries may vary. In addition, individual countries also have their own legislation in this area. Most of these requirements form a framework and are not specific. With the exception of Norway, no countries currently apply any general requirements stipulating that construction products must disclose the contents of the substances they use. Under the Construction Products Regulation, the member states are able to enact regulations limiting hazardous substances in construction material. However, national chemical requirements that are specifically aimed at construction products are few. In Sweden, there is a bill recommending that keeping a logbook of construction materials should be a requirement, Government Bill 2013/14:39. In Norway, both the building regulations and the Product Control Act "the substitution principle" demand that a user of a product documents any hazardous substances and tries to identify an alternative product without these substances.

A number of voluntary initiatives have been initiated, primarily, in Sweden and Norway, where requirements have been set for the certification of buildings through various private and joint industrial actions, but also for the reporting of the environmental impact of construction products. Sweden has currently made the greatest progress concerning hazardous substances with three established systems (Basta, Byggvarubedömningen (Building Material Assessment) and SundaHus) in the market, whereby construction-related products are assessed based on their environmental properties. The main focus of the assessments lies on the contents (chemical content) and two of the systems (Byggvarubedömningen and SundaHus) also address other environment-related lifecycles. In order to obtain this information, the industry has prepared a joint document, a classification in which information about content and the environmental performance of the product is declared in the *Building Product Declaration, version 3*, where work is in progress to update and develop the document. This work should be taken into account later in this project.

Regarding EPDs, both Norway and Sweden have established program operators that assess a building product's life cycle according to stipulated requirements under different standards, EPD Norway and International EPD in Sweden.

Norway has made the greatest progress concerning CO^2 emissions due to materials and many building owners demand documentation of this and also demand emissions below defined limits for specified products.

The first part of the Nordic Green Guide to Sustainable Material Project shows that the joint legal requirements on the subject are relatively few and pointless but, at the same time, they form a shared platform for the industry. Many positive initiatives exist and these should be addressed in continued efforts. The obstacles that could impede the work is based on the fact that there have not been any previous procedures for the information flow between various supplier chains, and that there has not been any significant demand for the content. One problem is that many products derive from parts of the world where these requirements are still considered insignificant and, in view of the size of the Nordic market, it could be difficult to demand relevant information from these suppliers.

1.3 The environmental legislation on buildings and national targets

1.3.1 Environmental regulations for construction sector

Today, the construction sector environmental protection in Finland is mainly covered by the waste act and decree, as well as the land use and construction law. The regulations provide environmental protection guidance for construction waste, re-use and disposal, as well as building materials safe and correct use. The Waste Directive (2008) obliges Member States to increase the recycling rate of waste as material, which will contribute to more efficient use of resources. Finland's objective is to achieve a 70% recycling rate for construction waste recycling as materials by 2020 (Finnish Ministry of Environment).

For the new building products, environmental control is currently based mainly on the CE marking and type-approval. Construction products CE marking has been mandatory since 1.7.2013 as stated in the new building regulation. The regulation defines the harmonized method for product approval, but the levels are country specific. The CE marking in Finland is based on the law for certain construction products approval (954/2012). CE-marked construction products cover about 80 percent of all construction products Finnish Ministry of Environment.

Other regulations covering the construction material environmental impacts are Ecodesign Directive: Guidelines (2009/125 / EC) laid down at EU level, that are nationally deployed in the eco-design act (1005/2008 var 1009/2010, Finlex.). YM and TEM are responsible for supervising and coordinate the preparation of national laws and regulations and consult the stakeholders.

It is important to act at the earliest possible stage when the regulation is considered. Eco-design aims to improve products energy efficiency by integration of environmental aspects and life-cycle aspects already in product design phase. The second Framework Directive which is closely linked to the construction sector is the Energy Labelling Directive (2010/30 / EU) concerning the energy efficiency of products that includes e.g. HVAC equipment.

1.3.2 Latest development in the environmental regulations

Energy efficiency of buildings has been paid a lot of attention lately. Renovation project energy regulations were renewed with the energy efficiency directive (2010/31 / EU) and the elements of the energy certificate was renewed (Act 50/2013 energy certificate) e.g. to cover the environmental impact of energy production. Energy efficiency is also encouraged by the energy efficiency agreements, which are based on the EU's Energy Efficiency Directive (2012 /27 / EU). Ministry of the Environment and the Finnish Environment Agency has now turned their eyes towards the environmental impact of building materials. The importance of materials is emphasized during the building's life cycle as the energy consumption emissions are reduced. Similar trend is evident in the other Nordic countries as in project example below.

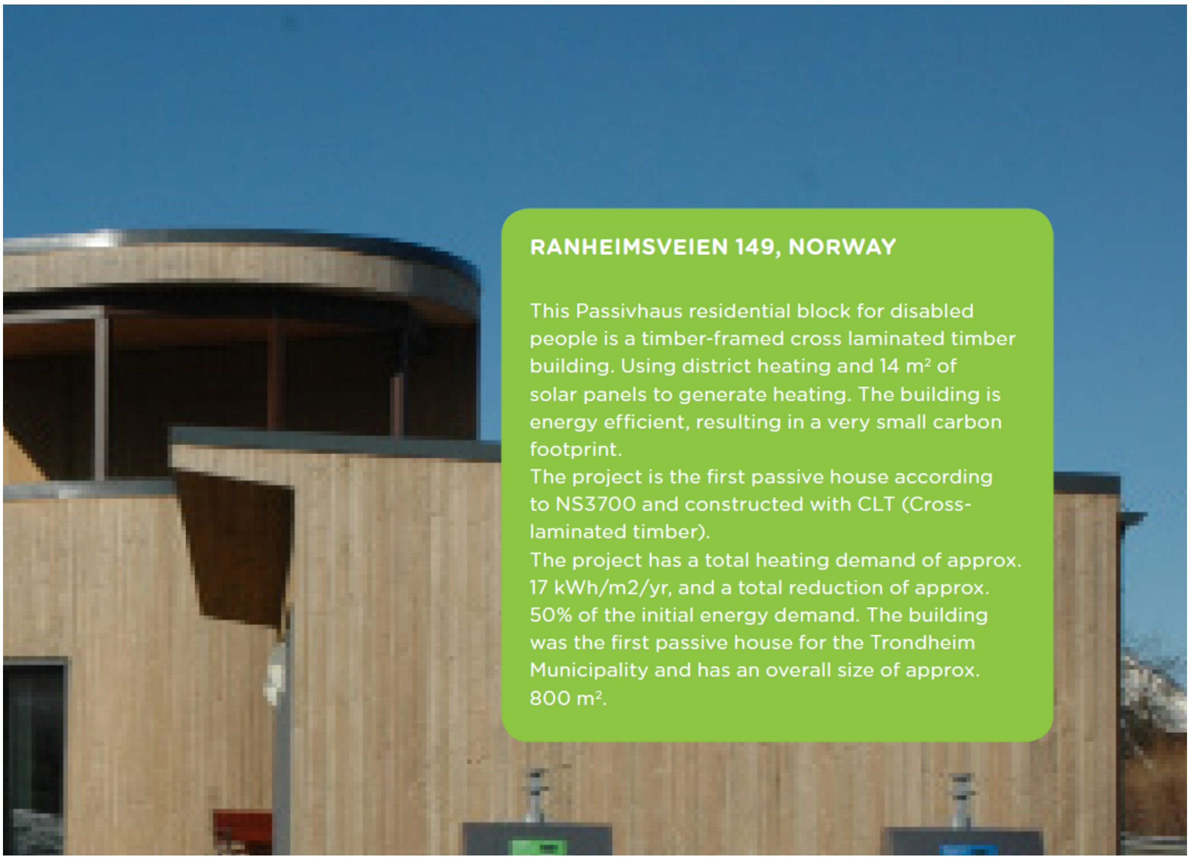


Figure 1.Passivhaus residential block for disable people is the first passive house for Trondheim in Norway

1.3.3 Future development in the environmental regulations

The government program (2011) included the encouragement of building materials and products life cycle analysis. Additionally the different environmental classifications (LEED = Leadership in Energy and Environmental Design and BREEAM = BRE Environmental Assessment Method) and assessment tools promote the use of LCA. The life cycle modeling also becomes more efficient as the use of building construction information models increases and information becomes more readily available. Life-cycle accounting standardization has also developed a family of standards CEN TC 350 (Sustainability of construction works). In the background is the EU goals and directives, according to which by 2020 greenhouse gas emissions must be cut by 20%, improve the building energy efficiency 20% and use 20 % more renewable energy than on 1995 (Hakaste). The Finnish government also gave resolution on promote sustainable design with clean tech solutions in public procurement.

2. SUSTAINABILITY ON THE BUILDING LEVEL

2.1 Sustainability of a building

Sustainability of a building depends on numerous of factors like service life of building and building materials and components, maintenance need of different materials and components, amount of needed materials, energy efficiency of building and building process, etc. However, the sustainability of building will be concluded mostly during project planning. Ability to influence on the sustainability of the building will decrease during the process all the time while, at the same time, effects of decisions in the beginning and during the building process will be constantly realised (see Fig 2).

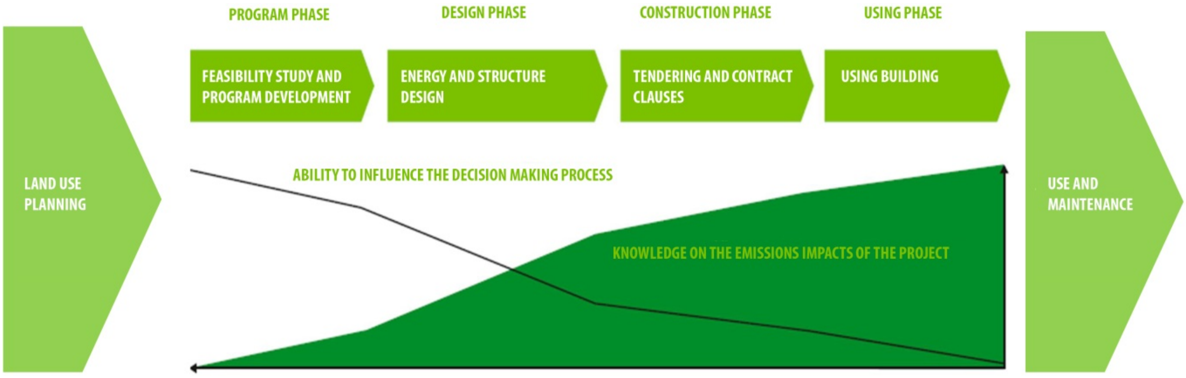


Figure 2. The ability to influence the decision making process and knowledge on the emissions impacts of the project (Modified from Building Performance Indicators 2013)

In the material efficiency point of view the amount of soil needed for construction together with materials for buildings frame are crucial during buildings construction phase because both are needed relatively huge mass. To the amount of needed soil as well as coarse and fine gravel depends strongly on the construction site and what will be constructed. So the possibilities to influence on land use and need for soil in the construction process is during land use planning and project planning.

Proportional share of buildings frame from all construction materials with the exception of land use is more than 50 % in an office building, see chapter 3.1. The material choice for buildings frame is not totally free. The frame must fulfil several requirements like loads, moisture stress, fire resistance, dynamic properties etc., so architecture of the building together with building site has a strong influence on buildings frame. Building frame materials are decided in very early phase during project planning.

The frame of the building is designed for 100 year service life in normal case. In individual project financial or using period for the building is usually much lower. This means that in the material efficiency point of view, the flexibility requirements and usability of the building are more crucial than service life issues. For the new building must be planned also the second use or even third use during project planning.

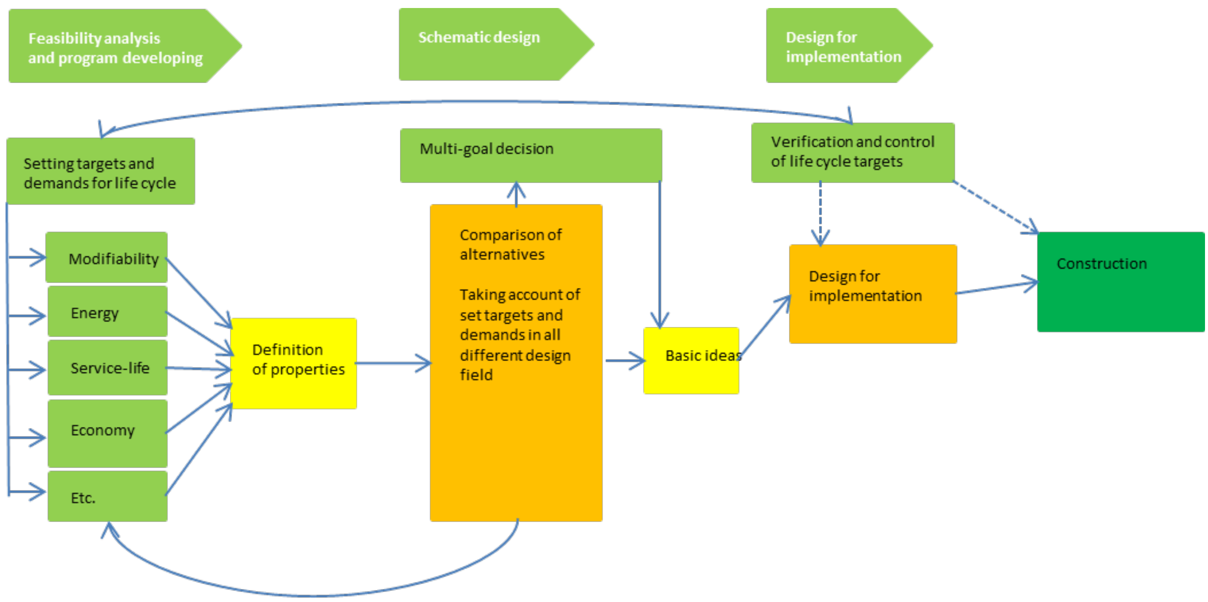


Figure 3. Several targets and demands set in the beginning of the project are verified and controlled during the project (Modified from RIL 216-2013)

2.2 Life Cycle Assessment (LCA) perspective

Life Cycle Assessment (LCA) is a way to analyse the inputs and outputs of materials and energy, and the environmental impacts that are directly attributable to a product, a process, or a service from getting raw materials to abandon of material or product.

