Resource efficiency in the building sector

Final report

Client: DG Environment

Rotterdam, 23 May 2014

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Introduction

This report documents the evidence base developed to support the preparation of the European Commission's planned Sustainable Buildings Communication.

The Communication will provide strategic direction for developing a more sustainable buildings sector. This report uses a life cycle approach to the analysis of the current and future sustainability of the building sector. It provides a concrete basis for the problem formulation and objectives of the Communication, explores the scope of relevant existing policy and initiatives in the area of buildings and construction, identifies potential areas ripe for policy intervention, and describes the processes and outcomes of the public consultation on the selected policy options. The policy solutions and environmental and resource analysis in this report and the Sustainable Buildings Communication address the lifecycle environmental impacts of buildings, to complement existing initiatives related to energy consumption during the use phase of the building.

The assessment of the environmental performance of buildings was considered as a practical, achievable and viable avenue to pursue that would both facilitate the improvement of building sustainability and address existing market barriers to enhance business opportunity within the sustainable buildings industry.

This report was prepared for the European Commission by experts of Copenhagen Resource Institute, Ecorys and Triple E Consulting.

Executive summary

Resource use, efficiency and productivity of buildings

The first part of the report provides novel empirical evidence on resource use and consequent environmental impacts from buildings and assesses the significance of the policy problems related to resource use for sustainable buildings. In line with the contents of the Communication on Sustainable buildings under planning at the time of implementing this part of the study in late 2012 and early 2013, this project addresses residential, public and commercial buildings, but excludes industrial buildings.

In order to identify and prioritise areas where policy action could be used to increase the sustainability of buildings, an empirical overview and calculation of estimated resource use and associated environmental impacts from buildings was necessary. Cradle-to-gate LCA figures were used covering the resource extraction to final product (i.e. steel), since the future management of waste arising from materials used for buildings in present times is rather uncertain and therefore difficult to cover. Waste generation, land use, embodied and operational energy use, embodied and operational water use and biodiversity were also quantified to the extent possible. The LCA based calculations cover the following impact categories in details: abiotic depletion potential (ADP), global warming potential (GWP) and toxicity impacts. These three categories have been used to give a useful overall picture of sustainability, without overburdening the analysis with specific impacts within each category – particularly that of toxicity impacts[1]. We found that the use of materials for building construction represents a significant share of our total use of abiotic materials. Looking at the split of total aggregated impacts from the materials used in buildings, it is clear that steel, copper and aluminium dominate. We conclude that these three metals are collectively responsible for about 80% of all impacts stemming from the (cradle-to-gate) production of the studied materials, even despite the fact that benefits of recycling for these materials are included in the calculations.

We estimated that embodied energy in building products was around 1.9 Million TJ in 2011. Steel and aluminium together are responsible for approximately 51 % of the total embodied energy in building materials with concrete responsible for another approximately 17 % of the total embodied energy in building materials. In 2010, the operational energy in residential buildings was nearly 7 times the embodied energy in all newly produced building materials. However, in 2007, at the height of the building boom, this ratio was down to 4.5. This was due to the larger production volume (in 2007) and, thus, higher embodied energy, and not because of a lower energy use in buildings. The embodied energy in building products can also be compared with the total final energy consumption in the EU27, of which it made up 5.4% in 2006, or with the EU27 industry's final energy consumption, of which it made up 20% the same year.

Existing policies in Europe

The evidence on resource use and associated environmental impacts were complemented by an overview of European policies concerning resource efficiency in buildings in order to establish a baseline scenario.

[1] Please see section 2.3.3 for a more detailed description of the impact categories

It was found that there is already a comprehensive range of policies at EU and Member State level addressing energy efficiency in buildings. However, the promotion of sustainable buildings taking a broader view on environmental performance has not benefited from such prolonged policy action. In fact, there is far less focus on other life cycle impacts of buildings. Certain policies exist at both EU and Member State level that sometimes directly but more often indirectly influence the sustainability of buildings either by targeting building materials or as strategies encompassing the wider urban environment. Importantly, several initiatives point to the need of a lifecycle approach which incorporates a wider spectrum of resource uses and environmental impacts.

In relation to the current assessment and certification of environmental performance of buildings, it was found that the majority of the existing certification schemes are private and fall outside the traditional scope of "policy", although there is often a public-support element in their initial development in the verification/certification process or on-going aid and recognition. These schemes can however be used to broaden the concept of the environmental performance of buildings by including several life cycle stages and resource uses.

Current state of development of certification systems in Europe

The analysis showed that the market for the voluntary certification of the environmental performance of buildings in Europe consists of multiple competing commercial schemes, such as BREEAM, LEED, HQE and DGNB. Around 80% of the market of certified (mainly new) commercial buildings belongs to BREEAM. However, due to the differences in areas covered and indicators used in existing schemes, very little generated data is comparable across the EU. Even within a single scheme, it is often difficult to produce aggregated figures.

According to our estimates, there were approximately 0.04% of commercial buildings and 0.32% of residential buildings certified in Europe in 2013. However, these buildings are largely concentrated to a limited number of countries and there are several EU MS where voluntary certification schemes have not been developed yet, and which rely primarily on the mandatory EPC system implemented under the EPBD.

In particular, environmental certification of residential buildings is still lagging behind in most countries as it presents extra costs and complexity where specific efforts to meet the needs of the residential market have not been made. However, when specific efforts have been made, certification of residential buildings has been proven to be cost effective and attractive. In the case of France, 40% of residential buildings of private developers are certified.

Analysis of impacts – Business as usual scenario

Under the BAU scenario, we estimate that the share of environmentally certified commercial as well as residential buildings in Europe will slightly increase by 2020 and 2030, although the situation is not expected to improve much for the residential sector, which constitutes 75% of the total floor area in buildings in Europe. The energy efficiency of buildings is foreseen to improve, however, as the recast EPBD is expected to be fully implemented by 2020. Businesses investing in buildings with better environmental performance are expected to derive economic benefits related to decreased operating costs, increased building value, increased asset value and decreased payback time for green investments. While costs related to the actual certification of buildings are unlikely to change significantly in the future, the costs for environmental improvements are expected to slightly decrease due to economies of scale and more standardisation of green design and construction processes over time. SMEs in particular may encounter problems with the existence of several schemes and possibly varying legal requirements across borders and would therefore benefit from more coordination and streamlining between initiatives. With slow increase in number of environmentally certified buildings via different voluntary schemes, related social benefits and job creation are expected to continue to expand slowly. Similarly, environmental impacts are difficult to determine, but the opinion is that if the focus is only on energy efficiency, there is a clear risk of having buildings not necessarily performing very well with respect to other environmental criteria, such as water, waste, indoor air quality and embodied impacts. This is why it is considered important to use a multi-criteria approach when assessing the environmental performance of buildings.

Analysis of impacts – Voluntary framework scenario

To increase the number of environmentally assessed buildings and as such improve the environmental performance of buildings in Europe, assessment has to become more attractive and the benefits more obvious to the public. This would be supported by having an EU wide assessment framework with core indicators, which would allow for generation of reliable and comparable data. Different routes can be foreseen: the framework could be incorporated as a module in existing and future assessment schemes next to their larger sets of indicators and, if sufficiently wide in its scope, it could also be used on its own, in particular in countries where certification in general is low today. It could be an affordable solution initially for non-residential and later on for residential buildings, once experience has been gained. The development cost would be borne by the EU and the costs related to the running of the scheme by the Member States or their respective Green Building Councils. These costs will depend on the complexity of the scheme. The framework would have benefits for manufacturers of construction products, architects, builders, developers, investors and property owners (in terms of a more harmonised system and generation of comparable data to be used in decision making, decreased operating costs, increased asset value) and individual owners/ tenants (better quality of buildings). In particular, policy makers will be able to base decisions on better information and knowledge on resources use and environmental impacts along the life cycle. Costs related to certification and "greening" the buildings are expected to go down per building as more buildings are foreseen to be assessed. SMEs will be positively impacted as more guidance will be provided to stakeholders compared to the BAU. Similarly, it is expected that more jobs will be created compared to the BAU, both directly and indirectly. The environmental impact is difficult to determine quantitatively as it will depend on the content of the core indicators and how they will be used but it is foreseen that the framework will result in more life cycle impacts being taken into account to a larger extent than today.

Analysis of impacts – Mandatory framework scenario

A mandatory framework for the assessment of the environmental performance of buildings can be introduced for public buildings, which implies the introduction of core sustainability indicators. According to the public consultation, 70% of the respondents believe this is an effective or somewhat effective option. The use of a mandatory framework with a set of core indicators would increase the demand for sustainable buildings and at the same time provide a system to collect comparable data across the EU and an incentive for better environmental performance. The benefits of such a framework for companies active in the building sector could be important as these actors would benefit from an expanded market and substantially improved market information. Certificates, based on a set of core indicators to assess the environmental performance of buildings are seen as a powerful tool to create a demand-driven market for sustainable buildings, as they allow economic agents to estimate costs in relation to environmental performance. It is not expected that certification costs would significantly increase if additional "sustainable" core indicators would be introduced into the existing system. Innovation would be stimulated as a mandatory scheme would be an incentive for market players to innovate and thereby obtain a share of the market. A mandatory certification scheme to assess the environmental performance of public buildings is likely to have a modest effect on the number of additional jobs as i) more trainers are needed to upgrade existing assessors; ii) the number of buildings to be assessed is expected to increase by one percent per year; and iii) increased use of recycled materials has the potential to increase employment.

The introduction of a mandatory assessment scheme can have a positive effect on health and wellbeing. As the option is aimed at public buildings, the development and monitoring of the schemes by governments causes some administrative costs, but are expected to be modest. Similar to the voluntary option, the environmental impact is difficult to determine but would most likely exceed the improvements resulting from a voluntary approach.

1 Policy context

1.1 Europe 2020

Europe 2020 is a 10-year strategy proposed by the European Commission on March 3, 2010 with the aim of stabilizing the European economy after the global economic crisis and setting out a vision for Europe's social market economy for the 21st century[2]. The Europe 2020 agenda puts forward three mutually reinforcing priorities:

- **Smart growth:** developing an economy based on knowledge and innovation;
- **Sustainable growth:** promoting a more resource efficient, greener and more competitive economy;
- **Inclusive growth:** fostering a high-employment economy delivering social and territorial cohesion.

In order to define specific economic and social goals for the year 2020, the European Commission has proposed a number of EU headline targets which represent the three priorities of smart, sustainable and inclusive growth. The EU has put forward seven flagship initiatives to catalyse the progress for each of the headline target. As far as resource efficiency is concerned one of the seven flagship initiatives is of special interest.

1.2 Flagship Initiative 4: “Resource Efficient Europe”

The Commission’s Flagship initiative "Resource efficient Europe"[3], adopted by the European Commission in January 2011, aims to help decouple economic growth from the use of resources, support the shift towards a low carbon economy, increase the use of renewable energy sources, modernise the EU’s transport sector and promote energy efficiency. To accomplish these aims at EU level, the initiative aims to create a framework for action in key policy areas to:

1. boost economic performance while reducing resource use;
2. identify and create new opportunities for economic growth and greater innovation and boost the EU's competitiveness;
3. ensure security of supply of essential resources;
4. fight against climate change and limit the environmental impacts of resource use.

The Flagship calls for the development of several medium- and long-term measures in order to pursue the goals of the EU 2020 strategy. One of those initiatives most relevant to this study contract is the *Roadmap to a Resource Efficient Europe*, which was developed in the context of previous environmental and resource efficiency policies.

1.3 Roadmap for a Resource Efficient Europe

The Roadmap to a Resource Efficient Europe (RERM) was published in September 2011[4]. Building on all the previous policy work, the RERM sets out a vision for a resource efficient Europe by 2050 and outlines the practical steps to reach this vision, including actions at EU and Member State level. It is divided into three central action lines:

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[2] COM(2010) Final Communication from the Commission Europe 2020 A strategy for smart, sustainable and inclusive growth
[3] COM(2011) 21 A Resource-efficiency Europe – Flagship Initiative under the Europe 2020 Strategy
[4] COM(2011) Final Communication from the Commission: Roadmap to a Resource Efficient Europe

- Transforming the Economy;
- Addressing natural capital and ecosystems services;
- Tackling key sectors (food, buildings, mobility).

Buildings are highlighted as one of three key sectors to be addressed in the RERM. According to the RERM, better construction and use of buildings could help making significant resource savings: it could influence 42% of our final energy consumption and about 35% of our total GHG emissions, 50% of the extracted materials, and it could save up to 30% of water in some regions.

Energy efficiency and renewable energy use in buildings is covered extensively by existing policy at the EU level. However, these efforts need to be complemented with policies that promote resource efficiency, and to cover a broader range of impacts, taking into account the full lifecycle of buildings, from initial planning and manufacturing of construction products to final demolition and waste treatment and disposal. Improving the resource efficiency along the lifecycle of buildings will make the construction sector more competitive as well as reduce material use and environmental impacts associated with our built environment.

The RERM includes the following milestone for improving buildings[5]

By 2020 the renovation and construction of buildings and infrastructure will be made to high resource efficiency levels. The Life-cycle approach will be widely applied; all new buildings will be nearly zero-energy and highly material efficient and policies for renovating the existing building stock will be in place so that it is cost-efficiently refurbished at a rate of 2% per year. 70% of non-hazardous construction and demolition waste will be recycled.

In relation to improving the resource efficiency of buildings, the RERM states that the Commission, together with Member States, will:

- Assess how to support skills investment plans, apprentice schemes and communication on the best resource efficiency practices in the industry;
- Take measures, using an 'SME test' where appropriate, to stimulate demand and uptake of resource efficient building practices through life-cycle costing and suitable financing arrangements; to further widen the scope of the Eurocodes to design criteria related to sustainability; to develop incentives to reward resource efficient buildings, and to promote the sustainable use of wood in construction, (Communication on the sustainable competitiveness of the construction sector, 2011, **Communication on sustainable buildings, 2013**);
- Asses how best to encourage private sector innovation in construction.

[5] COM(2011) Final Communication from the Commission: Roadmap to a Resource Efficient Europe

2 Problem definition

2.1 Scope, limitations and definitions used

The purpose of this chapter is to provide an empirical overview **of resource use and consequent environmental impacts from buildings** and to provide the evidence and asses the significance of the policy problems related to **resource use and efficiency implications** on sustainable buildings. This is intended to broaden the evidence base on the priority areas of action, which will be carried forward to the assessment of potential policy instruments that could be used in these priority areas.

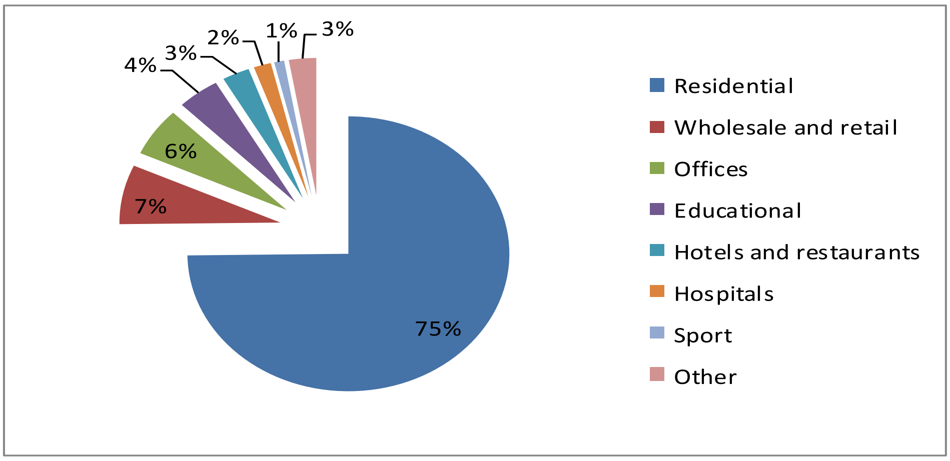
2.1.1 Residential, public and commercial buildings

In line with the contents of the Communication on Sustainable Buildings[6] under planning at the time of implementing this work in late-2012 and early-2013, **this project addresses residential, public and commercial buildings, but excludes industrial buildings.**

Industrial buildings represent less that 1% of total building stock in the EU and less than 11% of the total surface area. Moreover, their highly varied use and performance requirements make them less suitable for overarching policy options. Residential buildings include single-family houses, multi-family houses and high-rise buildings. Commercial buildings include office buildings, warehouses and retail. As the figures (Figure 2.1) below illustrates, **residential buildings make up to 75% of building stocks followed by wholesale and retail and office buildings.**

It is estimated that 12% of the building stock is public and 88% are private buildings.

Figure 2.1 Existing building stock in Europe (excluding industrial buildings)



Source: Ecorys, Ecofys and BioIntelligence (2010)[7].

2.1.2 Delineation of buildings from their environment

Furthermore, this project addresses buildings and their immediate surroundings, and as such **does not address urban, utility or infrastructure planning**.

[6] COM(2011) Final Communication from the Commission: Roadmap to a Resource Efficient Europe

[7] Ecorys, Ecofys and BioIntelligence (2010): Study to Support the Impact Assessment for the EU Energy Saving Action Plan.

2.1.3 *Buildings as part of construction*

The existing literature **and data sources do very rarely differentiate the building segment from construction in general**, which largely includes road construction (outside the scope of this study). Hence, many examples are available on construction rather than solely on buildings. **This study focuses exclusively on residential, public and commercial buildings, and as part of the study, deeper analysis was conducted to separate the data and effects of buildings from data and effects of construction** (including material extraction and production of building materials) **in general**.

2.1.4 *Type of resources*

This project considers the following resources primarily for the **total of the EU27 countries in terms of geographical coverage** (with some figures on other European countries as well):

- **Materials** – including metals, minerals, concrete and wood (timber) used in construction;
- **Energy (embodied) and related GHG emissions** – this is energy used linked to the extraction of materials, manufacturing of construction products, the construction phase itself, construction and demolition, but not energy used directly during the use-phase (see below);
- **Water** – this relates to the full cycle but primarily to water use in buildings. However, quantifications of embodied water have been excluded after thorough investigation of existing literature due to a high level of uncertainty with the figures;
- **Land** – with land we understand direct use of land (land take);
- **Biodiversity** impacts.

It is important to note, however, that the focus areas under this study **excludes the consumption of, and impacts from, energy consumption in the use phase of buildings lifecycle**. This is addressed by a range of other policy initiatives and studies. Hence the focus of this study is on other resource use during the full life cycle.

Although a wider examination of resource use and potential policy interventions is useful and valid in a wider context, within the context of the Sustainable Buildings communication the focus will be on buildings as the nexus of policy application.

2.1.5 *Resource efficiency*

In the context of this project, resource efficiency in general is understood as the broad principal concept aiming at using resources efficiently, sustainably and by minimizing impacts on environment as addressed by the RERM[8]:

> 'resource efficient development (…) allows the economy to create more with less, delivering greater value with less input, using resources in a sustainable way and minimising their impacts on the environment.'

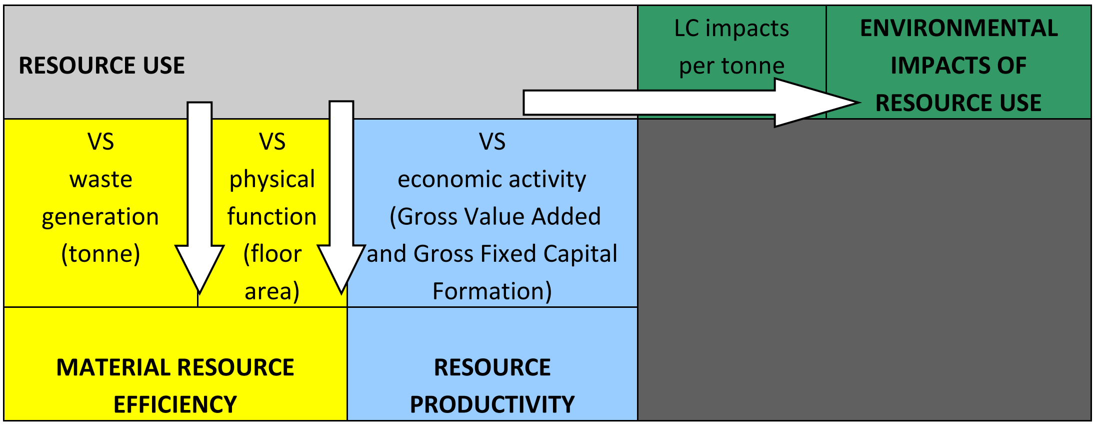
Resource efficiency in the context of moving towards more sustainable buildings is understood as the broad concept aiming to reduce resource use and limit the environmental impacts from buildings throughout their lifecycle - from material extraction for use in the construction phase, through resource use during occupancy and maintenance, to material recovery at demolition.

However, for the sake of this project the following terms – each understood as inherent characteristics of resource efficiency – shall be used consistently.

[8] COM(2011) Final Communication from the Commission: Roadmap to a Resource Efficient Europe

RESOURCE EFFICIENCY
Resource use – how much is used?
Material resource efficiency – how much resources are used for achieving the desired purpose?
Resource productivity – how much economic output is produced from certain resource inputs?
Environmental impacts of resource use – what are the environmental impacts associated with the use of resources?

In order to tackle the most important identified aspects of resource efficiency, the same logic is also applicable to create indicators:



Key variables for main indicators are therefore going to include the following:

- Resource and material use (tonne);
- Environmental impacts of resource use (cradle-to-gate life cycle impacts);
- Floor area (m^2) – as the basic service provided;
- Waste generation (tonne);
- Gross Value Added (GVA, million EUR) and Gross Fixed Capital Formation (GFCF, million EUR).

2.1.6 Resource use

Resource use associated with **buildings is firstly understood as the mass** (typically expressed via physical units) **of resource inputs** (i.e. tonnes of gravel extracted). Furthermore, it is also understood to cover any outputs posing a pressure on the natural sink functions (i.e. tonnes of GHG emissions, amount of waste generated). In this regard, the environmental impacts are excluded from this definition.

2.1.7 Material resource efficiency

Material resource efficiency is used in this report to **describe the efficiency of using materials and other resources**. This is typically the efficiency of resource input against the actual resource output extraction/waste) or resource input vs. a physical function provided (i.e. tonnes of material used (ending up in the building) per m^2 of floor space created.

As such this indicator is not directly linked with economic outputs and environmental impacts that are separated below.

2.1.8 Resource productivity

Resource productivity is defined as the **economic output from certain activities measured against the resource use associated**, for example GDP/Domestic Material Consumption or GVA/Domestic Extraction.

This term describes how much economic value is produced from a certain amount of resource use. This term is used on the one hand to create a link between economic and environmental aspects of resource use and on the other hand may in fact demonstrate that similar material (technical) resource efficiency as described under the previous point may result in different levels of economic value created.