Life Cycle Assessment bases on several ISO/EN standards. Standardisation is coordinated by CEN/TC 350, see Fig. 3. According to standards LCA contains four phases:

- definition of targets and area of application
- Life Cycle inventory (LCI)
- Life Cycle Impact Assessment (LCIA)
- Interpretation of results.

Concept level	User and Regulatory Requirements				
	Integrated Building Performance				
	Environmental performance	Social performance	Economic performance	Technical performance	Functional performance
Framework level	EN 15643-1 Sustainability Assessment of Building – General Framework (TG)				
	EN 15643-2 Framework for Environmental Performance (WG1)	EN 15643-3 Framework for Social Performance (WG5)	EN 15643-4 Framework for Economic Performance (WG4)	*Technical Characteristics*	*Functionality*
	ISO 2193 -1 Framework for Assessment of Environmental Performance			*ISO 15686-1 Service Life Planning – General Principles*	
Building level	EN 15978 Assessment of Environmental Performance (WG1)	pr EN 16309 Assessment of Social Performance (WG5)	Assessment of Economic Performance (WG4) *ISO 15686-5 Life Cycle*	*CEN Standards on Energy Performance of Building Directive (EPBD)*	

			Costing		
Product level	EN 15804 Environmental Product Declarations (WG3)	(see Note below)	(see Note below)	*ISO 15686-2 Service Life Prediction,* *ISO 15686-7 Feedback from Practice,* *ISO 15686-8 Reference Service Life*	
	ISO 21930 EPD of Building Products	**Note:** At present, technical information related to some aspects of social and economic performance are included under the provision of EN 15804 to form part of EPD			
	EN 15942 Comm. Form. B-to-B (WG3)				
	CEN/TR 15941				

Figure 4. CEN standards for sustainable construction and the most important related ISO standards according to CEN/TC 350 by 2012

On a building level, it is important to take into account the whole service life of the building in the LCA analyses. Service life of building varies, but usually it is between 50 and 100 years. During long service life the energy required in a building over its lifetime usually plays the major role in eco-efficiency. Typical target service lives for different building types and building components are presented in table 2.1. However, the move towards low or nearly zero energy houses and the share of embodied energy of building materials becomes more and more important. For instance, the greenhouse gas emissions of materials of a zero-energy house in Finland, counted for the emissions of a 50-year life cycle, are about one quarter of total greenhouse gas emissions, see Fig. 5. It is about half of the emissions used for heating, hot water and electricity. The share of the building materials (external and internal walls, ceilings and floors) amounts to approximately half of the greenhouse gas emissions of all materials.

Table 2.1. Target service lives for buildings and building components (RIL 216-2013)

Class	**Target service life for building or building component**	**Typical buildings in the class**	**Typical building components, technical systems and modules**	**Reason for end of service life**
1	1-5 years	Temporary buildings (very unusual)	Coatings with short service life	Old-fashioning Degradation
2	25 years	Temporary buildings, like portable barrack	Roofs, windows, doors, other supplementary components Coatings with long service life	Old-fashioning of buildings Degradation or old-fashioning of building components
3	50 years	Ordinary buildings	Foundations Frames External wall assemblies Roofs Supplementary components	Old-fashioning or degradation of buildings Degradation of building components
4	100 years	Public buildings	Foundations Frames External wall assemblies	Old-fashioning or degradation of buildings Degradation of building

			Roofs Supplementary components	components
5	more than 100 years	Monumental buildings	Foundations Frames External wall assemblies Roofs Supplementary components	Old-fashioning or degradation of buildings Degradation of building components

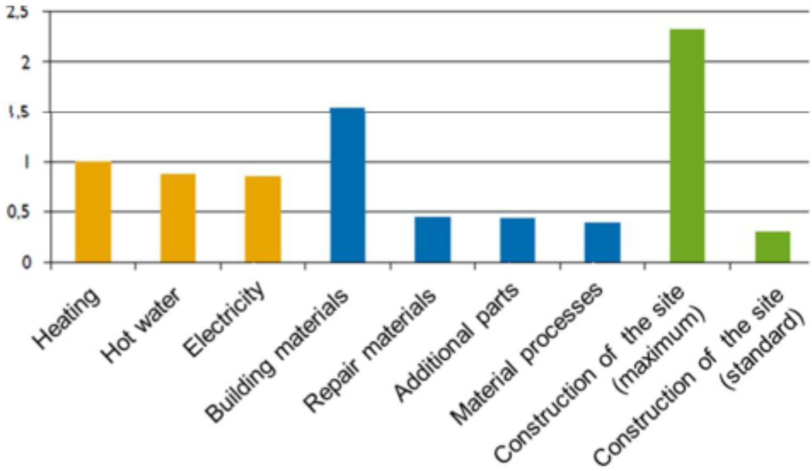
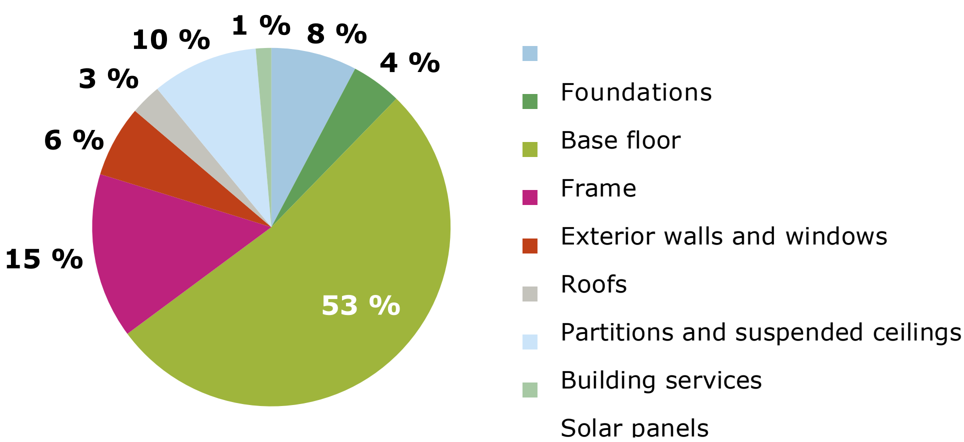


Figure 5. Relative greenhouse gas emissions ($CO_{2\ ekv.}$) of a six storey concrete building in Helsinki, Finland (Ruuska et al. 2013)

In another case the carbon footprint of 4 131 brm^2 new construction office building (Avialine 3) was calculated with carbon footprint calculation software Ilmari[i]. With Ilmari the carbon footprint of the building materials can be assessed at various stages of the planning process. The calculation takes into account the major structural elements such as foundations, frame structures, facades and other wall structures. Garden structures and coatings were not considered. Also, the technical building systems were calculated on top of the Ilmari calculation. Carbon footprint takes into account the manufacturing process of materials, typical transport in Finland, as well as material waste at the site (EN 15804 principles, taking into account). In addition, the calculation took into account any renewals of structures during the life cycle (VTT).

In the calculations it was assumed that the building is used for 60 years. HVAC system lifespan was estimated to be 25 years. Service life for the windows has been assumed to be 45 years. The calculation considered material-specific life cycles in the tool. The material information was based on the reported construction list information, IFC model as well as material supplier's information.

The total foot print of the building was 1 524 648 CO_2 kg$_{CO2eq}$ that is 354 CO_2 kg$_{CO2eq}$/brm^2. The picture below shows how the emissions are divided between the different major structural



elements.

Figure 6. Relative greenhouse gas emissions ($CO_{2\ ekv.}$) for Avialine 3 office building in Vantaa, Finland

The structural choice of framework affects significantly to the carbon footprint of a building. In the above case, the frame structures caused more than half of all emissions. Since the mid-sole structure is typically large in office buildings, often even a small improvement results in overall far smaller carbon footprint for the whole structure. Additionally, there are new hollow-core slab alternative structures, whose impact on the environment should be investigated. The effect of technical building systems materials emissions was about 10% in the study, but the impact for energy consumption during use and its emerging greenhouse gas emissions is significant. For the case above the life-cycle impacts resulting from energy use of the building exceed the construction life-cycle impacts approx. at 14.5 years of use.

Assumptions made in the report of the building structure lifecycles for technical building systems and windows ware based on estimates. In practice, the user requirements of indoor air quality, adaptability and the appearance of the surfaces may result in significantly faster upgrades, which contribute to increase the carbon footprint. Also the area development and attractiveness have an effect to the renovation and repair needs. That should also be considered in the design phase to avoid unnecessary masses at the planning stage, if the need for the structures is for shorter periods.

2.3 Environmental certification systems

A great number of certification systems to assess the environmental quality of buildings have been introduced over recent decades. They have a significant impact on many project decisions worldwide. Such certification systems are being developed and promoted mostly by the national branches of the Green Building Council (GBC) or by similar organizations. The most commonly used certification schemes are LEED (Leadership in Energy and Environmental Design) from US. and BREEAM (BRE Environmental Assessment Method) from Great Britain that are commonly used all over the world with over 72 000 certification projects done with LEED in over 150 countries and 200 000 buildings certified with BREEAM. [ii] Additionally, there are several national modifications from common environmental certification systems in use, for example: DGNB (Denmark), BREEAM Norway, Miljöbyggnad (Sweden) and Building Performance Indicators (Finland).

The focus of certification on various environmental categories is different in each system. Some emphasize indoor air quality; others are more energy or process-oriented. Building resource efficiency can be represented by “materials” and “waste” categories that occupy altogether less than 20% in all of the selected systems as demonstrated on Fig 7. As it can be noticed, different certification systems are not comparable. According to Schmidt (2012) less than 5 % of credits are attributed directly to the life-cycle performance of building products and materials in the four major schemes (BREEAM, LEED, DGNB and HQE), and LEED does not utilize LCA results at all.

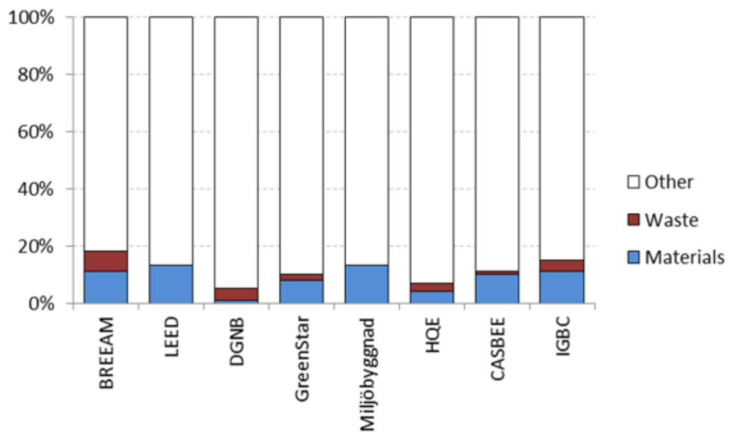
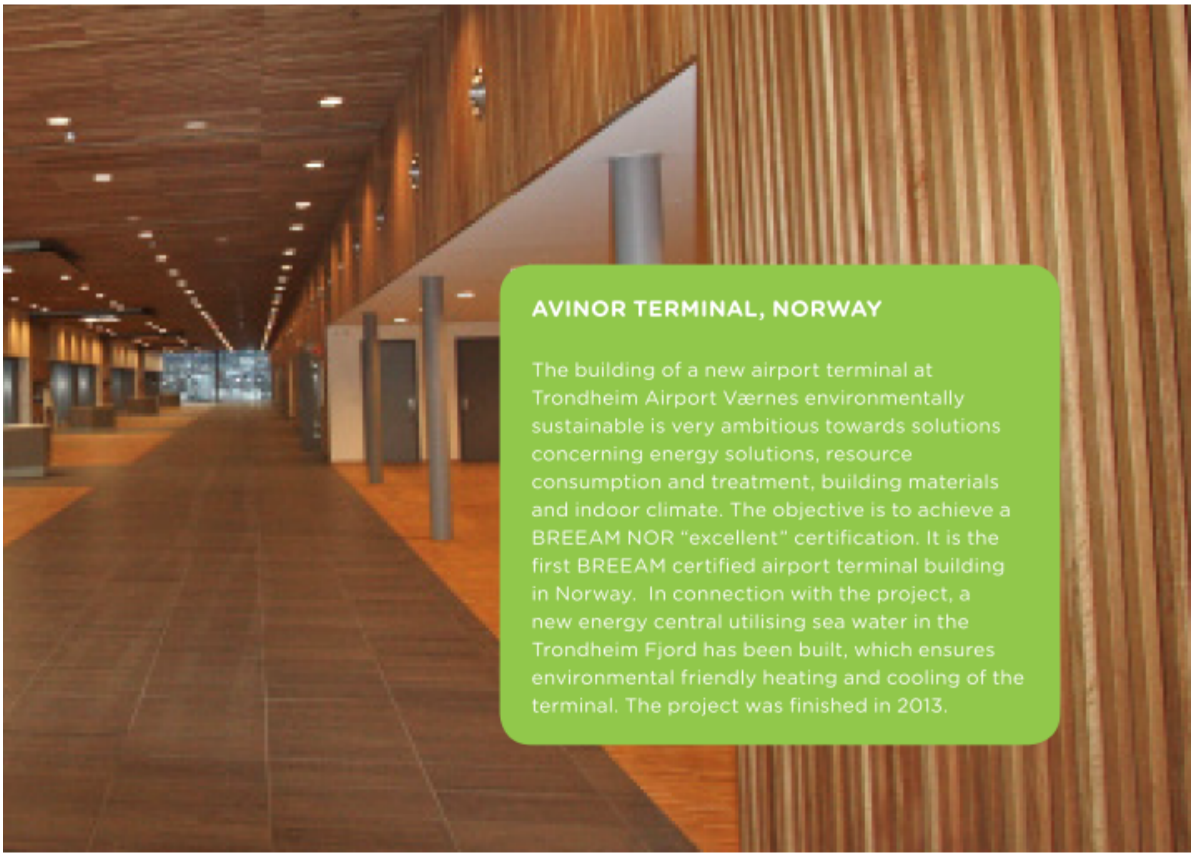


Figure 7. The proportion of "materials" and "waste" categories (Heincke et al. 2012).