2.1.9 Environmental impacts of resource use in different life-cycle stages of buildings

The lifecycle of buildings extends from the extraction of raw materials, through the construction and use phases to demolition and eventual waste disposal and/or reuse. Resources are used, and environmental impacts created, throughout the lifecycle of buildings. Environmental impacts of (any kind of) resource use is understood as the quantified or qualified impacts associated with the actual use of resources. The environmental impact of the use of material resources in buildings arises at various stages of the building life-cycle, from the impact associated with the material extraction, through to processing and production of construction products, transport, construction itself, the use of the building including renovation and maintenance and eventual demolition and reuse or disposal. Each of these stages has an associated environmental impact. Although, ideally, impacts should be described based on Life Cycle Analysis (LCA) information or complex modelling (e.g. climate change impacts of GHGs), often a best-available proxy might be the actual pressure (e.g. using total CO_2-equivalent emissions to quantify the impacts). We apply **cradle-to-gate LCA figures covering the resource extraction to final product** (steel, concrete, etc.), since the future management of waste arising from materials used for buildings in present times is rather uncertain and therefore difficult to cover.

2.2 Resource use, efficiency, productivity and environmental impacts

Methodology description

The overall purpose of this exercise is to provide the evidence for and asses the significance of the problems related to resource use and efficiency for (sustainable) buildings, excluding those associated with energy use in the use phase.

This is intended to broaden the evidence base on the priority areas discussed later in the paper, carried forward to the assessment of potential policy instruments that could be used in these priority areas.

In order to identify and prioritise areas where policy action could be used to increase the sustainability of buildings, **an empirical overview and calculation of estimated resource use and consequent environmental impacts from buildings as a basis is necessary.**

This task is to exploit existing knowledge base combined with own assessments for the life cycle impacts of buildings based on desk research and ad-hoc contact with expert stakeholders as appropriate for additional information and data, mainly in order to:

- Quantify the impacts based on information and data uncovered;
- Make qualified estimates to cover eventual knowledge gaps;
- Identify where in the life cycle and in what resources the impacts of buildings occur.

Our study is based on the relevant information from own prior work as well as international, European and national sources. Throughout the last few years and in preparation of the proposal for this report, the experts of CRI and Ecorys have already identified a large body of literature on the topic from which information and data has been used throughout the project implementation. Additional information and data sources and ad-hoc, informal contacts with expert stakeholders were also deemed necessary.

Initial scoping revealed the important resource flows related to buildings and the anticipated environmental impacts (excluding those related to energy in the use phase of buildings). Data availability on the resource use associated with buildings subject to this study is rather poor: there is little information regarding the use of materials in countries, and distinguishing between material used in “construction” and that used in “buildings”[9] relies on expert estimates rather than hard data.

Nevertheless different assumptions and figures fall within a reasonably close range based on data from:

- NAMEA (National Accounting Matrix with Environmental Accounts) and MFA (Material Flow Accounting) based estimations;
- Eurostat Prodcom statistics;
- Data from industry associations;
- LCA based information;
- and coefficients found in other literature and industry associations.

Between November 2012 and February 2013 the project team approached key stakeholders to supplement the publically available data sources on the use of materials and, in some cases, products, in the building industry. These included:

- Laia Perez Simbor, Copper Aliance;
- Francesco Biasioli, ERMCO;
- Karl Downey, CEMBUREAU;
- Christine Marlet, Eurogypsum;
- Bertrand Cazes, Glass for Europe;
- Agnes Schuurmans, Rockwool.

The following material streams together with LCA-based associated environmental impacts were completed and verified by different stakeholders:

- Aggregates (gravel, sand and crushed stone);
- Aluminium;
- Bricks;
- Clay;
- Concrete;
- Copper;
- Glass;
- Stone;
- Steel;
- Wood;
- Selected insulation materials (glasswool, rockwool, EPS).

Where possible, time series indicators are used to illustrate resource use in order to feed directly into the business-as-usual (BAU) scenario to be described. Our overview contains a profile on how

[9] Construction includes infrastructure and buildings. The study focuses on buildings alone.

the material use has changed over the last decade. The methodology for identifying impacts of resource consisted of the following steps:

- mapping annual material resources used in Europe (both construction and maintenance) for buildings;
- identification of per unit impacts (per kg) based on LCA inventory database and embodied energy figures of building materials;
- selection of main impact categories for further calculations;
- calculation of aggregated resource use impacts (with and without potential impacts of recycling) and embodied energy;
- comparison of results to estimated impacts from annual aggregated energy use of buildings, in order to verify our calculations with findings on buildings specific LCAs found in literature.

Quantifying the environmental impacts of buildings is a key objective of this activity, but it should be noted that these **impacts are a function of the environmental impacts from a unit of resource use and the quantity of the given resource[10] used.**

As such, the first step in the quantification process is to **assess the magnitude of resource flows** and the damage caused by unit resource use. Based on this, the environmental impacts can be deduced. Extensive data on both resource use in buildings (or more often "construction") and the environmental impacts of buildings (again, subject to different levels of aggregation) already exists.

As such, this exercise uses **existing sources, own calculations based on LCA databases and information gathered from various stakeholders** to provide a synthesis of the existing data with which to approach a cohesive illustration of the current state of resource use and environmental impacts associated with buildings. This can be used to identify which lifecycle stages and which resources are responsible for the most pressing environmental impacts.

A number of analytical methodologies have been used in past studies to assess environmental impacts and resource use, often approaching the problem from either a top down or bottom up perspective. For example, environmentally-extended input/output analysis (NAMEA) provides useful top down macro data on material flows within and between sectors in an economy, while Life Cycle Analysis (LCA) based data can provide bottom up information about the environmental impacts and resources used for a given product. In order to maximise the evidence base, this task requires a pragmatic approach and the use of the results of both analysis types to form a more comprehensive picture.

A variety of impacts are considered. The relative importance of the quantity of resource use is not only linked to the associated environmental impacts, but also to the amount of that resource available. This is generally evaluated by the project team to be of lesser importance when assessing buildings as none of the required materials that are used extensively are scarce. This is particularly true for materials like aggregates and the primary metals used in buildings.

However, renewable resources like timber and water, and non-renewable resources like land are evaluated in light of their availability. As these resources are not commodities in the traditional sense, and their use can be described as more or less local, it must be emphasised that the relative importance of these resources (in particular water and land) is highly dependent on local availability.

[10] As a first step, the total impacts will be calculated on the basis of 100% virgin material use for each resource. All resources, will, however, contain a certain fraction of recycled material. Uncertainty about the size of this fraction and the environmental impacts of the recycled material compared to the virgin material mean that adjusting total impacts based on recycled content would/will necessarily introduce and consider a higher level of uncertainty.

However, information about many of the impacts and resource use in buildings are not available as full time series, but only as one-off studies, LCA analyses with limited time series and/or limited geographical coverage. The following chapter presents our findings in details.

2.3 Results: resource use and its related environmental impacts

2.3.1 Material resource use

The material requirement of buildings currently represents one of the greatest resource use challenges **in terms of mass of resources used**. Even though this consumption does not always manifest itself in a direct and visible problem, issues like climate change, biodiversity loss, and desertification and soil erosion are all linked to extensive material use.

More than 30-50 % (different sources give different numbers) of total material use in Europe goes to housing[11] and mainly consists of iron, aluminium, copper, clay, sand, gravel, limestone, wood and building stone. Minerals have the highest share of all materials in buildings. Around 65% of total aggregates (sand, gravel and crushed rock) and approximately 20% of total metals are used by the construction sector.

Material flow accounts[12] shows a more or less stable total material use in the EU over the last ten years. Similarly, the consumption of construction minerals remained rather stable, with a slight increase during 2005 and 2008. Material productivity for the construction sector, measured as GDP in the construction sector/DMC construction minerals, has grown by 45% during the last ten years, to be compared with the overall material productivity which has grown by 30% during the same period.

The assumptions used to attribute the share of materials used for buildings subject to this study from data covering total material consumption of the construction sector are based mainly on estimations from various industry sources.

Table 2.1 shows the coefficients used for each material and the source for that coefficient.

Table 2.1 Estimated percentage of total construction materials used for buildings (residential, public and commercial, but excluding industrial)

Material	Materials used for buildings as % of total consumption	Primary data sources on total consumption	Assumptions
Aluminium	**25%**	PRODCOM	European Aluminium Association: 25% of Aluminium is used for construction of buildings.
Bricks	**70%**	PRODCOM	70% of bricks are used for buildings.
Clay	**70%**	PRODCOM	70% of clay used for buildings. This category includes clay not accounted for under bricks above.
Concrete	**75%**	PRODCOM	Cembureau Activity Report 2011: 75% of construction activity is for buildings. According to common practice, around 77% of concrete consists of aggregate materials. This

[11] EEA, 2010. SOER2010 Material resources and waste — SOER 2010 thematic assessment.

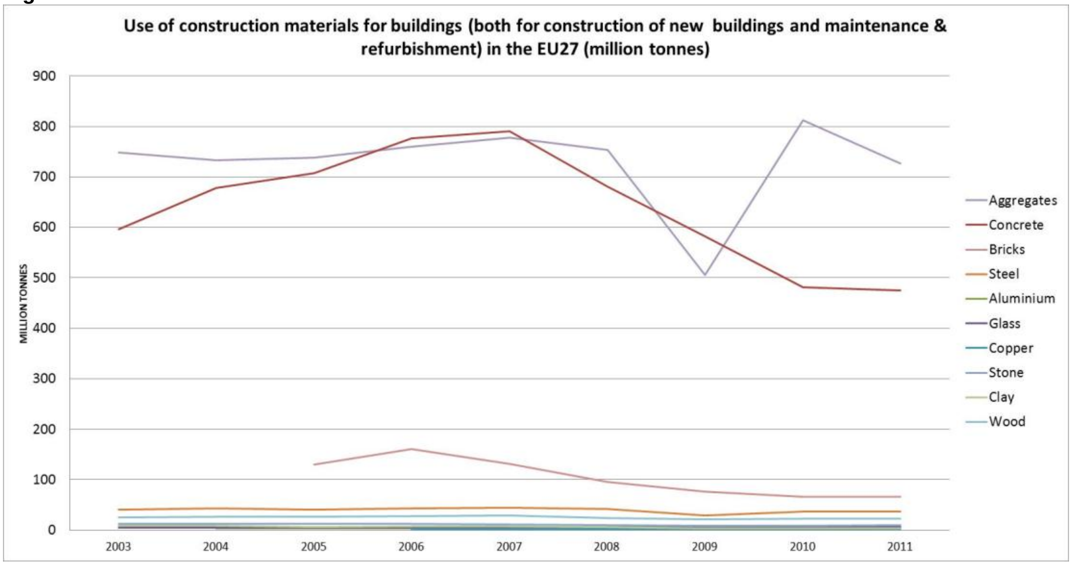
[12] http://epp.eurostat.ec.europa.eu/portal/page/portal/environmental_accounts/data/database

Material	Materials used for buildings as % of total consumption	Primary data sources on total consumption	Assumptions
			quantity is deducted from aggregate materials to avoid double counting.
Copper	**35%**	PRODCOM	Copper Alliance (personal communication): approximately 35% of copper used for building construction in 2011.
Glass	**65.5%**	PRODCOM and Glassforeurope	5.5 mil of 8.3 mil tonnes of flatglass in consumed in Europe for buildings that equals to 65.5%
Aggregate materials* *(sand, gravel and crushed stone)*	**65%**	PRODCOM	UEPG Report (2012) that 65% of aggregates are used in buildings. According to common practice, around 77% of concrete consists of aggregate materials. This quantity is deducted from aggregate materials to avoid double counting.
Stone	**34.5%**	OSYSSEE	According to TNO (2012) 46% of bulky materials are used in construction and according to CEMBUREAU 75% of construction used in buildings, therefore 34.5 % of stone used in buildings.
Steel	**21%**	PRODCOM	Steel in figures (EUROFER, 2011) - 28 % of steel used in construction. Cembureau 75% of construction is for buildings = 21 % of steel used in buildings. According EUROFER (personal) communication, 26% of steel is used for all buildings, including industrial buildings (outside our scope).
Wood	**37.5%**	FAOSTAT (Plywood + sawnwood (c) Sawnwood (NC)	47 % of sawnwood used in construction and 19 % in packaging. Assume that 50 % of both types used for construction. Cembureau 75% of construction used in buildings = 37.5 % wood used in buildings'.
Total figures on material use	**n.a.**	NAMEA and MFA	Used for crosschecking total aggregated figures and shares of materials in total.

Source: CRI estimations based on various sources and expert judgement.

The EU27 consumed between 1.200 - 1.800 Million tonnes of construction materials per annum for new buildings and refurbishment between 2003 and 2011. Figure 2.2 and Figure 2.3 illustrate the material composition of this total.

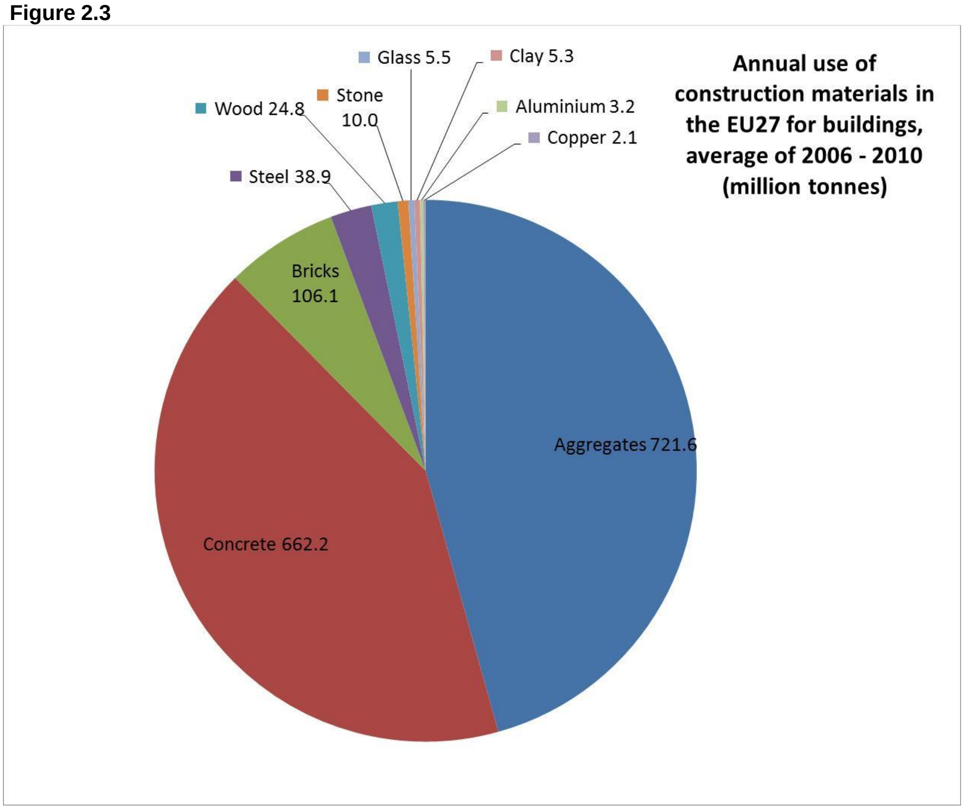
Figure 2.2



Source: CRI calculations.

Data and information collected on use of construction materials suggests that **concrete, aggregate materials (sand, gravel and crushed stone) and bricks make up to the 90% (by weight) of all materials used**.

Figure 2.3

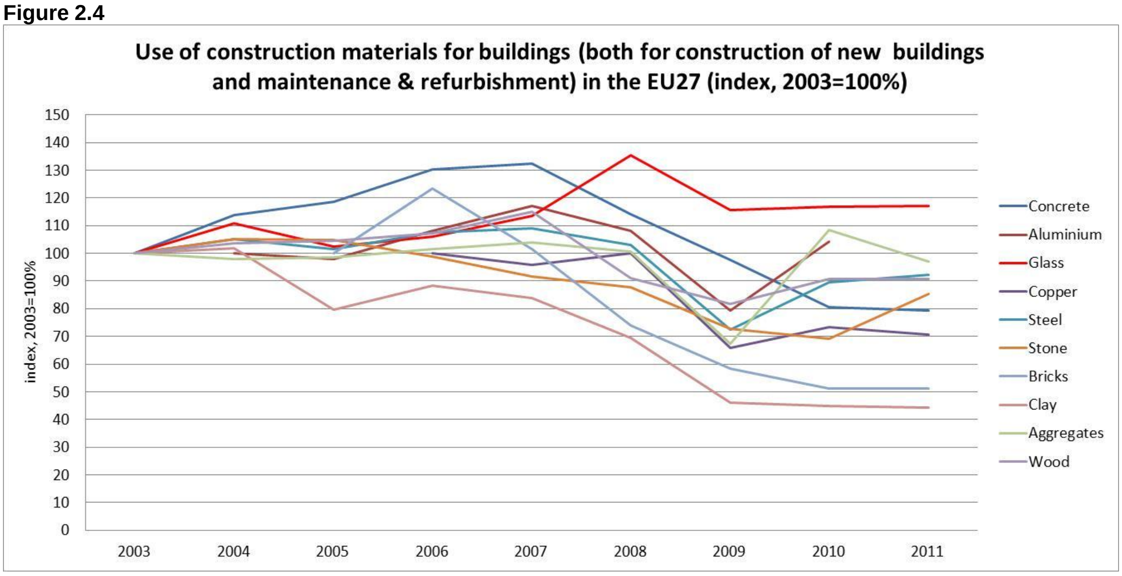


Source: CRI calculations.

The biggest fraction is **aggregate materials, which represent about 45% of the total materials by weight**, even when the amount of aggregates used in concrete are excluded. **Concrete, with 42% is the second next** fraction by weight, then **bricks with 6.7%**. The **largest metallic fraction is steel, which accounts for about 2.5% of materials use by weight**. Wood (timber) which is the largest biotic fraction, accounts for around 1.6% of material use. The rest of the materials (including copper, glass, aluminium, etc.) each make up to less than 1% of material use.

The indexed change in material use for buildings by material between 2003 and 2011 is illustrated in Figure 2.4. While there is no clear pattern to be observed, the economic crisis from 2008 onwards had a dramatic impact on the sector and caused a reduction in the consumption of materials.

Figure 2.4

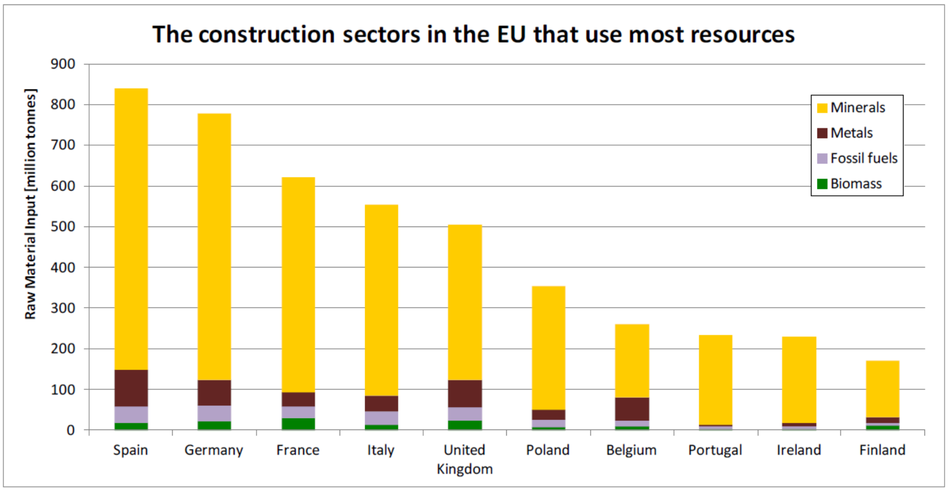


Source: CRI calculations.

Differences between EU Member States

Data on **use of materials for buildings in various Member States is not directly available**. Therefore, in order to demonstrate the difference between EU Member States in terms of **total use of resources as construction materials**, we provide figures on raw material inputs based on a recent report (BIO IS, 2013). The data from 2007 (recorded just before the burst of the housing bubble from 2008) suggest that countries that use the most material resources as construction materials are the **most populated countries**, such as Spain, Germany, France, Italy, the United Kingdom and Poland.

Figure 2.5



Source: BIO IS, 2013[13].

[13] BIO Intelligence Servie (2013) Sectoral Resource Maps.

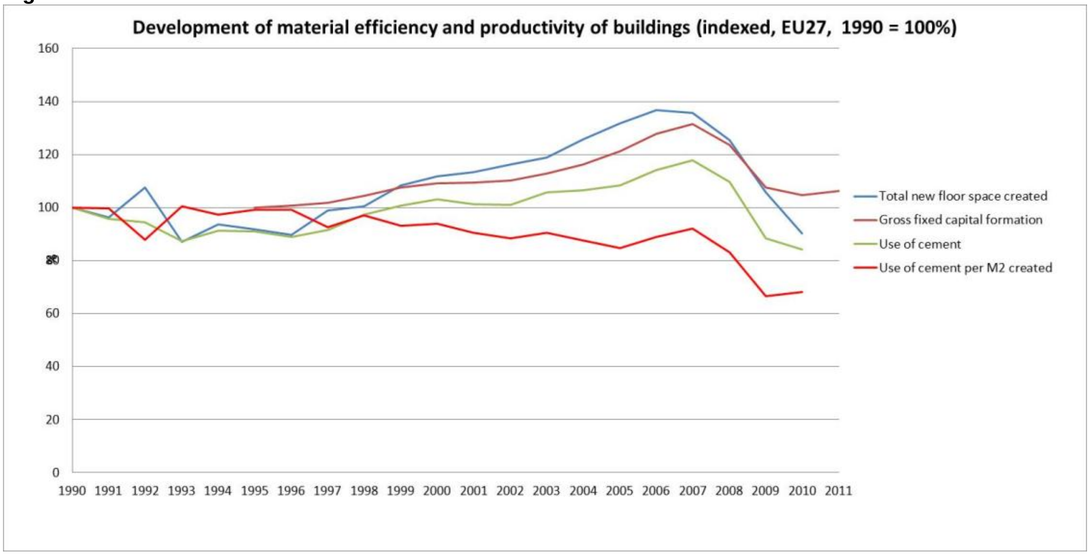
2.3.2 *Material efficiency and productivity of resource use*

In order to estimate the physical volume of building activities with longer time series than those available for the construction materials, **data on production of cement were selected as the best available proxy indicator**. International trade in cement is very limited, therefore production is used directly in the country. It was found that this indicator correlates with the use of concrete, the material used in highest volume (in terms of weight) but for which data is only available for a shorter time period.

The use of cement is compared to new floor space in order to estimate whether material use has been decoupled from the actual function (floor space) buildings are to provide. Figure 2.6 illustrates that after an initial period (1998-2007) of relative decoupling between resource use (cement) and function provided (new floor area), the trend changed dramatically from 2008. This change, due to the economic recession, **suggests a 25% drop in use of materials per m2 created between 2007 and 2009. Taken at face value, this would appear to be a significant improvement in terms of resource efficiency**.