2.4 Location of a building

Land use planning is a key factor for sustainable land use and construction. In a sustainable point of view complementary building on urban or suburban areas is more sustainable than new construction in green field areas, because infrastructure, like roads and water and savage lines as well as district heating pipes (in many cases) already exists on those areas. In several cities this mean enlargement of existing buildings, demolition of existing buildings and new substitutive building in the same place or sitting new buildings on brownfield areas. Good examples for that can be found e.g. Helsinki Jätkäsaari or Kalasatama, where old shipyard and harbour areas near city centre is planned for block of flats, offices and public buildings, and therefore enables enlargement of the city without using any greenfield areas for this purpose. Often the building use is transferred from the original building use as in the example below.

Figure 8. Ramboll's office in Stockholm Sweden. Good location and renovated old building near the Stockholm city central and good transportation access Feil! Bokmerke er ikke definert.Feil! Bokmerke er ikke definert.

In land use planning it is important to take account utilisation of soil material of those planned areas or nearby. This is equally important both green field and brownfield areas, because with intelligent use of existing land mass in the certain area, unnecessary transportation and traffic on existing roads might be avoided.

Orienting new buildings intelligent so that solar energy can be utilized as much as possible but overheating of buildings indoor air can be avoided at the same time is a challenging task. The point for this is energy saving during buildings service life. This needs dynamic modelling of whole area during land use planning.

Location of buildings is always tight to city planning made by local authorities. When city planning is ready and accepted by authorities it is very complicate to change it during building process. This mean quite big responsibility and ability to far looking visions is demanded for people who are making those plans and decisions.

2.5 Form and structure of a building

Building form and structure is mainly determined by the building use. Offices, homes, industrial and warehouse structures are all different and so are the environmental effects to be discussed in the design and construction phase.

The building type has an effect to the choices that are made during design phase. As an example, if office building is designed, the common choice is about the type of offices: individual offices, small open-plan offices, and large open-plan offices are all common in Nordic workplaces. Individual offices prove to be common in Norwegian, Finnish and Icelandic enterprises, whereas in Denmark, small open-plan offices are the most common form (Bakke John). It seems that in new buildings the choice is more often open plan offices. In USA more than 75 % of offices have open plans (Bortolot Lana).

Open plan offices are more adaptable and the access for natural light is better. This leads to narrow frame depth and minimization of strengthening concrete walls in areas where they minimize the building adaptability. The amount of partition walls is minimized and form is kept simple. Therefore the most material load is on external walls. The load bearing structures are the ones that should be examined. In industrial buildings the amounts of load bearing vertical structures are even less to maximize the open space. Additionally the external walls are usually light structures that are easily modified. Therefore the horizontal structures are long and bear a lot of load (Bonde Jensen 2012). In homes there are a lot more internal walls and those are also load bearing. Usually the environmental load is there where the mass is, so the investigation should be lead to the places where the load is. In apartment buildings and offices are also a lot of midsoles and gaps for stairs, HVAC lines and elevators. The structures are load bearing and therefore should be investigated.

The plot, building design and foundation design has a significant effect on the carbon footprint emissions. The need of soil stabilization and massive asphalting in yard construction are the main reasons for considerably increased environmental impacts.

Form of the building is designed by an architect. Cubic form is the most energy efficient for the building, but not necessarily the best for usability of the building. Building design is always a compromise where energy efficiency, material efficiency, usability and suitability of the building must fulfil satisfactorily with costs. In the sustainability point of view the usability and suitability of the building are the most important factors for architectural design. If the building is extremely well usable for its purpose it will be used for long time.

In architectural design there are several possibilities to improve sustainability. For example placing the building on the site so that land use and need for soil and gravel is low, using architectural elements for shading direct sunshine to rooms instead of need for cooling systems and using sustainable materials, which has long service life and low maintenance need.

2.6 Meaning of building components

Building components have different relative meaning on carbon footprint of the building. According to Ruuska et al. (2013) the major $CO_{2\ ekv.}$ impact is caused by external wall assemblies, partition walls, intermediate floors, roof and balconies in basic block of flats, see fig. 9. Also complementary building components like windows and doors, furniture and surface materials has relatively high meaning as a groups (> 5 %).

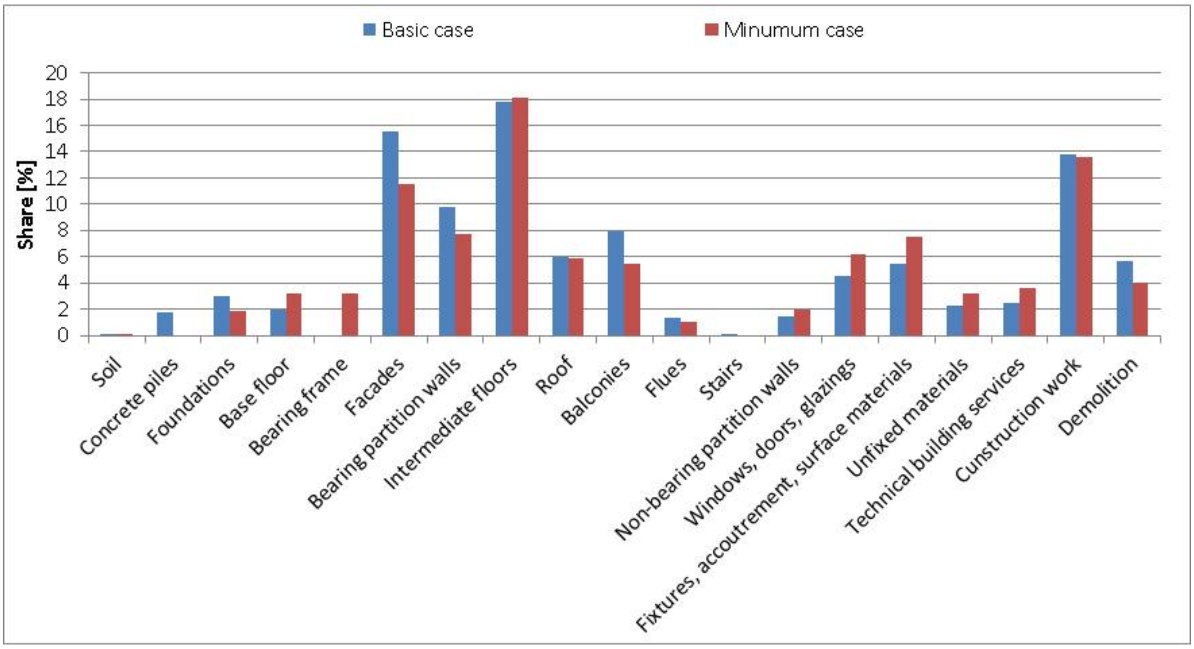


Figure 9. Building component's share (%) from total CO2ekv. in basic block of flats (Ruuska ym. 2013).

However, in column-beam frames, which are usually used in office and industrial buildings as well as in warehouses, the frame has a strong influence on carbon footprint of building. In fig. 10 has been presented model and total CO_{2ekv} from basic concrete column-beam warehouse. As can be seen the precast concrete frame presents 29 % (72 000 kg CO_{2ekv}) of total emissions. On single precast and pre-stressed beams emissions were 2270 kg CO_{2ekv}. The biggest emission affected by concrete slab on ground 108 000 kg CO_{2ekv} (43,6 %), while foundations for columns was 39 000 kg CO_{2ekv} (15,7 %). The share of energy use in situ was 10 % (29 000 kg CO_{2ekv}). The total emissions for this concrete frame were 248 000 kg CO_{2ekv}.

This example shows that in spite of concreting in situ is the major reason for emissions, totally 147 000 kg CO_{2ekv} (59,3 %), there is no alternative for it because the function of frame needs concrete foundations and usability of warehouse needs smooth concrete slab on ground.

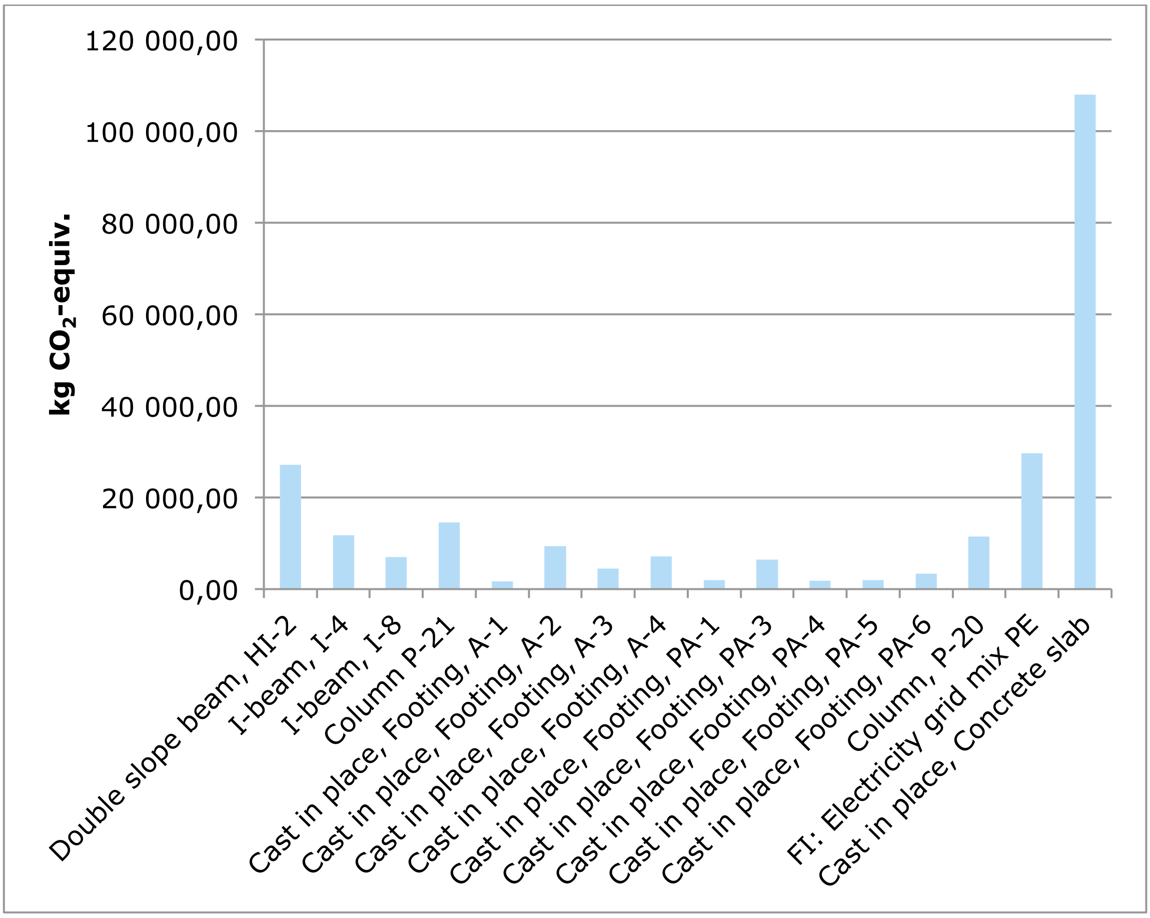


Figure 10. Frame component's share (%) from total CO_2ekv. in basic concrete column-beam warehouse (Lahdensivu et al. 2015).

2.7 Materials role in the life-cycle of the building

Building materials should be selected keeping mind the alteration possibilities for current and different building uses, maintenance need, demolition and final disposal. All materials should be possible to recycle as material or as energy. Ideally the materials should be recycled as materials without any waste load to environment to achieve circulation economy. The circulation economy is well-planned economy, where waste of materials and the generation of waste are minimized and resources are used efficiently. The raw materials value will be better. In practice, this may mean, for example, that the product is designed so that the materials are separable and recyclable (Sitra).

All materials have created environmental load during harvesting, processing and transportation. The determination of the product environmental load when it is used can be difficult with the current information available. Good way to collect information of building materials is to collect building material EPD (Environmental product declaration) sheets into the building service manual. Environmental product declaration is an independently verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of products. The information of the material environmental load can then be combined to the Building information model (BIM) and used in the determination of the most efficient construction solution. Most commonly the materials are selected to full fill the needed service life, weathering, strength, as well as fire resistance properties. Therefore in the selection of materials for certain use have only a limited number of possibilities.