However, there are some factors specific to the construction of buildings that could also influence this trend. For example, the statistics used in this analysis register buildings once they are finished, and the construction of buildings typically span two or more years, with the materially intensive part of the construction (at least in terms of cement) completed first. This would suggest that the post-2007 drop in cement per m2 could be attributed to the reduction in the commissioning of new building projects (so starting fewer of the materially intensive constructions), while at the same time as completing existing building projects (for which the materially intensive part of the construction had already been completed). In addition to this, many building projects (particularly in countries particularly exposed to the housing bubble) stalled in 2007-2008, once the construction of the materially intensive base structure was complete. Finishing of these building projects in later years would demand, therefore, fewer resources than an entire new building.

Figure 2.6



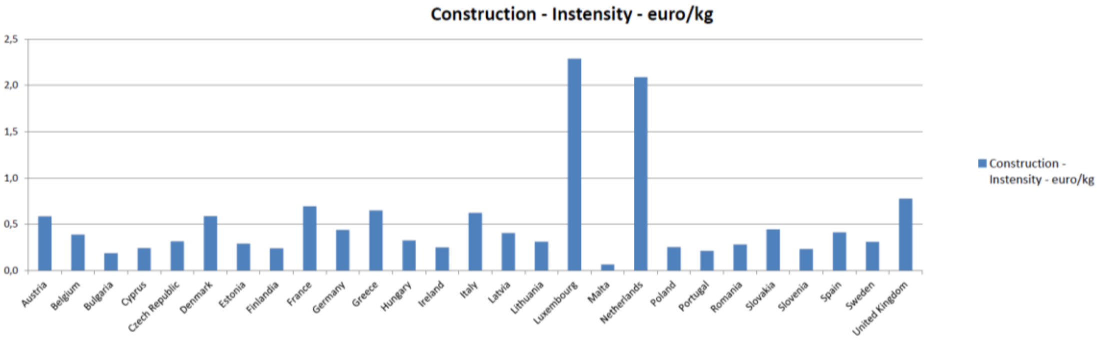
Source: CRI calculations.

In terms of **resource productivity (resource use vs. economic outputs), there has been a slight relative decoupling** between 1990 and 2010. This, however, will probably have been influenced by the housing boom of the early 2000's, when real estate prices increased quickly. Completion of stalled projects could also help explain the stabilisation and slight recovery in Gross Fixed Capital Formation in 2010 and 2011, while Member State initiatives to support the construction industry through public commissions could also play a role. However, we have no evidence to verify this hypothesis.

Differences between EU Member States

Again, data on productivity across Member States is not available on buildings, but in total construction activities only. Figure 2.7 illustrates the intensity of production (euro per kg) for the EU Member States, based on data from 2007. Luxembourg and The Netherlands stand out; this is primarily due to the high intensity (EURO/kg) of non-metallic minerals in these two countries..

Figure 2.7



Source: DG ENV F1 based on BIO IS, 2013[14].

2.3.3 *Per unit environmental impacts of construction materials*

We use so called **mid-point impact categories**, or a problem-oriented approach that translates impacts into **environmental themes such as climate change, acidification, human toxicity, etc**. The impacts taken into account cover the following categories as a starting point for a selection of mid-point impact categories, for our more detailed calculations:

- greenhouse gas emissions (CO_2, CH_4 and N2O);
- acidifying substances (SO_2, NOx and NH_3);
- toxicity impacts of substances on freshwater and terrestric ecosystems and humans, covering a number of emissions (NOx, HCB, Pb, Hg, Ni, Cu, As, Cd, Zn, SOx, NH_3, Se, Cr, dioxins, NMVOC, PAH and PM10);
- photochemical oxidants (including CO, SOx, CH_4 and NMVOC emissions to air) creating ozone;
- abiotic depletion describing the decrease of availability of total reserve functions of resources: the more abundant a material is (like sand or gravel), the lower its contribution to depletion compared to reserves;
- emissions causing ozone layer depletion mainly by photodissociation of man-made halocarbons (CFCs, freons, halons);
- radioactive radiation.

The selection of impact categories depends on the purpose of the LCA, e.g. what kind of decision is going to be taken based on the LCA. Obviously, the choice also depends on the type of application of the LCA. Basically, **selection of impact categories is a matter of choice** and no methodology includes specific guidelines on which impact categories have to be included in LCA.

Figure 2.8 illustrates the different impacts of the studied materials **expressed as percentage (%) of the total global impact (in reference year 1990)** in the respective impact category associated with **cradle-to-gate production of 1 kg material**.

[14] BIO Intelligence Servie (2013) Sectoral Resource Maps.

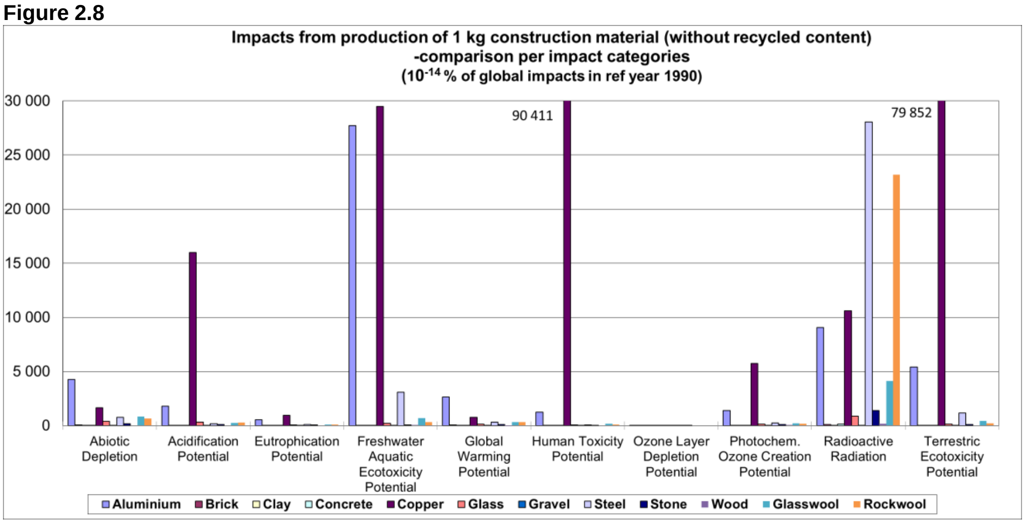
Please note: t**hese values are per unit, and do not represent the total impacts of building construction**.

The numbers shown are **based on the Gabi Professional LCA Database** and are related to the **production of building materials and products**, meaning **cradle-to-gate impacts** both for the construction of **new buildings and also refurbishment and maintenance operations of existing buildings**.

Furthermore, these figures account for production **only from primary raw materials, without any recycled content.**

For aggregate materials, impacts from gravel are used as a proxy for materials.

Figure 2.8



Source: CRI calculations – based on GaBi Professional Database.

These figures are based on standard characterization factors such as global warming potential (GWP) measured in CO_2-equivalents. Characterisation can be extended further, by normalizing the resulting impact values relative to an external benchmark. In our approach, the external benchmark is selected as the total global impact (in reference year 1990) in each impact category. This process aims at **assigning importance** to the impacts **compared to a benchmark** and allows for **all impact categories to have the same unit, i.e. % of global impacts measured in a reference year** (1990 in this case). Please note that this approach, by design, treats all impact categories as equally important.

Based on the information presented in preceding sections covering resource use and per unit impacts, we have selected three impact categories for further examination:

- A combined **Toxicity Potential** (TP):
  - An average of human, freshwater aquatic and terrestric eco-toxicity potential.
- **Abiotic depletion potential** (ADP):
  - Due to the high level of material use and significant impacts for some materials.
- **Global Warming Potential** (GWP):
  - As this is well understood, high on the policy agenda and has a measurable impact per unit.

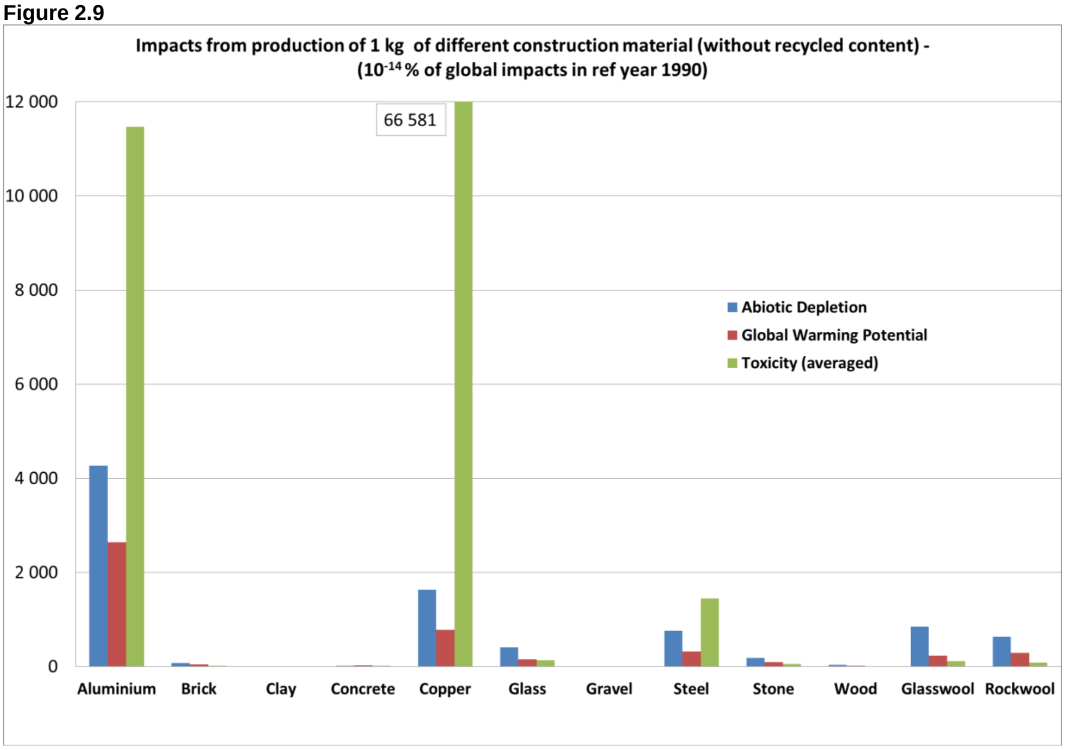
Other impact categories have been **excluded** from the following analysis:

- **Acidification potential** and **ozone creation potential** are only mildly significant for copper, which is used in very small quantities;

- Although it has a relatively high per unit impact, **radioactive radiation** is excluded from further calculations. This is because it is mainly related to the mix of primary energy sources used to generate the energy need for the production of materials. Embodied energy is discussed separately.

Figure 2.9 examines the impact categories selected above – GWP, ADP and averaged TP – for the building materials for which data was available. Copper stands out in terms of toxicity followed by aluminium and steel – again, all in terms of per kg impacts of building materials.

Figure 2.9



Source: CRI calculations– based on GaBi Professional Database.

Two typical **insulation materials (glasswool and rockwool)** are also presented. These have a moderately high per unit (kg) impacts compared to the construction materials presented. Nevertheless, these are used in a very low quantity compared to the rest of the materials. **Exact consumption figures were not found** for these insulation materials after thorough investigation. Data acquired directly from the insulation manufacturing industry for 2004 for some insulation materials suggest that these materials represent less than 2 % of the total weight of materials in buildings.

Potential trade-offs between the increased environmental burden associated with the production of insulation materials and the energy saving benefits they deliver **are discussed under the section on embodied energy**.