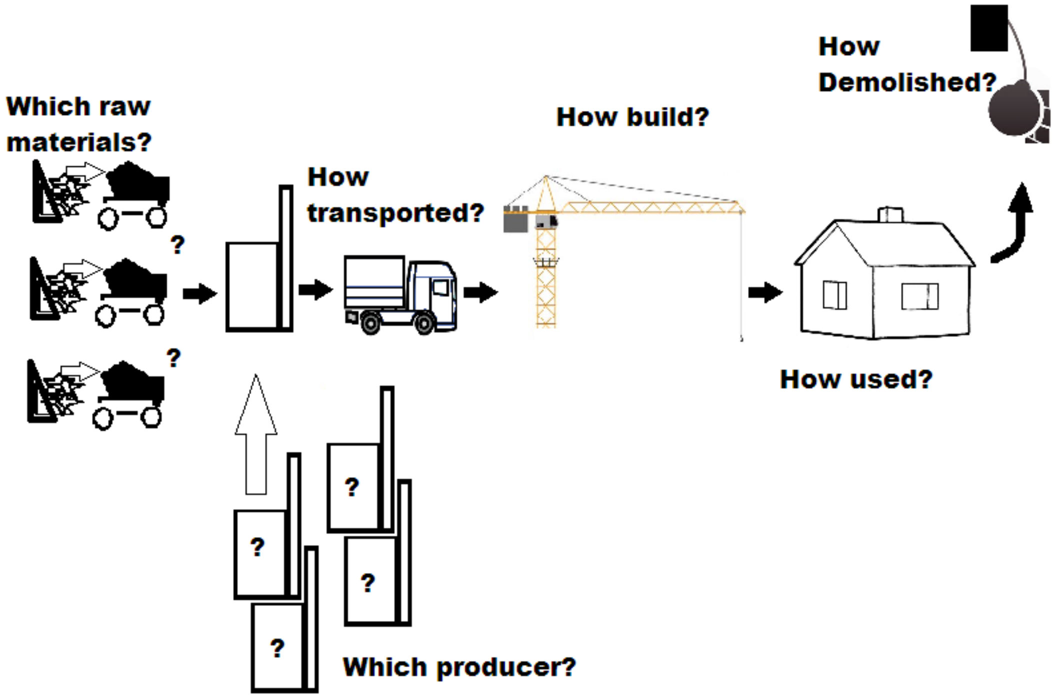


Figure 11. Building material selection dilemma

In the LCA calculations, the variations of materials have resulted up to half larger CO_{2eq} sum result than with other material selections (SYKE). [iii] This is a lot. However, the CO_{2eq} is only one of the most researched environmental impacts and other impacts should be researched as well. There is also a lot that can be done in the disposal phase that minimises the environmental impact. The efforts that increase the material efficiency in the disposal phase are not taken into account in the LCA calculations, because that can only be taken into account in the ”optional” phase of calculation as the standard EN15978:2011 advices to calculate. However, the biggest saves for environment are the ones which cause now material addition as in the project example below.

Figure 12. Aarhus municipal building in Denmark: an example of a building that used recycled materials and preserved biodiversity by renovating instead of new building. Feil! Bokmerke er ikke definert.Feil! Bokmerke er ikke definert.

Even same materials have a different environmental impact depending on the material processing techniques, construction techniques and transportation of the materials to the process and forward to the construction site. Good example is concrete that is usually used a lot in the building industry as retail buildings are most commonly structured with concrete or steel. The main material in concrete is cement that requires a highly energy intensive manufacturing process. However, the amount of cement in concrete varies, manufacturers can use recycled concrete to replace virgin materials and the energy used in production can come from numerous sources. Additionally the products used at the site have different amount of concrete. As an example hollow-core structure can be lighter with the same strength features and the structure contains much less concrete than with the spot casting technique that requires. Spot casting requires also temporary structures that increases the environmental load and has a longer building time.

The most important environmental impact is from the biggest masses of structures. Usually these are foundations, exterior walls, partitions, floors, roofs and balconies as explained earlier in this report. Therefore the effort should be contributed to the major material masses. Additionally some materials are extremely harmful for the environment. For example chemicals used in paints, and steel structures are extremely dangerous. Anti-corrosion agents and flammability prevention chemicals should be discussed in the construction projects. From the material efficiency point of view in selection of materials attention should be paid to:

- long service life of materials
- low maintenance need of material
- easy repair of material
- recyclable of material
- reuse of material
- low environmental impact during service life.

Typically materials used in the same purpose have different service life and need for maintenance during the service life of building. E.g. wooden façade needs usually maintenance painting after 15 year service life, which means 3,3 over painting times during 50 year service life of façade. At the same time painted concrete façade needs only one over painting. Service life of building materials depend strongly on the outdoor climate exposure during their service life. Typical service lives of materials exposed to outdoor climate is presented in table 2.2.

Table 2.2. Typical service lives of materials exposed to outdoor climate and maintenance actions and times during buildings service life.

Building component	**Target service life**	**Maintenance period**	**Maintenance action**
Elastic sealants in facades	20 years	20 years	replacement
Mortar joints in facades	20 years	20 years	replacement
Concrete facade	50 years	50 years	Patch repair of degradations or covering
Masonry façade	50 years	50 years	Replacement of mortar joints (outer surface)
Planked facade	50 years	15 years	Repainting
Rendering on brickwork	50 years	25 years	Repainting
Rendering on thermal insulation	40 years	20 years	Repainting with protective coating
Concrete balconies	50 years	50 years	Patch repair of degradations or replacement
Waterproofing on the roof	30 years	30 years	Replacement

The maintenance of the structure is taken into consideration in the LCA of the building. The effects of the building orientation and necessity of the façade painting should be considered case by case. Additionally if “general calculation values” are used, that should be very clearly shown in the results and discussed when the project continues to material selection. Even the transportation length can make the building materials produced closer to become more ecological while the actual manufacturing causes greater carbon footprint.

Frames of the building are usually sheltered from wind driven rain (WDR) and other harmful outdoor climate. So, the service lives of frame material are not depending on ageing of materials instead of changes in loads or accidental deterioration. Changes in the use of the building may cause changes in requirements and properties of building frame e.g. load carrying, fire resistance, sound insulation, etc., which may shorten the service life of the building in practice. However, these changes can't be taken into account in LCA.

2.7.1 Manufacturing materials and products

Material manufacturing emissions are material specific and the best possible information available for the construction case should be used. Material manufacturing environmental load information can be found from environmental product declarations (EPD) for different material producers. In the appendix you may find an example of Norwegian EPD for a cement product. Additionally, from literature contains so called “general material information for certain products” that can be used for emission estimations for projects in the early design phase. Below there is an example of one table available for public use that contains construction product carbon dioxide emissions for early phase LCA calculation. In the appendix, there is an example of one table available for public use that contains construction product carbon dioxide emissions for early phase LCA calculation.

The emissions for a manufacturing process in the EPD are shown for phases A1 raw material supply, A2 transport for processing and A3 Production. There is usually also a description of the production process for the subscriber. The environmental effect of a certain raw material is shown with many different environmental indicators such as global warming potential (GWP), Ozone depletion potential (ODP), Acidification Potential of soil and water (P), Eutrophication Potential (EP), Photochemical Ozone Creation Potential (POCP), Abiotic Depletion Potential for Elements (ADPE) and Abiotic Depletion Potential of Fossil Fuels (ADPF). With EPD information available the environmental impact of the material can be used in the selection process as an indicator together in addition to the other selection criteria such as financial control.

2.7.2 Transportation of materials and products

Transportation of materials and products causes need for traffic, emissions from vehicles and abrasion of roads etc. However, comparing to material use of construction the share of transportation is usually relatively low. Transportation distances in Nordic countries are usually relatively low. 100 km radius covers well most areas in each countries where construction, and therefore need for materials and products, is active. Emissions caused by transportation of one concrete beam presented in chapter 2.6 for 100 km is 64,2 kg CO_{2ekv}. Transporting all columns and beams needed for the ware house will affect emissions of 4 250 kg CO_{2ekv}.

If those frame materials are manufactured in southern Finland and will be transported to southern Norway by trucks via northern Sweden, the distance is approximately 2000 km to one direction. So this means 1284 kg CO_{2ekv} emissions for one beam or column and 85 000 kg CO_{2ekv} for whole concrete frame. This increases total emissions of concrete warehouse for 25 % compared to 100 km transportation distance. Quite a lot of construction materials are transported to Nordic countries from Europe or Far East, like China. Long distances for material transportation will decrease sustainability of construction phase. The emissions of transportation depend strongly on used vehicle. For long distances ship is usually more sustainable than road transportation. In Norway and especially in Island ship transportation is the most efficient transportation method for materials and products because the situation by the sea.

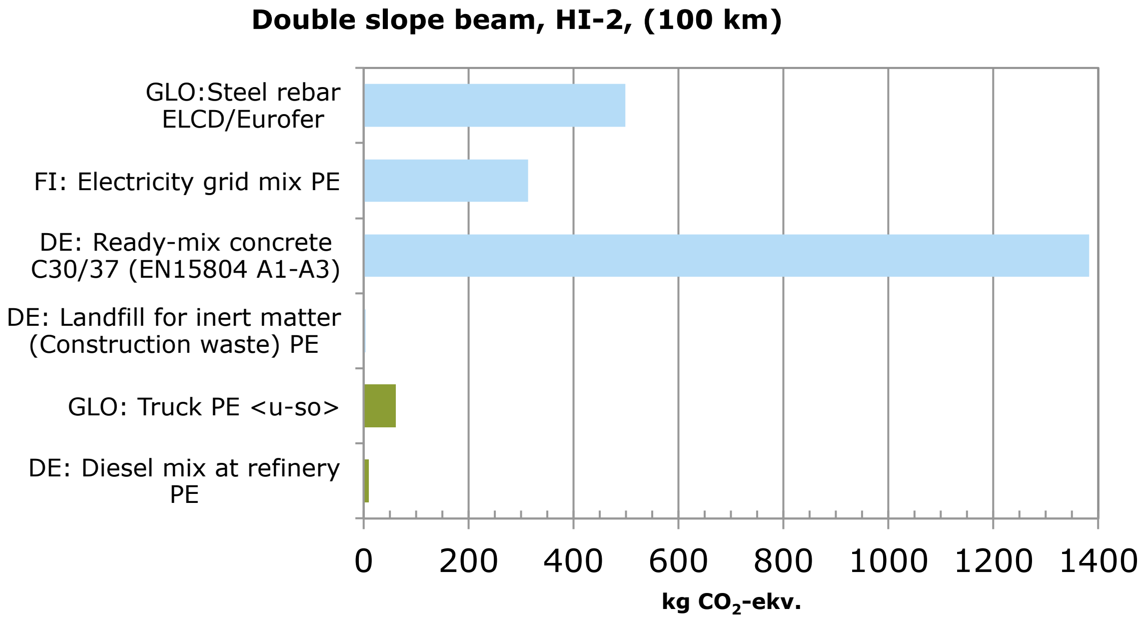


Figure 13. Total emissions of single double slope beam, transportation distance with truck 100 km. (Lahdensivu et al. 2015).

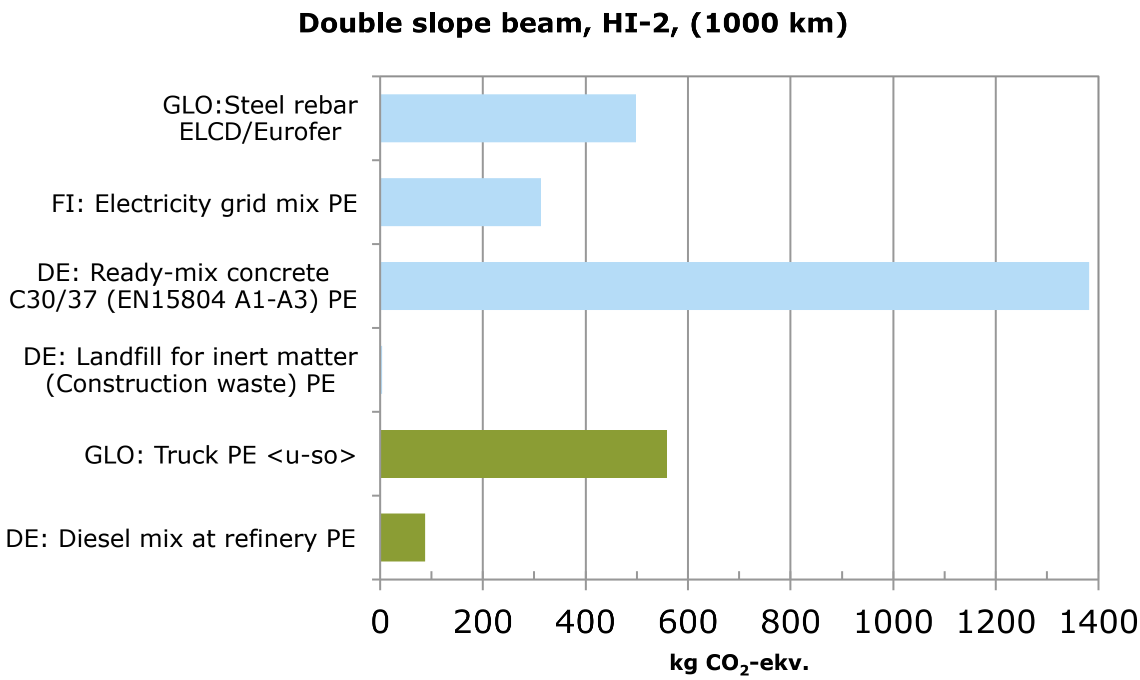


Figure 14. Total emissions of single double slope beam, transportation distance with truck 1000 km. (Lahdensivu et al. 2015).

3. SUSTAINABLE MATERIALS AND PRODUCTS

3.1 Sustainability of building products / Norway, WP2

3.1.1 Four sustainability indicators

The four participating countries have agreed upon four sustainability indicators to be used to the define sustainability of building materials and products.

Other indicators have also been discussed in the process defining practical indicators, either as separate indicators or as an indicator as a replacement of one of the four mentioned above. An example of this is energy use as an indicator instead or in addition to global warming potential (GWP). Since GWP is based both on energy use and type of energy, both important factors to reduce greenhouse gases, we choose not to prioritize between these indicators but leave it to the producers to choose the most efficient measures to reduce the greenhouse gases in the production of new products.

An important principle has been that all indicators could be found from existing documentation systems, either from one single system or from several systems that document only one or some of the indicators.

The four indicators are

- Global warming potential – greenhouse gases (GWP)
- Material resources
- Hazardous substances
- Emissions to indoor climate

Verified EPDs are the most central documentation since these are based on international standardization. All four indicators can more or less all be found in at least Norwegian EPDs but also to some extent in EPDs from other national programme operators. All EPDs include information about the two first indicators, while Hazardous substances and Emissions to indoor climate are included in some EPDs.

If such information is lacking, it must be found through other documentation, such as safety data sheets, self-declaration from the producer or certification labeling systems.

3.1.2 Three levels for each indicator

In the beginning of the project, most participants expected to end up with only one level for each indicator representing the most sustainable level for building products. As we got to know each other's varied experiences and different systems across the borders, we realized that each indicator needed several levels to be able to take differences into account.

Norway has experience from all four indicators from existing environmental assessment systems and building projects where one or several of the indicators are part of the procurement. EPDs for building materials are well established and are quite often required in building projects. The Norwegian EDP-database (EPD-Norway) has in the spring 2015 around 250 EPDs for building products from more than 90 different companies). Most producers are Norwegian but in the last years the interest on EPDs on the behalf of international producers has increased.

The well-established declaration system Building Material Assessment (BVB) dominates the Swedish building industry together with BASTA when it comes to documentation of building products that exceed declaration of performance according to international laws. These systems focus mostly at harmful substances. Building Material Assessment and BASTA have harmonized criteria and the declaration system is revised in 2015. There at some EPDs for building materials in the Swedish system operated Environdec.

The Finish Emission Classification of Building Materials (M1) from The Building Information Foundation RTS is well established, and the most common labeling system used for both manufacturers, importers and exporters of building products in the Nordic countries. The Finish building product association plans to reestablish EPD for building materials and has started the process early 2015.

Iceland has only few producers of building materials and imports materials and products from more than 100 countries. The challenge is to require products with sustainable qualities without criteria describing the conditions.

Due to the large variation of experiences in the Nordic countries, will both the need for more documentation and given sustainable levels contribute to further development of sustainable building materials in all countries.

Consequently, both type of documentation and achieved quality are used as basis to split all indicators into three levels describing the ambitions of the sustainability of building materials.

Table 3.1. Three levels describing the sustainable ambitions for building materials

	Ambition level	Documentation
Product nn	Best Nordic practice	Given level based on standardized verified declaration
	High ambitions	Verified declaration
	Good ambitions	Self-declaration

The most ambitious level for each of the four indicators will be the best practice in one or several of the four Nordic countries. This means that the most ambitious level for one indicator can be best practice in one country, while the most ambitious level for another indicator can be decided based on best practice from another country.

Greenhouse gas emissions and Material resources follow this main principle more or less like described above, while Harmful substances deviates a little, especially according to the experiences from Sweden, where it is possible to be some more detailed about the quality levels. For Emissions to indoor climate, there are also standardized test methods and levels that can be used to define the levels.

Table 3.2. Principles used describing the sustainable ambitions for building materials

	Greenhouse gas emissions	Material resources	Hazardous substances	Emissions to indoor climate
Product nn	Given level based on verified (LCA) declaration	Given level based on verified (LCA) declaration or Certification	Given level based on declaration	Given level based on verified declaration or Certification
	Verified declaration	Verified declaration	Given level based on declaration	Given level based on verified declaration
	Self-declaration	Self-declaration	Self-declaration	Self-Declaration

The level called "Good ambitions" is represented by self-declaration for all indicators since it is important to at least declare the performance even if it is not based on either existing standards or third part verifications. Examples of such self-declarations are the Swedish Building Material Assessment or laboratory tests by the producers themselves.

The level called "High ambitions" is represented by declaration based on international standards and verified by a third part. Examples of this are for instance EPD based on ISO 14025 and EN 15804 and Ecolabel based on ISO 14024.

The level called "Best Nordic practice" is represented by the best practice in one or several of the participating Nordic countries. This means that if one Nordic country has criteria or systems for one or several of the indicators that is more ambitious than the other countries, the most ambitious level define the most ambitious level for all the participating Nordic countries.

3.1.3 How to group the materials?

Independent of how the materials are grouped, the grouping will not be correct for all kind of functions that the product fulfils. Insulation and building boards must for instance both fulfil one or more of the functions regarding thermal conductivity, fire resistance, density, acoustics and so on. Grouping of materials might therefore be difficult, but is still done even of all these differences, both in this project but also when we talk about products in general. We define products in groups like insulation, building boards, slabs, columns, windows, flooring products and so on.
When designing buildings most of these product groups have to be defined much more detailed when the products are given needed functions. Examples of these is when insulation is split into unflammable and flammable insulation, density groups etc, building boards are split into gypsum, chipboards etc while beams are split into concrete, steel and wooden beams.
Another aspect that have been discussed regarding grouping of products with the sustainability aspect is if the various PCRs should be taking into account since the EPDs for comparable products might be based on different PCRs. This means that the PCR is the basis of the group, and all products included in the PCR constitute a product group. The major problem with such approach is that comparable products with EPDs from two different EPD-operators will not be in the same group even if they are more or less the same product. The conclusion of such discussion is that products might me compared independent of which PCR that is used, but still *a comparison have to be done with caution*, especially if scenarios are included in the comparison basis. When using this indicator in procurement documents, it have to be considered carefully if the indicator level represents products that fulfill all the needed functional requirements.
Since the Best Nordic practice-level for the greenhouse gas and the Resources indicators are based on EPDs, it is a need of enough data to establish such reference levels.
Possible product groups discussed are:

- Concrete
- Concrete elements
- Steel constructions
- Insulation
- Building boards
- Windows and doors
- Flooring products
- Roofing products
- Wooden products

For some product groups it is necessary to split into more detailed material groups since functions are obtained by using various sub products. One example is for instance windows made of either wood, plastic or metals were some of the indicators might vary dependent of type of materials used in the product.

Greenhouse gas emissions

Summary: The most ambitious levels for each product group are more or less based on the established Norwegian method Ecoproduct. The indicator is described as greenhouse gas emissions lower than given limits specified for some product groups.

The most ambitious levels are the most challenging to decide, especially on greenhouse gas emissions where the experiences on levels are fairly low in all countries except Norway. Several Norwegian building projects sets today criteria for maximum acceptable greenhouse gas emissions from products. The ambitious level must be given at a level that is either not too high or low.

The Norwegian Ecoproduct and Klimagassregnskap.no, both databases on greenhouse gas emissions, can be used as basis for a Nordic level. Another reference, as for instance industry-norms, is perhaps the most useful references, like the classification of concrete defined by the Norwegian Concrete Association. Both Ecoproduct and Klimagassregnskap.no are described in Annex 3 in the report from work package 1 in the Nordic guide-project.

The reference value will be based on comparable products. An important question to ask is "When are products comparable?" According to the standard EN15804:2012+A1:2013 comparisons between construction products can be carried out in the context of their application in the building". This means that products can be compared when (all) the same functional requirements are met, and the influence of the whole construction and the building are taken into account. Comparison of a product against the requirement must therefore be done with caution since the product might have different properties except the property used for when the reference value is decided.

When establishing the first reference levels both these databases mentioned above, and values from several EPDs are used as basis. This reference values will probably be changed some when more products are documented with verified EPDs and further development towards more sustainable products.

Table 3.3 The three levels of the indicator Greenhouse gas emissions

Best Nordic practice	Less than the reference level, A1-A3
High ambitions	Verified declaration
Good ambitions	Self-declaration

Material resources

Summary: Material resources are based on used secondary materials in the production of new materials. The levels are based on experiences from projects and EPDs. For wooden based products the level criteria is that the wood comes from certified forests and does not include any tropical wood.

What kind of indicator that could describe the use of material resources on a material level have been discussed widely. As a basis of this indicator, the input must be able to find in EPDs.

All EPDs according to EN 15804 include information about type and amount of energy and material resources used to produce the material and how much secondary materials and water that have been used. Some few EPDs also include a module D, which is outside the boundary systems in EPDs, that inform about the reuse/recycling-potential of the product based on scenarios for given markets.

In the Norwegian Ecoproduct-method that interpret EPD-results and present the result simplified, the indicator Resources is split into Material resources and Energy parameters and both are weighted the same. The Material resources are split into three other sub-parameters "Use of renewable and non-renewable materials, Use of secondary materials and Use of water. All have the same weighting.

As a simplification from Ecoproduct, an alternative might be to only use the most "critical and relevant" parameter regarding material resources and not all sub-parameters as in Ecoproduct and EPDs.

What is the most critical and relevant parameter, and is it possible to limit this indicator to only one parameter? This might differ from one material to another, and must be defined specified for each materials, as the reference level is defined for greenhouse gas emissions.

The most critical and relevant parameters that are not included in the other indicators, are at least the type of materials and if these are renewable or not. The use of renewable materials depends more or less, on what types of materials are evaluated, and might be difficult to have as a general parameter. It is for instance impossible to produce concrete slabs based on for instance more than 60 % renewable materials, while wooden slabs are produced by almost 100 % renewable materials.

The indicator "Use of secondary materials" is a concrete value of how much material that is recycled from previous use or waste (scrap metal, broken concrete, broken glass, plastic etc) which are used as material. According to ISO 14021 which is the basis for EPDs, only pre-consumer and post-consumer materials are considered as recycled content or secondary materials. Internal scrap from its own production, is not considered in the use of secondary materials.

The indicator secondary materials do not make any difference if the materials is up – or downcycled, and can both be renewable and non-renewable, with or without energy content. The use of secondary materials is to some extent included in the greenhouse gas emission indicators, but this parameter is probably not enough to stimulate to more use of secondary materials in production of new materials. This parameter is important regarding secondary economy focusing on more reuse of existing resources. The same is the D-module in EPDs informing about the reuse/recycling-potential, but both because this information is based on scenarios for given markets, and that still it is quite few EPD that include this information, it is probably better to focus on the concrete values that Use of secondary materials represent.

Use of secondary materials is therefore an appropriate indicator to use for most material groups, with some exceptions. The most important exception is wooded products where it is more important to focus on how the wood is produced instead of if the product is based of secondary wooden materials. Another exception could be that the use of secondary materials is not always the most sustainable if the use of secondary materials leads to disproportionately long transport distances with high emissions.
At the same time the indicators have to reflect best practice in the Nordic countries – and therefore must be relevant for the specified materials and products.

Despite all these incompleteness's, a simplification were the single "Use of secondary materials" as a portion of the total weight is used as an indicator of Use of resources, unlike Ecoproduct that also include the parameter defining use of renewable and non-renewable materials.

Hazardous substances

Summary: The Best Nordic Practice and High ambition level are based on the ambitious levels for various Nordic assessment and labelling systems. The list of criteria is the same for all product groups. As a principle, all established major Nordic assessment and labelling systems can be used as documentation despite the minor deviations between the systems.

The Swedish BASTA and Building Material Assessment (BVB) focus primarily on harmful substances with fixed criteria for a list of given substances. The Building Material Assessment includes even three different levels; Recommended, Accepted and Avoided were recommended is the strictest level.

The Accepted level in the Building Material Assessment (BVB) harmonizes with the BASTA-level, Sunda hus level B and the Norwegian SINTEF Technical. The criteria for the Nordic Ecolabel are at least as strict as the Accepted level in addition to more chemicals than included in the assessment system.

The two most ambitious levels in the Norwegian Green Ecoproduct-level meet respectively the two most ambitious levels in this Nordic guide.

The levels are more or less the same for all types of products in the various declaration systems. The exception is Ecolabel that has some variation in criteria depending on type of product.

In the Nordic guide regarding Hazardous substances these existing declarations systems are used as basis defining the three levels of ambitions. Since Ecolabel, BASTA, SINTEF Technical approval and Recommended and Accepted in the Building Material Assessment all are at a high ambitious level, the most ambitious level in the Nordic guide, is established at the BASTA/TG-level. A comparison of these three levels is given in Appendix 1.