2.3.4 Methodological limitations

This study is subject to a number of methodological limitations, primarily related to an absence of data:

- Lack of time series for LCA data that could capture the improvements in production efficiency (reduction of per unit impacts) of different construction materials;

- Lack of data on the recycled content of different construction materials at the EU level;
- Analysis covers cradle-to-gate rather than full life-cycle of materials (although recycling is included in the analysis, see below).

Based on the assumption of improvements in both domains, the first two factors might lead to an overestimation of the environmental impacts from the production of these materials as presented. The third factor leads to an underestimation of the "total" impacts from buildings.

In addition, another important limitation in terms of policy application is distinguishing between materials used for the production of new buildings and those used for refurbishment and maintenance. CEMBUREAU[15] estimates that approximately half of the expenditure on cement was used for refurbishment and maintenance. However, this economic figure is difficult to translate into a volume of the different construction materials.

The following sections attempt to describe the potential significance of this problem while quantifying the impacts.

Improvement in production technology

Life Cycle Assessment (LCA) data are based on Life Cycle Inventory (LCI) information quantifying each process' exchanges with the environment (emissions to air, soil, water and waste generation). These emissions are then translated into environmental impacts with the help of impact assessment methodologies.

LCI information is updated very rarely, therefore the data for many processes are outdated. This is because the collection of LCI data is very time consuming, expensive and is hindered by the reluctance of industry to reveal confidential information. Therefore, **the technological advancements within industry are not encompassed by the LCIs** which can lead to an overestimation of environmental impacts (e.g. industries are generally becoming more energy efficient) over time. Within the framework of this project, one could expect that building **materials production** (especially of metals) technologies **are becoming less damaging per unit** in general through increased efficiency due to improved energy efficiency and increased use of secondary materials.

However, the efficiency increase, although quantitatively unknown in details, **is not expected to influence the prioritisation of focus materials for policy analysis** as the changes are not large enough to cover the differences among the materials. For example, the JRC estimated that the CO_2 intensity of steel production will be improved (reduced) by 16% between 2010 and 2030[16] that **corresponds to a 0.75% efficiency improvement per year**. In a similar study, JRC estimated **the annual improvement of CO_2 intensity to be ca. 0.85% for cement production[17]**. This technological advance potential is, however, difficult to generalize and to extend to the production of other construction materials.

Environmental benefits of recycling

Recycling has a positive influence on the production of materials as the production from waste (or scrap) is less burdening for the environment. Increasing recycling rates, for some materials in particular, substantially decrease the environmental impacts from their production regardless of the development in their total consumption by the construction industry.

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15 CEMBUREAU Activity Report 2011 (http://www.cembureau.eu/activity-reports).

16 N. Pardo, J.A. Moya, K. Vatopoulos, 2012. Prospective Scenarios on Energy Efficiency and CO_2 Emissions in the EU Iron & Steel Industry. JRC, 2012.

17 J.A. Moya, N. Pardo, A. Mercier, 2012. Energy Efficiency and CO_2 Emissions: Prospective Scenarios for the Cement Industry. JRC, 2012.

However, the percentage of recycled material used is not sufficiently known. ICE V2.0[18] from the University of Bath provides with some world average figures for the recycled content in some construction materials. The recycled content, as estimated by ICE V2.0, is 59 %, 33 % and 37 % for steel, aluminium and copper in general respectively which are the most important metals if impacts and overall volume in the EU are taken into account.

Table 2.2 Estimated recycled content of construction metals

Material	Recycled content
Aluminium	33%
Copper	37%
Low-alloyed Steel	59%

Source: ICE V2.0.

Concrete, bricks and other bulky materials contain little or no recycled material (in the case of concrete recycling can only contribute to the aggregates in the concrete, but not in the cement production which is responsible for the bulk of the impacts). Therefore, it is only the metals that are expected to contain substantial amounts of recycled material.

As shown in several life cycle assessments, using recycled materials have a much lower environmental impact than using virgin raw materials, especially metals. One of the most widely applied approaches is to account for the CO_2 equivalent greenhouse gas emissions associated with production using virgin raw materials to those using recycled materials. In case of energy-intensive processes, **this is often a very accurate proxy for the overall environmental impacts.**

In order to take the benefits of recycling into account, we apply figures found in the Ecolizer 2.0[19] design tool based on the Eco-indicator '99 methodology[20], where the environmental impacts are measured in milli-eco-points (mPt) of 1kg primary and secondary product. The difference between the impacts of primary and secondary production routes can be significant, as illustrated in the table below.

Table 2.3 Environmental benefits of recycling (measured in eco-points according to the Eco-Indicator '99 methodology)

	Primary (mPt /kg)	Secondary (mPt/kg)	impacts of secondary as % of impacts from primary
Aluminium	1045	134 (from old scrap) 45 (from new scrap) 89 (on average 50%-50% old and new scrap)	12.82% 4.31% **8.52%**
Copper	774	76	**9.82%**
Low-alloyed steel	231 (converter)	195 (average)	**84.42%**

Source: Ecolizer 2.0.

Cradle-to-gate not full lifecycle

Another limitation of cradle-to-gate information is that it **excludes impacts from the transportation of materials** from gate to the building sites, **construction activities** and **waste**

18 University of Bath. Inventory of Carbon and Energy (ICE) Version 2.0 http://www.circularecology.com/ice-database.html#.U0UQczbCTcs.

19 OVAM Ecolizer 2.0 Ecodesign Tool http://www.ecodesignlink.be/images/filelib/EcolizerEN_1180.pdf.

20 Pre Consultants, Eco-indicator 99. Manual for Designers.

management after demolition of buildings. Nevertheless, the impacts from these activities are minor compared to the cradle-to-gate impacts and of course the impacts from the use phase of buildings, primarily stemming from operational energy consumption. Regarding the construction activities, the IMPRO[21] study found that ***"the minor relevance of the construction operation has been justified in several studies and the operation of construction generally does not exceed 2% of the life cycle impacts"*** and therefore the construction operation can reasonably be neglected even for complete LCAs on buildings.

The transport of bulky aggregate materials constitutes a significant proportion of the total cost, making it uneconomic to transport aggregates over long distances, consequently limiting its attribution to the overall life cycle of building materials. Transport costs in the extraction sector account for around 13 % of total costs, which makes it **uneconomic to transport the materials further than around 35–50 kilometres** (dependent on diesel prices)[22].

The end-of life impacts (demolition and waste management) account for only -1.3 to 2.7% of the environmental impacts as found by the IMPRO study[23].

2.3.5 *Estimated impacts of material resource use*

The impacts presented in the following sections include the effects of recycled content and estimated environmental benefits of recycling. I**t is not possible to distinguish the benefits of recycling between the individual impact categories**, and the average improvement potential calculated from the figures for the various materials are used universally across impact categories. These figures also illustrate the relative importance of construction materials in terms of their overall environmental impacts when both their volume of use and their relative environmental impacts are taken into account.

The graphs are expressed as impacts stemming from the **cradle-to-gate production of materials** used for construction and maintenance of buildings **as a percentage of global impacts measured in reference year 1990 - as they are recorded in the GaBi Professional Database**.

Global Warming Potential

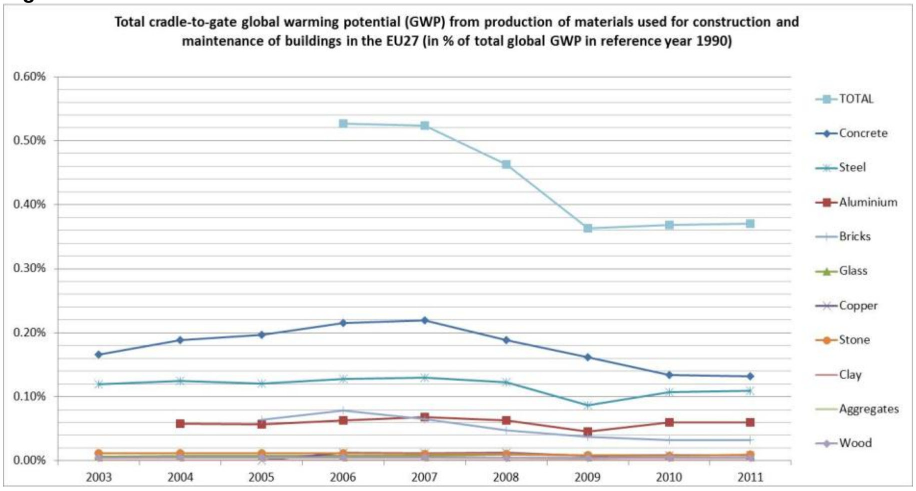
The results of our calculations (Figure 2.10) suggest, that the **total GWP impacts from the cradle-to-gate production of the materials used for buildings in the EU27 make up 0.35 - 0.50% of the global annual GWP impacts.** This comes in the form of the emission of various GHG gases. The reference emission for 1990, according to GaBi professional database, was **44 508 Million tonne CO_2-eq.**

[21] Nemry and Uihlein, 2008. Environmental Improvement Potentials of Residential Buildings (IMPRO-Building). JRC EC, 2008.

[22] EEA, 2008. Effectiveness of environmental taxes and charges for managing sand, gravel and rock extraction in selected EU countries.

[23] Nemry and Uihlein, 2008. Environmental Improvement Potentials of Residential Buildings (IMPRO-Building). JRC EC, 2008.

Figure 2.10



Source: CRI calculations.

These annual emissions from the (cradle-to-gate) production of the construction materials used for buildings included in the study altogether **correspond to about an annual emission of 155.76 – 222.53 Mt CO_2 equivalent, that is approximately 3 - 4.7 % of the GHG emissions of the EU27 in the last decade.** These figures can be compared to the annual emissions of Belgium (138.48 Mt CO_2-eq. in 2010) or The Netherlands (217.82 Mt CO_2-eq. in 2010)[24].

The production of concrete is responsible for close to one third of all total GWP impacts from building construction materials, while impacts from steel, aluminium and bricks are also significant.

It is also worth to note that, despite aggregate materials representing the largest fraction of materials in terms of use by weight (see Figure 2.2), **their total GWP impacts are negligible compared** to concrete and metals. This is also true for the ADP and TP impacts associated with aggregate materials.

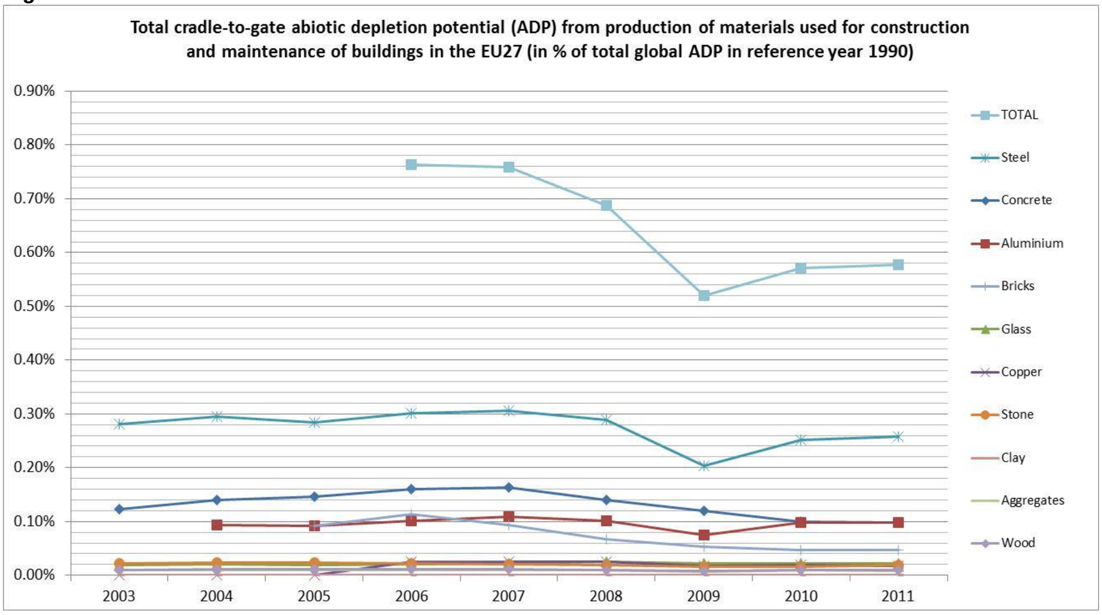
Abiotic Depletion Potential

Abiotic depletion potential (ADP) **describes the decrease of availability of total reserve functions** of resources. As the **construction materials are rather abundant materials**, their relative (per weight) ADP is also low, given the vast reserves these resources have.