Table 3.4 The three levels of the indicator Hazardous substances

Best Nordic practice	Substances less than limits in Table 2.11, Best Nordic practice or Ecolabel, BVB recommended, Green Ecoproduct level 1, Sunda hus level A
High ambitions	Substances less the limits in Table 2.11, High ambitions or BASTA, BVB accepted, Sunda hus level B, SINTEF Technical approval, Green Ecoproduct level 3 [2]
Good ambitions	Self declaration and less than 0,1 % substances on the Reach candidate lists

The three levels are based on international and national legislation, with either EPD or more sophisticated and detailed evaluation of hazardous substances as basis for the level each products has.

Emissions to indoor climate

Summary: The Best Nordic level corresponds to the criteria for Low Emission materials described in EN 15251.

The indicator "Emissions to indoor climate" is only relevant for products that affect the indoor environment. For Norwegian conditions, this is described as products on the inside of the vapor barrier or as a part of the vapor barrier system. For other countries, other references might be more appropriate to use based on the national construction methods.
The international standard EN 15251 is the basis for this indicator. The criteria for Low emission materials are:

Examined qualities for low emitting materials after 28 days	[mg/m2h]
• The emission of total volatile organic compounds (TVOC)	< 0,2
• The emission of formaldehyde(HCOH)	< 0,05
• The emission of ammonia (NH3)	< 0,03
• The emission of carcinogenic compounds belonging to category 1A or 1B in Annex VI to Regulation (EC) No 1272/2008	< 0,005

Criteria for Emission Classes in the Finnish classification system

The Finnish emission classification of building materials has three emission classes. Emission class M1 corresponds to the best quality and the low emitting class in EN 15251, and the most ambitious level in the Nordic guide-system. M2 correspond to the medium ambitious level. Classified materials have to fulfill the following criteria at the age of 4 weeks.

Table 3.5 Criteria for Emissions Classes

Examined qualities	**M1 [mg/m²h]**	**M2 [mg/m²h]**
The emission of total volatile organic compounds (TVOC). A minimum of 70% of the compounds shall be identified.	< 0,2	< 0,4
The emission of formaldehyde(HCOH)	< 0,05	< 0,125
The emission of ammonia (NH_3)	< 0,03	< 0,06
The emission of carcinogenic compounds belonging to category 1A or 1B in Annex VI to Regulation (EC) No 1272/2008 [1*]	< 0,005	< 0,005
Odour (dissatisfaction with odour shall be below 15 %)[2*]	Is not odours	Is not odorous

1* does not apply to formaldehyde
2* The result of sensory evaluation shall be at least + 0,0

Emission class M3 includes materials whose emissions exceed the values specified for materials in category M2.

Other testing methods might also be used, for instance GEV-Emicode for flooring materials and the GUT label for carpets. Ecolabel has emission criteria corresponding to low emitting materials for flooring products from 2015.

Based on this is the M1 level established as the minimum level, except for sealants were EC1 Plus is the minimum level.
The three levels regarding Indoor air emissions in the Nordic guide are as following:

Table 3.6 The three levels of the indicator Indoor air emissions

Best Nordic practice	Low emission level (according to EN 15251) Documentation as M1, EC1, GUT, Ecolabel or corresponding level based on these certification systems
High ambitions	Medium emission level Documentation as M2 or corresponding level based on this certification system
Good ambitions	Self-declaration

3.1.4 Accepted documentation

To meet the described levels several types of documentation can be used depending on the ambitious level and the sustainability indicator.

Table 3.7 Types of documentation depending on ambitious level and indicator

	Greenhouse gas emissions	**Material resources**	**Hazardous substances**	**Emissions to indoor climate**
Best Nordic	• Verified EPD • Green	• Verified EPD • Green Ecoproduct	• The Swan • Building Material	• M1 • GEV Emicode EC1

practice	Ecoproduct	• PEFC/FCS e.g certification for wooden based materials • The Swan	Assessment Recommended • Sunda Hus level A • Green Ecoproduct level 1 • Safety Data Sheet • Verified EPD with additional info.	and EC1 Plus • GUT • SINTEF Technical approval • Green Ecoproduct • The Swan (only flooring) • Verified EPD
High ambitions	• Verified EPD • The Swan	• Verified EPD • The Swan	• Building Material Assessment Accepted • BASTA • Sunda Hus level B • SINTEF Technical approval • Green Ecoproduct level 3 • Safety Data Sheet • Verified EPD with additional info	• M2 • CEV Emicode EC2 • Verified EPD
Good ambitions	• Building Material Declaration • Other self-declaration	• Building Material Declaration • Other self-declaration	• Safety Data Sheet • Building Material Declaration • Other self-declaration	• Self-declaration based on laboratory tests

3.2 Verification of environmental product data of Nordic products

The main purpose of Work Package 3 has been to increase awareness of Environmental Product
Declarations (EPDs) in the Nordic building market and map the knowledge and the use of EPDs
in the market.

This report shows the main results of two surveys which were conducted in Iceland, Norway,
Sweden and Finland during the summer of 2015 (July - Sept). The two surveys were aimed at different target groups; *1) Building owners, consultants and contractors* and *2) Producers and providers of building products.*

When the two surveys are analyzed, it is important to bear in mind that answer rates and participation is different for each country.

In the survey for **building owners (1)**, there seems to be a rising interest in getting more detailed information on environmental properties of materials and in being able to compare different building materials. However for this group, due to lack of knowledge and/or experience in working with EPDs in the sector, it is somewhat easier to use labelled products than to analyzing the information in an EPD for a given product. Cost is still considered high since this is not yet common practice. It is also considered problematic that the different EPDs are currently not harmonized in all stages which can make the comparison between products more difficult.

In the survey for **producers and providers (2),** the majority of answers came from Sweden and Norway. Hence, the second survey does not reflect the building market in the Nordic countries very well. The results show that there is a growing demand for environmental data of building products in these countries, and producers are expected to present information in an accessible way that makes it easier for consumers to make informed decisions in selecting building materials. It is also required that information provided in EPDs to be open and accessible since the growth of registered EPDs in the market will only increase their accuracy and value.

This development goes in hand with the increased use of international certification systems in
the Nordic building market but also reflects developments in EU and international laws and regulations. One of the main obstacles mentioned in the surveys for the use of EPDs is the lack of market demand. The challenge today is to expand the market for EPD certified products, and make the information both transparent and understandable for both decision makers and those that have influence on the procurement of building products.
One of the main driver for the implementation of EPDs is the use of environmental certification systems for buildings, but other factors such as willingness to gain market advantage for a quality product are important as well.

3.3 Re-use and recycling of building materials and recycled materials in buildings

The demolition of existing buildings is in Finland highly concentrated in growth areas where also new construction is most active. Majority of the demolished buildings consist of industrial and warehouse buildings as well as office buildings. However, the demolition of residential buildings has to date been minor. (Huuhka & Lahdensivu 2014). It can be foreseen that more buildings will be subject to demolition in the future. Due to the high volume of concrete construction even a small increase will result in high increase in demolition waste.

The European waste framework directive (2008), in which also the national legislation is based, promotes the re-use of products instead of crushing material recycling. More than 4 tonnes of construction and demolition (C&D) waste per capita is generated in Finland every year. This waste contains over 75% of soil and other excavation which is normally not being accounted for. Therefore, the estimated amount of C&D waste in Finland (1 ton per capita) is below the EU-27 average of 1.1 tons per capita. Approximately 77% of this waste is recovered according to Meinander & Mroueh (2012), and 26% is re-used or recycled according to the BIO Intelligence Service estimation based on 2009 data. Although most of the structural unit systems have not been deliberately intended and designed for partial dismantling and reuse, various pilot projects have proven it feasible.

3.3.1 Product approval

According to the Construction Products Regulation (CPR) Product approval i.e. CE marking of construction materials and products has been mandatory since July 1st 2013. In the first place product approval is needed for materials and products when they are coming to markets. Discussion is still going on between EU member states whether construction products already were on the market before the obligation of CE-marking are subject to CE-marking. It has been proposed that CE marking should only be required on new construction products and not on reclaimed building materials and architectural salvage. However, products which are further processed before recycling probably fall under the requirement for CE marking.

CE marking of reclaimed construction product might meet some challenges. CE marked products must be traceable i.e. all information about manufacturing process and originality of raw materials must be declared. In re-used construction products which have been manufactured a long time ago this is usually impossible. Another challenge is the quality control of the re-usable construction product. Probably this requires new procedures for quality control and also amendments to product standards.

General quality requirements to be considered in the re-use of construction products (Wahlström 2014)
The building material does not contain restricted compounds (according to today's requirements)
The product has not been subjected to activities leading to pollution of the material.
The previous use of construction material has not endangered the technical properties (e.g. material ageing)
The deconstruction of the material has not harmed its technical properties

3.3.2 Planning new building components for reusable

Easy and effective constructability has been the most common starting point for design for decades. In fact all development has been focused on easier and faster installing of construction materials and product on site. The shorter constructions time the lower costs. In the future the designer will increasingly be able to judge how building parts can reasonably be repaired or dismantled without breaking them, and how the remaining lifetime of the dismantled parts can be utilized in new applications. Dismantling of the building should be taken into account already in program development and schematic design phase, and it should be a part of life cycle assessment of building components and structures. Good design takes into account future needs, making it easy to repair the components or recycle the demolition materials.

Design building components for deconstruction (DfD) refers to the design of the building so that the parts are easily dismantled and separated from each other for re-use or recycling. Good design solutions promote further use of components and materials. Many examples can be found already. Usually those connections have been made with bolts: precast concrete columns and beams, glued laminated timber beams and columns, steel columns and beams, etc.

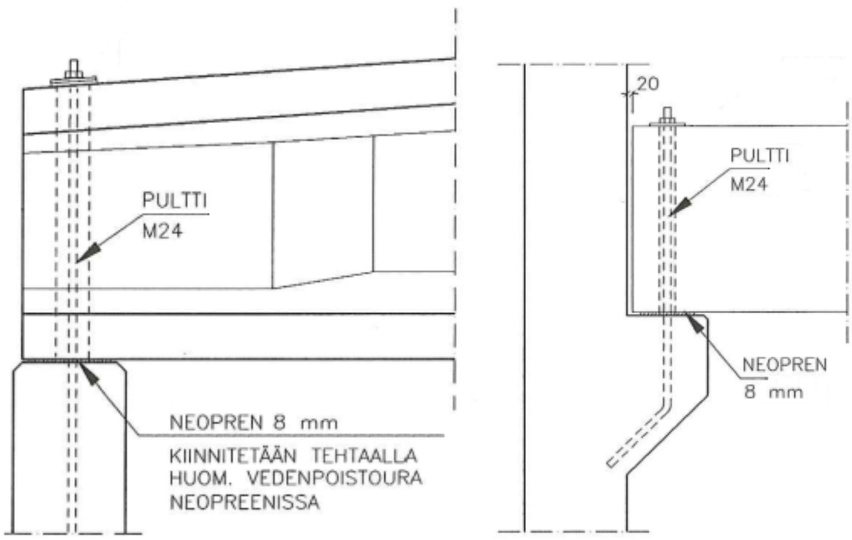


Figure 15. Examples of easy dismantled connections in concrete structures (Building industry 1995).

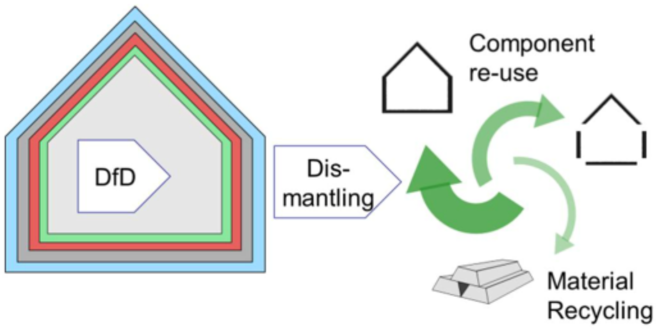


Figure 16. Re-use of building components is remarkably easier if the building has been originally designed for deconstruction (DfD)(Talja 2014).

Advantages on designed for deconstruction and recycling (Talja 2014)
Re-use and recycling save non-renewable resources
Re-use saves the energy and emissions required to manufacture new products.
The maintenance and replacement of building elements and HVAC system is easier, reducing the costs of the future
Better adaptability of the building increases the possibility to change the spaces to alternative purposes.
Opportunities for resale and re-use of the undamaged salvage parts and objects will be greatly improved.
A higher score can be achieved in environmental quality classification, which will improve the ecological image of the company.
Dismantling costs and environmental impacts due to dust, noise or other harmful emissions are reduced.
Landfill waste due to repair and demolition will be reduced in the future.

3.3.3 Using re-used building components

Concrete buildings made with girder and post frame have a very high recovery potential, because girders and columns can usually be used as such in new construction. Warehouses, industrial and office buildings as well as commercial buildings are usually made with girder and post frame. In most cases, precast columns and beams are connected together with bolts, which can usually be disassembled relatively easily. TT-slabs are connected to beams either welded or with bolt joints. Both are usually rather easy to open. Blocks of flats are also made with precast concrete panels, but the panels are connected together with reinforced and cast joints. These joints must be opened by chiseling or cut with a diamond saw. The diamond saw also cuts tie bars from the panels.

Table 3.15 Re-usability of different structural connections.

Connections	**Suitability**	**Note**
Cast and reinforced connections	sometimes suitable	Usually will damage both elements and connection steels.
Welds	mostly suitable	Usually can be replaced with new welds and connection steels.
Bolts	suitable	Usually easy to open without damaging the elements.

The assessment of old structural members and building components needs an accurate knowledge of the amount and situation of reinforcement as well as strength properties of used materials. Re-used structural members must carry the loads demand according to the current design standards. A summary of good practices in the re-use of structural building components and elements is found in the following paragraphs.

Assess the damage

Do not use structural members from areas of accelerated localized corrosion or frost-damaged material or where there is other evidence of localized section loss. Avoid beams with big existing holes in locations of high stress concentration. Do not use pre-stressed concrete beams or slabs with wide cracks or corroded steel. Do not use timber structures with holes or suffering rotten.

Focus on connections
Avoid elements if there are wide cracks in the console area of a column or the connection area of a beam. Connecting steel must be safe and sound in all panels.

Know the history
If original drawings and specifications are not available, a testing programme must be initiated. Avoid using elements from bridges or similar dynamically loaded structures because of the accumulated fatigue damage. Consider the possibility that high moisture levels of structure may have caused corrosion problems or even frost damage. Timber structures might have signs of mold or even rotten.

Prepare the documentation
Show the location and building structure where the members were originally in use, including the date of construction of the original building. Provide certification of all re-used concrete structures as regards to the section properties and material grade as specified on the drawings or general notes.

Especially the weather exposed structures in the existing building stock usually have some extent of repair needs due to environmental loading or indoor air pollution. This leads to the need to assess the reuse potential of these structures individually. It is thereby unlikely to achieve the common service life requirement of 50 years using these reused parts. The reuse of structural members is affected by the age and purpose of the existing building and its materials, the loading they are subjected to during their lifetime and the intended purpose of the reused parts. Structure parts that can be easily detached and reassembled have the highest reuse potential. One of the greatest risks for damaging the reuse parts are in fact involved in its detaching, handling and transportation.

3.3.4 Re-use of building frame

The building frame is usually located inside the building envelope and in most cases it is in good condition and can be re-used. In the case of indoor air polluted buildings, the uncontaminated parts of the building pose potential for re-use.

All structural members, such as columns, beams and slabs, are designed individually case by case, i.e. reinforcement of concrete structures, the section of steel structures as well as wooden structures, etc. has been calculated according to design norms and guidelines in force for design loads. The design codes that give regulations for material properties and loading have changed regularly since the beginning of precast concrete construction. It has to be looked after that the re-used parts are not subjected to greater mechanical or environmental loading than in the present structure. Also the existing thermal insulation of the external walls is not sufficient to the current code and will require added insulation.

Carbon footprint calculations of the reuse of an obsolete warehouse with a column-beam frame support re-use of structures from the environmental point of view. Even though the carbon footprint of the transportation of re-used structures has to be taken into account in re-use feasibility analysis, it is minor compared to the fabrication of new members. For example re-use of column-beam frame presented in chapter 2.7 gives 72 000 kg CO_{2ekv} smaller carbon footprint compared to totally new frame.

3.3.5 Recycled building materials in new construction

Reinforced concrete structures are made either in situ or as precast concrete elements. In situ-cast concrete structures are not re-usable as whole structures or part of it. Crushed concrete is recyclable as an aggregate of new concrete, and mostly replaces natural aggregate in soil construction like roads, etc. Reinforcement is recyclable as are metals in general, but it must be separated from concrete during the crushing process. Crushing of concrete is noisy and dusty work, so concrete should first be transported to a suitable crushing places.

4. GUIDELINES FOR PLANNING AND DESIGN

4.1 Feasibility analysis

During feasibility analysis the most important task is to find out the client's needs. First of all any client do not need any kind of building in the first place. The client need spaces for his/her activities, which could be like living, working, storing goods or product something, etc. From the material efficiency point of view, important questions are as follows:

- What is the purpose of the space?
- What kind of spaces will be needed?
- Where the spaces should locate?
- Are these spaces already available?
- How many square metres will be needed and how these square metres should be designed (principles)?
- What is the client's budget for new spaces?
- Can the client go short of his/her demands for spaces?
- For how long period client needs those spaces?

In a usual project, client's needs or wishes do not meet the expenses of the project. There is usually one or more rounds, where the client must think what he/she really need. It is also important to find out how long-lasting investment the client is making. Living is definitely long-term investment, but in the e.g. commercial buildings the investment period is usually between 5 and 10 years.

From the sustainable point of view, the most sustainable building is the building, which will never be built. That's why it is very important to ask for the client if some existing building will meet requirements. In many cases existing building is more sustainable than a new one even if there is need for modifications in the existing building. For the short period investments, a light modification of existing building is the most reasonable solution both from an economic and environmental point of view.

If there are no suitable existing buildings available, and the client wants to build a new one, from sustainable point of view it is very important to find out:

- Service life of building
- User environmental policy aspects for maintenance, waste handling, water use and heating
- Level of sustainability – best Nordic practice, High or Good ambitious
- Energy efficiency of building
- Sustainability class of building according to e.g. BREEAM, LEED, etc.
- Maintenance periods of the building and its components and materials in general
- Possibilities to reuse old building components from some other buildings
- Possibilities to use recycled materials in the building.

Service lives of buildings and its components vary a lot. In a normal case foundations and frame of the building are designed for 100 years use while e.g. facades are designed mostly for 50 years and windows and roofs for 30 years' service life. These service lives together with maintenance periods have strong impact on materials and structures of the building. The longer service life and maintenance period demands, the higher durability demands for the materials and building components. In the material efficiency point of view, the flexibility requirements and usability of the building are more crucial than service life issues. For the new building must be planned also the second use or even third use during project planning.

After ball, the cubic form of building is the most efficient in energy use and consumption of building materials. In the first place the form and frame of the building must fulfil the requirements of users' needs. Set targets for energy efficiency class of the building has strong effect on material efficiency of building. High energy efficiency demands for buildings might increase the amount of building materials, especially amount of thermal insulation but also amount of construction frames where the thermal insulation is installed. This will decrease the material efficiency of building and increase CO_2 footprint of construction period. On the other hand, during the whole service life of the building total CO_2 savings of the building are higher due decreased energy consumption than affected by increased material use. Therefore it is more important to consider structural factors that minimize the energy consumption. Besides the insulation these are: use of passive heating/cooling from sun with shadows and light trespassing structures and openings, energy storages and optimal building shape considering the use. The best way to do this is to make an energy simulation model of the building and check the optimal solutions case by case with the model.

Decisions related to sustainability
During feasibility analysis at least following items related to building materials should be taken into account in the decision process.

CHECK AND ASK THE DESIGN TEAM TO DOCUMENT:
Material efficiency: total material requirement per square meter (TMR)(ton/m^2)
Form and structure of the building
Flexibility
Reuse of building components and design for reuse
Design building components for deconstruction (DfD)

4.2 Program development and schematic design

From the sustainability point of view, the project planning phase is the most important phase in all building projects. To design as sustainable building as possible, the most important decisions will be made in this phase. Project planning phase is usually divided in two phases:

- feasibility analysis and
- program development and schematic design.

Client’s needs will be developed to design program for architects and technical designers. Based on architect's schematic design, structural designer will make the first plan for the frame of building and other technical designers will make their own sketch. These schematic plans will be estimated based on set goals.

Structural engineer makes a proposal for the frame and structural system for the building based on architectural design. Materials for the building frame must meet demands on structural safety, fire safety and stability of the building in the first place. After those requirements, comes cost and material efficiency. Size of the building, different loads, long spans, etc. might reject free choice of frame materials.

Based on architectural and structural schematic design it is also possible to estimate costs of the project as well as sustainability of the building. Schematic designs will be developed by the designers based on the feedback from the client and authorities so far that architectural plans and frame system of the building as well as the most important structural types can be decided for basis of actual design phase.

Targets for energy efficiency class of the building have strong effect on material efficiency of building. High energy efficiency demands more or more efficient thermal insulation and better windows as well than regular building. On the other hand total energy consumption in low-energy or passive house is lower in long period and therefore total greenhouse gas emission are usually lower in long term. In the buildings with long service life the material choices which will need as little maintenance, repair or renewal as possible during their service life are usually the best choices also for material efficiency point of view because the total consumption of materials is usually lowest as completeness. Minor repair and renewable need has positive effect on the disturbance –free use of the building, too.

Concrete buildings made with girder and post frame have a very high recovery potential, because girders and columns can usually be used as such in new construction. Warehouses, industrial and office buildings as well as commercial buildings are usually made with girder and post frame. In most cases, precast columns and beams are connected together with bolts, which can usually be disassembled relatively easily. Easy and effective constructability has been the most common starting point for design for decades. In fact all development has been focused on easier and faster installing of construction materials and product on site. The shorter constructions time the lower costs.

So, the most important decisions for materials, material efficiency and sustainability of the building will be made in the end of project planning.

Decisions related to sustainability
In the final design program and schematic design at least following items related to building materials should be taken into account in the decision process.

CHECK ANDASK THE DESIGN TEAM TO DOCUMENT:
Form and structure: How client's needs are realized?
Service life for materials and building components: ▪ **Foundations (years)** ▪ **Frame (years)** ▪ **Facades (years)** ▪ **Wet rooms (years)** ▪ **Roofs (years)** ▪ **Supplementary building components (years), etc.**
Material efficiency: ▪ **Total material requirement (TMR), (ton/m^2)** ▪ **Material choice for frame and facades**
Reuse of building components and design for reuse

4.3 Design development and working drawings

During design phase schematic drawings will be developed for working drawings. Nowadays, when design process is made more and more with the help of *building information modelling* (BIM), it makes designing more efficient; all drawings needed on site or in prefabricated factories can be converted from the model. And for cost and sustainable point of view bill of quantities in every single materials used in the building is possible to get from the model. This means that every change made in structures or materials can instantly be seen in material efficiency of the building.

Service life and maintenance need during use phase should be kept in mind when considering materials exposed to outdoor climate or some other harsh environment like sea water or chemical stress. Usually durable and long-lasting materials are more sustainable in long-term.

During design phase it should be kept in mind that materials and new building components designed for certain building should be designed so, that reuse of those components or materials are possible when the service life of designed building has ended. This is uncommon today, but in the near future there is a need for this kind of thinking. In a new building, there might be possibilities to reuse building components from dismantled buildings. E.g. beam-column frame can be originated from old demolished building. This kind of reuse increases material efficiency remarkably compared to a totally new frame.

Wall assemblies, roofs, windows, etc. building components together with technical installations, like HVAC solution, effect on energy efficiency of the building. Calculations must be made for all design choices keeping in mind national regulations and clients targets. Hygro-thermal performance of materials and building components has strong influence on indoor air quality of the building. Several materials have demands for lower structures drying out before installing.

In some cases the frame of the building has been changed from one material to another or from in situ made to prefabricated or vice versa. Sometimes this kind of decisions are made during design phase or even in construction phase mostly based on economic or time schedule reasons. However, original service life and usability demands, etc., must also be fulfilled after changes. Sustainability and material efficiency calculations must be done again after these changes.

Decisions related to sustainability
During design phase at least following items related to building materials should be taken into account in the decision process.

CHECK AND ASK THE DESIGN TEAM TO DOCUMENT:
Material efficiency: ▪ **LCA (Life Cycle Assessment) calculations and material choice for frame, facades and all other building components**
Service life for materials and building components: ▪ **Service life calculations for chosen materials and building components**
Energy efficiency: ▪ **Calculations for all design choices -> selection of structures and products**
Hygro-thermal performance level of building: ▪ **Calculations and material choices** ▪ **Effect on indoor air quality**
Use of recycled materials: ▪ **Calculations and material choices**
Use of renewable resources: ▪ **Calculations and material choices**
Use of reused building components: ▪ **Calculations and material choices**

4.4 Construction phase

During construction phase the contractor buys materials and products for the building. Sustainability of those materials and products (Environmental product declaration, EPD) depends on where those materials are produced and how long is the transportation distance as well as transportation vehicles. Sustainability of materials can be increased by buying materials, especially heavy and a lot of needed, near construction site to keep transportation distances minimum. The materials and products might be changed to more sustainable ones if properties are the same than in original. With functional criteria in the procurement and requirements on documentation, the building owner can have control that his ambition level is realized.

Avoiding material waste during construction phase is one of the most efficient ways to increase material efficiency in construction phase. In new construction the waste materials are mainly from material packaging whereas in the reconstruction projects the main part of the waste is demolition waste. Avoiding wetting of uninstalled materials and already completed spaces can save money and time as well as materials. Moisture level control is essential in all buildings where good indoor air quality is set goal. Clever use of building materials produces as little waste as possible. Using prefabricated products as much as possible decreases remarkably cutting or other tooling on site and, therefore also less waste is produced.

Most of the decisions for material recovery are done in the design phase. A lot effort should be paid to avoid unnecessary demolition and increase recycling rate of demolished materials with active sorting. The share of construction waste of the total waste amount in Finland is approximately 26 % (24.6 million tons) including both building construction and civil engineering work produced waste. Most of it is (up to 94 %) different soils (Ruuska etc 2013). Waste material handling is quite organized in the construction sites, but unnecessary material loss is occurring due to material storing. All materials must be stored on site according to material producers' instructions.

In many cases recycled materials can be used instead of virginal. For instance if recycled gravel from near neighbourhood is available it can be used to e.g. artificial fills instead of virginal gravel. Or crushed concrete might be used to loadbearing road base. But, if recycled materials or reused components are used to load carrying structures, the validity must be shown by suitable tests. Construction design is mandatory based on the test results. If recycled materials are used there is theoretical possibility to reduce e.g. carbon dioxide emissions instead of increasing (there is negative emission for the construction material).