The following figure on the other hand illustrates that, despite the low relative ADP of most building materials due to the high volume of use in the EU27, the total abiotic depletion potential **constitutes about 0.52-0.76% of the global annual ADP** (compared to reference year 1990).

[24] EEA, 2012. Annual European Union greenhouse gas inventory 1990–2010 and inventory report 2012 Submission to the UNFCCC Secretariat. EEA Technical Report 3/2012.

Figure 2.11



Source: CRI calculations.

The most impacting materials in this category are steel, aluminium, concrete and bricks. However, because known reserves also change over time and these **materials have no immediate scarcity implications in the short term,** the above figures for ADP **should not be understood as a tangible impact like GWP or Toxicity Potential**.

For example steel, the most critical material in terms of AD, is produced from iron. It is estimated that worldwide there are 800 billion tons of iron ore resources, containing more than 230 billion tons of iron[25]. According to estimates[26], currently known reserves (i.e. resources which could be economically extracted or produced at current conditions) are projected to last for about 75 years (McKinsey, 2011). Altogether, around 50 countries worldwide produce (extract) iron ore. Furthermore, iron ores are rather high grade compared to other ores, the average ore grade of the major producers is around 62-66%.

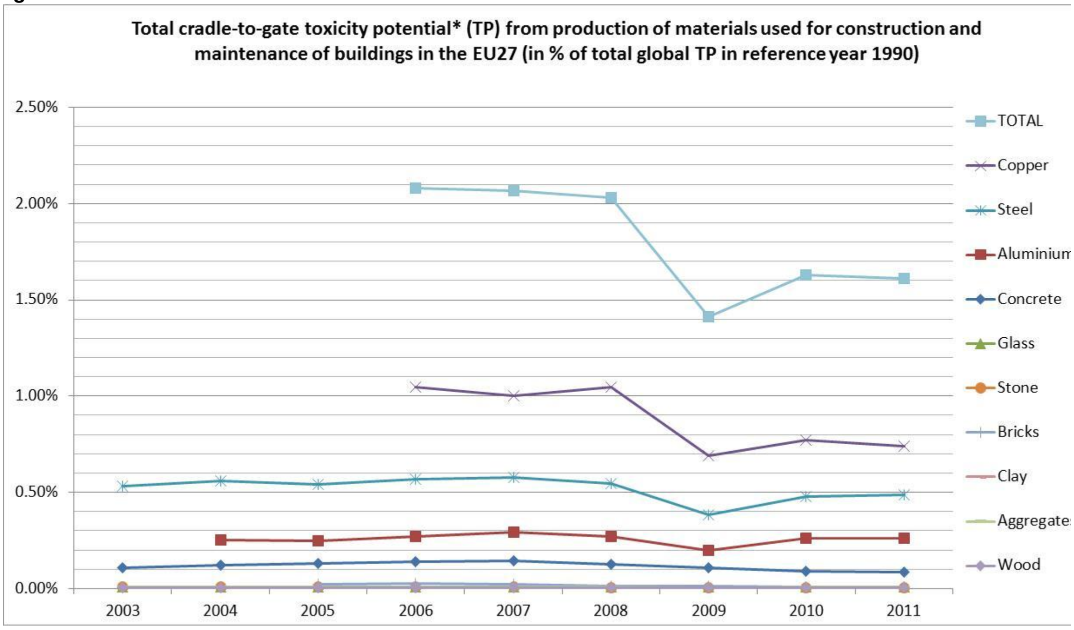
Toxicity Potential

Impacts from three toxicity impact categories (human, freshwater aquatic and terrestric ecotoxicity potential) were assigned equal importance and equal weighting in the following calculation. This impact category includes toxicity impacts of substances on freshwater and terrrestric ecosystems and humans, covering a number of emissions such as NOx, HCB, Pb, Hg, Ni, Cu, As, Cd, Zn, SOx, NH_3, Se, Cr, dioxins, NMVOC, PAH and PM_{10}.

25 Minerals Education Coalition (MEC) http://www.mineralseducationcoalition.org/minerals/iron.

26 McKinsey Global Institution (2011). Resource Revolution: Meeting the world's energy, materials, food and water needs.

Figure 2.12



Note: based on equal waiting of the following 3 toxicity potentials: Freshwater Aquatic, Human Toxicity and Terrestric Ecotoxicity Potential.
Source: CRI calculations.

The production of materials used for buildings in the EU27 is responsible for approximately **1.4 - 2.05% of the global emissions with toxicity potential.** This suggests a **rather high environmental burden** in terms of toxicity potential. This is primarily associated with the most impacting materials, namely **copper**, **steel**, **aluminium** and **concrete**.

2.3.6 *Comparison of impacts from production of materials and impacts from annual energy consumption of buildings*

Our calculations present the cradle-to-gate impacts associated with the production of building materials. Impacts in the use phase of buildings primarily arise from energy consumption for heating, hot water generation and electricity. It is useful to compare the impacts from use of resources in the construction of buildings with the impacts from energy use during building occupation. This provides an indication of the relative importance of the impacts from material consumption for building construction.

In order to achieve this, we calculated the **annual operational energy use of residential buildings, and from this, the impacts in the three selected impact categories.** This was done based on an average EU electricity mix and assuming that all heating in Europe is produced from natural gas.

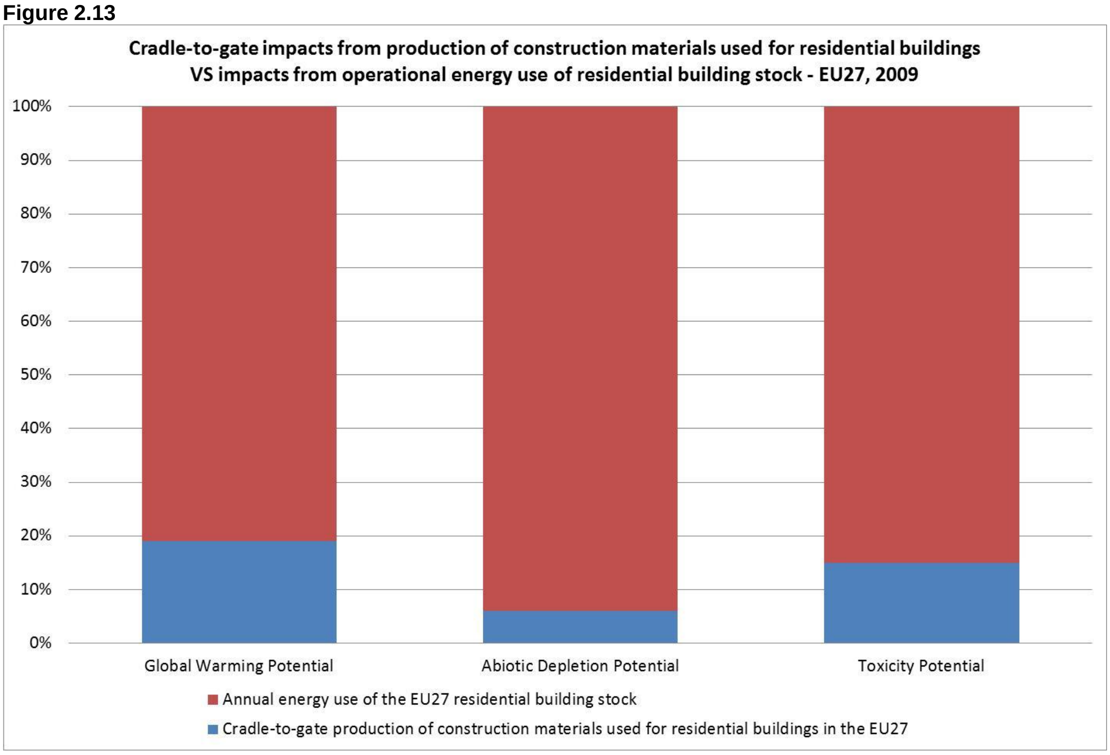
We present the numbers for 2009 showing the split of annual impacts stemming from production of building materials for *residential buildings* (we used the split in the building stock illustrated in Figure 1 to adjust the total impacts from all buildings in figures 10, 11 and 12) with the estimated impacts of annual energy use (in use phase) of residential buildings.

The exact energy mix of heating infrastructure is rather different between the EU countries and natural gas provides only 46%[27] of the energy used for heating. As such, the impacts stemming from operational energy use **are potentially underestimated** since these figures assume 100 %

[27] 2010 data - source: Odyssee.

heating from natural gas, which amongst the cleanest sources of energy carriers currently used for heating. However, we use it **as a best available proxy**.

Figure 2.13



Source: CRI calculations.

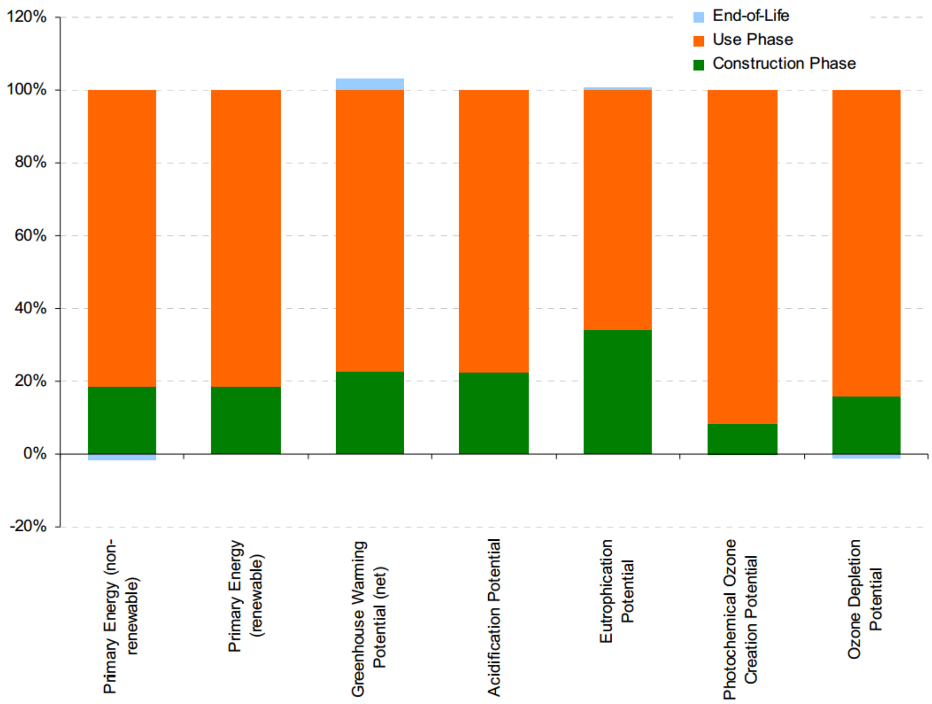
Nevertheless these figures based on aggregated resource use figures correspond approximately with findings from LCAs on buildings: around 80 % of GPW, 95 % of ADP and around 85 % of TP occurs during the occupation of buildings.