Research has shown that electricity and heating causes over half of the total site emissions, followed by ground works, material transportation and on-site transportation. Waste, water and temporary works cause insignificant emissions. No direct correlation was found between carbon intensity and cost intensity for the studied functions. Widespread carbon calculation was found to be challenging with current data management models of construction companies (Helsten 2012).

Cleanliness of construction site is the key-factor for indoor air quality. Spaces should be clean before technical installations, like air-discharge pipes etc. It's important that the building owner make quality check on building site that the provided product is actually used. By making a list over all approved products in the project, this list can be compared to used product during regularly quality checks at the building site.

Decisions related to sustainability
During construction phase several decisions are made related to building materials according to design program.

CHECK AND ASK THE DESIGN TEAM TO DOCUMENT:
Control of moisture level: - **Moisture content of structures before coating** - **Sheltering construction materials from moisture and rain during storing and after installation**
Cleanliness of ready spaces: - **Sheltering rooms and installations from dust and dirt** - **Cleaning ready spaces before installations**
Quality check: - **Materials emissions** - **Response to plans**
Waste management - **Sorting construction waste** - **Reuse and recycling construction waste**

4.5 Commissioning stage

During commissioning the building operation has to be verified so that the designed outcome is reality. Usually the insurance policies and warranty repairs needs the check-up. In this stage it is also necessary to check that the estimated environmental target level is achieved e.g. for recycling rate determination.

CHECK AND ASK THE DESIGN TEAM TO DOCUMENT:

Material efficiency: ▪ **Total waste amounts for project and calculate recycling rate** ▪ **Total use of recycled materials** ▪ **Building material EPD (Environmental Product Declaration) sheets are collected into the building service manual** ▪ **Check that there are instructions for repairing and maintenance of selected building materials**
Service life for materials and building components: ▪ **The right information is collected for maintenance into the building service manual (for cleaning and other maintenance)** ▪ **Moisture protection and check-up schedule for maintenance**

4.6 Use and maintenance

Use and maintenance phase is the longest period in the building: it will take decades. During this period, ageing of the materials in the building will lead to maintenance and repair needs. In a sustainable building also maintenance of materials and building components should be programmed. In proactive maintenance measures are made before any degradation can be visually seen. With this kind of maintenance large repairs can usually be avoided and maintenance costs remains on a reasonable level if materials and products are chosen right.

Decisions related to sustainability

During the use of building, maintenance needs correlates to material choices and quality of construction work. Decisions related to building materials are therefore done mostly in earlier phases.

CHECK AND ASK THE DESIGN TEAM TO DOCUMENT:
Material efficiency: ▪ **Observation of material ageing** ▪ **Maintenance of deteriorated materials** ▪ **Following instructions of maintenance book** ▪ **Using sustainable materials during maintenance and renovation**
Waste management ▪ **Recycling of waste** ▪ **Sorting of waste**

5. GUIDELINES FOR PROCUREMENT / FINLAND / ALL

1.1 Environmental aspects in the procurement process

In the building construction process it is important to ensure that the identified sustainability aspects are considered in all of the project phases. Especially it is necessary when moving from a project stage to another. In order to achieve the sustainability goals set for the project it is essential that owner's project requirements (OPR) and goals are defined and documented accurately throughout the project. After a successful project the final product, service or building operates as intended and corresponds to the OPR.

Procurements related to building construction are important decision making points from sustainability point of view: they are an effective instrument in promoting environmentally-friendly products and services and in encouraging eco-innovation, thus contributing to sustainable development. By using the purchasing power to choose environmentally friendly goods, services and works, we can make an important contribution to sustainable consumption and production.

In this chapter, some general guidelines and criteria examples will be represented for:

- purchasing building design (architects and designers) and construction (contractors and commissioning agents)
- purchasing building materials

The following guidelines are general and they must be considered case-specific. In addition, the national guidelines and legislation concerning procurements must be taken into account when planning criteria for sustainable procurements.

It must be underlined, that all the building materials must meet demands on structural safety, fire safety and stability of the building in the first place. After those requirements, come cost and material efficiency and other sustainability aspects of procurements.

In the procurement process, sustainability aspects can be included in (A) tenderer's suitability, (B) technical instructions (C), comparison criteria for tender or (D) contract clauses.

SUSTAINABILITY ASPECTS IN THE PROCUREMENT PROCESS

A) Tenderer's suitability
Sustainability aspects can relate to technical performance, education or professional competence of a tenderer.

B) Minimum criteria and technical instructions
Sustainability aspects, which concern for example the capacity, materials, ingredients, production, technic, transportation or packing of product, must be included in the technical instructions of purchase.

C) Comparison criteria
Sustainability aspects, which can be scored in the comparison of tenders

D) Contract clauses
Sustainability aspects, which contractor or service supplier must take into account when realizing the contract/performing the service.

1.2 European commission Green Public Procurement (GPP)

European commission has recognized *Green Public Procurement (GPP)* guidance as a good document to follow during the project phases. The EU GPP criteria are developed to facilitate the inclusion of green requirements in public tender documents. The criteria can be used also in private construction projects and procurement processes.

While the adopted EU GPP criteria aim to reach a good balance between environmental performance, cost considerations, market availability and ease of verification, procuring authorities may choose, according to their needs and ambition level, to include all or only certain requirements in their tender documents. The GPP contains the next issues[iv]:

- benefits and tools for sustainable procurement
- commitment to sustainable policy, definitions and goals
- priorities and criteria based to e.g. certification and eco-labelled products
- information, education, networking and follow-up measures to ensure project goal achievement
- procurement process and necessary legislative measures that should be fulfilled
- life cycle cost procurement business model and contacts to suppliers

- specifying the project case for invitation to tender and technical specifications to take into account the environmental impacts of purchased goods, works or services throughout their lifecycle
- specifications for tenderers green clean capability and sustainability measures and excluding the tenderers that do not fulfil the criteria
- contract conditions that encourage for clean tech solutions and evaluation of life cycle costs
- contract terms, follow up and possible corrective measures
- specific procurement measures for certain sectors such as construction sector

The GPP guidelines are general and the EU GPP process will to a large extent follow the structure of *the EU Ecolabel criteria*-setting procedure. It will provide stakeholders with the possibility to comment on the documents and the draft EU GPP criteria at several stages of the process. However, compared with the EU Ecolabel procedure, it will be shorter and will not involve the formal adoption of the criteria as a legal act.

5.1 Tenderer's suitability criteria

The tendering procedure for selecting the service supplier or contractor offers opportunities for improving the environmental performance of these services. The project architect, designers, contractors, commissioning agents should have knowledge in the best available sustainability practices. In the request for quotation (RFQ), the procurer can ask for the service supplier or contractor to prove his/her ability to manage the most important environmental impacts caused by the service or contract in question.

Environmental aspects can relate to technical performance, education or professional competence of a tenderer:

- Level of education (Bachelor of Engineering, Master of Science e.g.)
- LEED, BREEAM, Miljöbyggnad, energy efficiency or similar environmental or energy certification scheme qualification suitable for the project type
- Knowhow of certain project types (refurbishment, renovation, change of use) or building types (e.g. schools, warehouses etc.) or clean tech solutions such as solar power, LED illumination, heat-pumps, heat recovery processes etc. (listing of project experience to the offer with project information and own participation information)
- Technical capability (equipment or a software)
- Tenderer's environmental management policy or tool (e.g. ISO 14 001)

The ability to manage the most important environmental impacts caused by the service or contract in question must be proven by service supplier or contractor. Because, the sustainability aspects are case-specific, the selection criteria for the project team should include experience qualifications of certain project types and knowhow of clean tech solutions suitable for that certain project and area.

The specifications for sustainability such as certifications schemes and availability of sustainability professionals in the organisation for back up help can be used for all the cases. One way to ensure that the project team has enough understanding for sustainable solutions is to include a special advisor for the project team to take care of the sustainable development aspects follow-up.

SUSTAINABILITY ASPECTS IN THE PROCUREMENT PROCESS

A) Tenderer's suitability

Selection criteria example:

The contractor must prove its technical and professional capability to perform the sustainability aspects of the contract through:

- *an environmental management system (such as EMAS, ISO 14001 or equivalent, [insert other national or regional official systems]), or*
- *a BREEAM or LEED certification for the building*
- *an sustainability policy, work instructions and procedures for carrying out the service in an environmentally friendly way, or*
- *previous experience in applying sustainability management measures in similar contracts*

5.2 Minimum requirements and technical instructions of a purchase

A sustainable procurement means that the desired outcome is achieved with minimal amount of environmental impacts and the use of natural resources, energy and transport. A number of different indicators have been developed to measure the sustainability aspects of products and services and hence desired indicators and target levels should be determined at early stage of the procurement process. In a construction project the owner's sustainability requirements have to be documented explicitly in basis of design since the owner's project requirements (OPR) define ***the minimum requirements and technical instructions*** set for the target of purchase.

The target of purchase is here ***a designing service, contract service or a product and material of building.*** Sustainability aspects can relate to the capacity, materials, ingredients, conduct, production technic, transportation or packing of the target of purchase. If these aspects are set as minimum requirements of the target of purchase, the aspects must be included in the technical instructions of purchase. All the aspects must also be clear and measurable. If they are measurable, they can be verified and monitored by the byer. When defining sustainability requirements for a purchase it must be ensured that there are enough suppliers in the market, who can meet these requirements. If the procurer is not sure for that, he/she can carry out a market survey, where the supplier's ability to meet the requirements will be tested before the actual tendering process will begin.

SUSTAINABILITY ASPECTS IN THE PROCUREMENT PROCESS

B) Minimum criteria and technical instructions

Minimum criteria example for a service or contract in question:

The selected designer or contractor must compile a sustainability plan, where she/he describes how the ecological, social and economic sustainability will be promoted and the most environmental impact will be reduced in design / contract.

Minimum criteria example for a product or material in question:

Minimum criteria for products or material can be set for example by using the four sustainability indicators represented in Chapter 3 Sustainable materials and products. These indicators relate to:

- *Global warming potential – greenhouse gases (GWP)*
- *Material resources*
- *Hazardous substances*
- *Emissions to indoor climate*

In addition, the minimum criteria can concern:

- *Maintainability of product or material: How often the material or product is maintained? What are the maintaining requirements? → Will be defined in service instruction and in the period of guarantee of material or product.*
- *Reusability or recyclability of the product or material*
- *Selection of eco-labelled or recycled materials for [x] % of the total material requirement (TMR)*

5.3 Comparison criteria for tenders that fulfil the requirements of request for quotation (RFQ)

If the procurer has conducted a marketing study, and he/she is still not sure, if the suppliers in the market are able to meet the sustainability requirements for the target of purchase, the sustainability aspects can be set as comparison criteria for tenders. Comparison criteria for tenders must always relate to the target of purchase. The idea is that sustainability aspects related to the target of purchase will be scored in the comparison of tenders.

SUSTAINABILITY ASPECTS IN THE PROCUREMENT PROCESS

C) Comparison criteria

Comparison criteria example for the service or contract in question:

If not set as a minimum requirement:

Point can be given, if the selected designer or contractor can compile a Sustainability Plan, where she/he describes how the ecological, social and economic sustainability will be promoted and the most environmental impact will be reduced in design / contract.

Comparison criteria example for the product or material in question:

Comparison criteria for products or material can be set for example by using the four sustainability indicators represented in Chapter 3 Sustainable materials and products. These indicators relate to:

- *Global warming potential – greenhouse gases (GWP)*
- *Material resources*
- *Hazardous substances*
- *Emissions to indoor climate*

In the minimum requirements, there might be a minimum level for these indicators, and if the target of purchase will excel itself it will be scored according to the tables in Chapter 3.

In addition, points can be given if:

- *Calculation of life cycle impact (LCA) of the selected service or product is available*
- *Environmental product declaration (EPD) of a product is available. EPD is an independently verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of products.*

Sustainability aspects in the comparison criteria can relate to the capacity, materials, ingredients, conduct, production technic, transportation or packing of the target of purchase. In the minimum requirements, there might be a minimum level for these aspects, and if the target of purchase will excel itself it will be scored. When markets will develop and sustainability aspect will become more popular, the sustainability aspects in the comparison criteria can be moved to the minimum requirements.

Comparison criteria must be clear and measurable, like the minimum requirements of the target of purchase. Clear and measurable criteria will make the comparison of the tenders easier and ensure equal processing of tenders. Clear criteria will also prevent possible appealing processes. The points and scoring must be considered case by case.

Tenders can be evaluated according to costs or economically advantageousness. Criteria definition and tender valuation of tenders requires expertize from procurer as well and quality-costs ratio should reflect the basis of the owner’s project requirements. If the procurer makes purchase decision based on the economically advantageousness, European commission has recommended that the quality aspects/criteria should be considered with at least 60 % and the sustainability aspects/criteria should be 10-15 % of quality aspects.

5.4 Contract clauses

Contract clauses concern design services and contracts. In contract clauses the procurer should explicitly identify, how and when sustainability performance will be measured, reported and confirmed. The responsibilities and documentation method should be discussed clearly by which the desired features are verified. Very complicated clauses are difficult to confirm to be fulfilled. The contract clauses must be represented for the tenderers already in the request for quotation (RFQ) and discussed before project starts.

SUSTAINABILITY ASPECTS IN THE PROCUREMENT PROCESS

C) Contract clauses

Contract clauses example for the service or contract in question:

The selected designer or contractor must compile an Annual Sustainability Report, where she/he describes how the ecological, social and economic sustainability has been promoted and the most environmental impact has been reduced in design / contract. In contract clauses the procurer identifies, how and when sustainability performance will be measured, reported and confirmed.

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