Figure 2.14 below shows the LCA-based results of the IMPRO study[28] illustrating the share of environmental impacts in different impact categories occurring in the construction phase (including material extraction and production of building materials for the building) and in the use phase (including energy use but also use of materials for refurbishment and maintenance operations), and finally at the end-of-life stage for residential buildings.

It must be noted here, that **our calculations based on aggregated resource use** (Figure 2.13) **do not account for the end-of-life impacts of buildings or the impacts of transportation** that are included in Figure 2.14. However, these impacts are rather low compared to other stages of the life cycle.

[28] Nemry and Uihlein, 2008. Environmental Improvement Potentials of Residential Buildings (IMPRO-Building). JRC EC, 2008.

Figure 2.14 LCA impacts of residential buildings



Source: Nemry and Uihlein (2008). Environmental Improvement Potentials of Residential Buildings (IMPRO-Building).

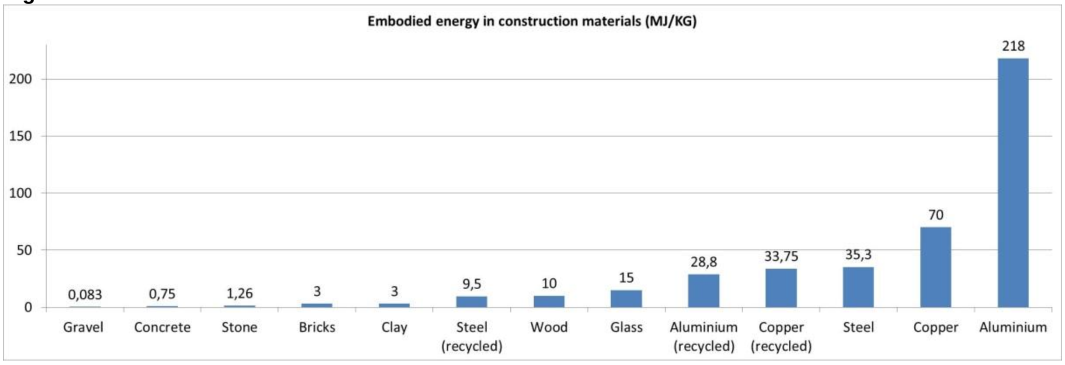
In most categories, including primary renewable and non-renewable energy use, greenhouse warming potential, acidification and ozone depletion potentials, **the impacts from the construction phase contributes to approximately 20% of the impacts in the total life cycle**. Furthermore, construction phase is estimated to be responsible for ca. 37% of impacts on eutrophication potential and only around 10% of photochemical ozone creation potential. This study excludes abiotic depletion and land use, but impacts are estimated to be in the same range, i.e. approximately 10-25% of impacts come from the construction materials.

In summary, Figure 2.13 and Figure 2.14 suggest that the impacts from energy in a use phase currently outweigh the impacts from production of construction materials by about 4 times on average. The importance of energy use during building occupation is expected to decrease in coming decades, however, as the building stock as a whole becomes more energy efficient.

2.3.7 Embodied energy compared to energy consumption of buildings

Several studies have been identified in order to collect coefficients on embodied energy in different construction materials. A**luminium, copper and steel have by far the highest embodied energy per unit** as illustrated on the figure below, and although recycled aluminium, copper and steel are significantly lower, these recycled materials still have a higher embodied energy than most other materials.

Figure 2.15

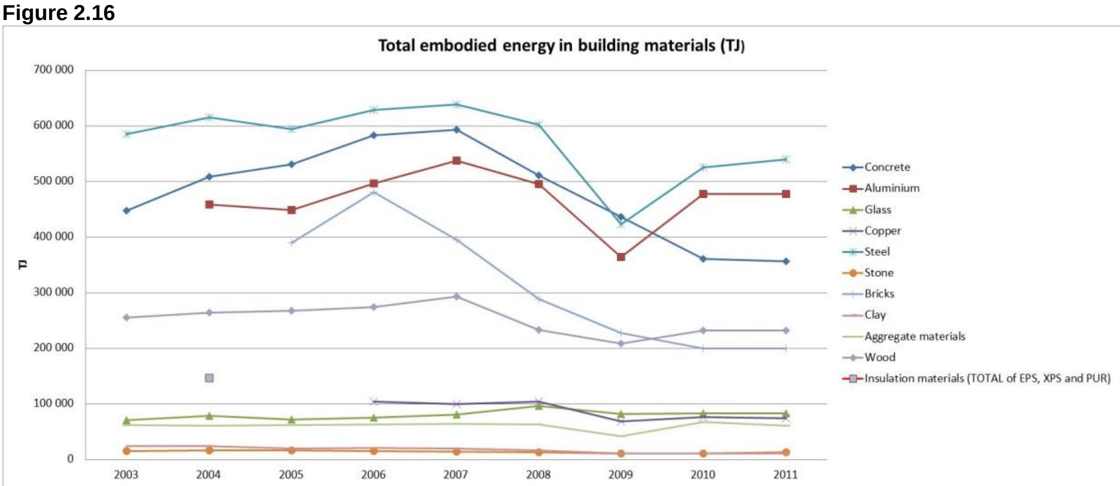


Source: ICE V2.0.

Similarly to environmental impact quantification in previous sections**, these values are used to calculate the total volume of embodied energy based on total use of resources**.

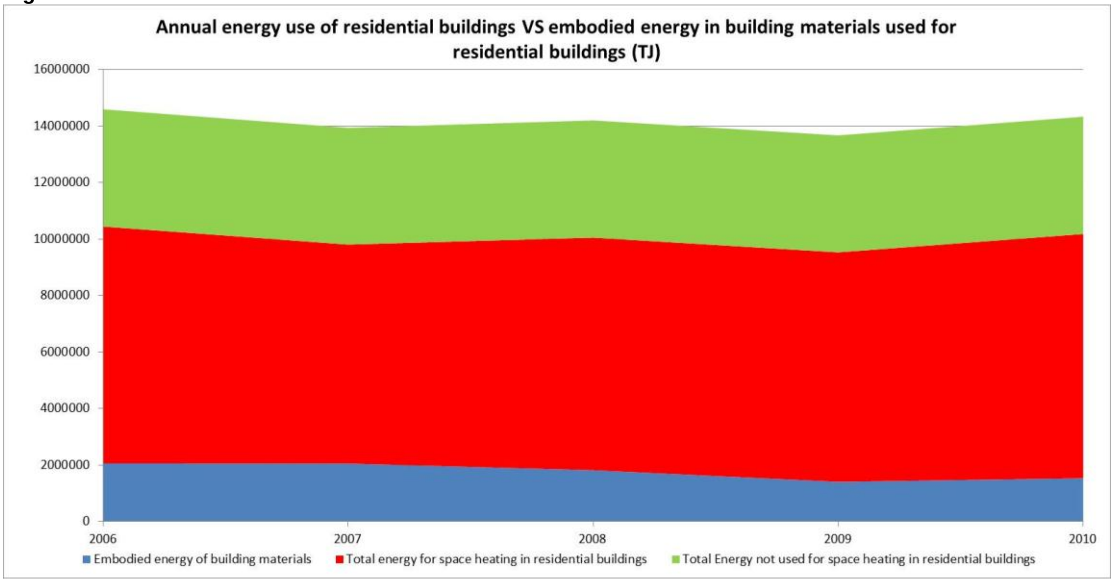
Weighting the relative impacts by mass of materials used, the **highest embodied energy is found respectively in steel, aluminium and concrete** (**Figure 2.16).** For most materials, results correlate with the figures on GHG impacts and abiotic depletion presented earlier. The calculations also illustrate that **GHG impacts from concrete stem not only from the embodied energy (energy used during production) but also the chemical reactions for cement production**.

Figure 2.16



Source: CRI calculations.

Figure 2.17



Source: CRI calculations and ODYSEE.

Our estimations show, that every year approximately **2.0-2.8 Million TJ (or 48-65 Mtoe) energy is embodied in new building materials**, while approximately 11.2 Million TJ is used by residential buildings for heating and all other forms of energy consumption including hot water and electricity. In the period 2006-2011, with the lower consumption of materials, the embodied energy also decreased from 2.8 to 2.0 TJ.

In 2006, when production was highest in the period 2006-2011, the total embodied energy (2.8 Million TJ or 65 Mtoe) corresponded to the 5**.4% of final energy**[29] **consumption of the EU27 or 20% of the EU27 industry's final energy consumption**. This value can also be compared to the annual final energy consumption of Poland or half of Italy's.

Trade-off between material use and energy efficiency improvements

Until recently, about 80% of the carbon emitted from buildings was associated with energy consumption in the use phase and about 20% with embodied energy, **but this is changing with increasing energy efficiency in the use phase**. It has been noted that, for an average building in the UK, the numbers are becoming closer to 60:40 and the embodied energy will probably become the dominating factor in the future[30]. Energy efficiency of space heating per m^2 increased in nearly all European countries between 1990 and 2008 where comparable data is available, as did the extent of the disparity between the efficiency of countries' building stocks. The extreme differences of energy consumption per m^2 between countries in 1990 decreased during the same period, in particular because countries with very inefficient building stocks made rapid improvements. Large differences still prevail however.

Nevertheless, while the energy efficiency is seeing general improvements, this is largely offset by growing floor area, both in absolute terms and per person. However, as Figure 2.16 illustrates, the **embodied energy in insulation materials** based on a single data point for 2004 **is not a significant contributor** to the overall impacts of construction materials.

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29 Eurostat: Consumption of Energy http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Consumption_of_energy.

30 Lane, 2007 quoted in EIO Thematic Report, 2011. Resource-efficient construction. The role of eco-innovation for the construction sector in Europe.

To an extent, energy efficiency improvements lead to increased use of insulation materials and for example may increase consumption of glass, but **these changes lead to a net improvement in overall performance due to improved energy efficiency.** For example PE NWE[31] presents the results of various studies demonstrating the net environmental benefits of using insulation materials over the whole life cycle of buildings. Regarding climate change, the **savings from the use of insulation materials are between 3.8 and 270 times more than the cradle to grave impact of the insulation**.

2.3.8 *Waste generation*

Construction and demolition (C&D) waste is estimated to make up 33 % of total waste generated annually in the EU (EEA 2010**). In the EU27, approximately 850 million tonnes of C&D waste is generated per annum. Data on the quantity and composition of C&D waste is, however, extremely poor.** This is mainly due to differences in definition and reporting mechanisms between member states but also to the unequal levels of control.

In a recent report[32] BIO Intelligence Service (BIO IS) tried to **estimate the more exact composition of C&D waste for a number of countries**, **by estimating (excluding) the amount of excavated material** based on figures from UBA[33].

Figure 2.18 Composition of C&D waste for a number of countries and regions

<table>
<tr><th>Country</th><th>Netherlands</th><th>Flanders</th><th>Denmark</th><th>Estonia</th><th>Finland</th><th>Czech Republic</th><th>Ireland</th><th>Spain</th><th>Germany</th></tr>
<tr><th>Year</th><th>2001</th><th>2000</th><th>2003</th><th>2006</th><th>2006</th><th>2006</th><th>1996</th><th>2005</th><th>2007</th></tr>
<tr><td>Concrete</td><td>40%</td><td>41%</td><td>32%</td><td rowspan="2">17%</td><td rowspan="2">33%</td><td>33%</td><td rowspan="2">80%</td><td>12%</td><td rowspan="2">70%</td></tr>
<tr><td>Masonry</td><td>25%</td><td>43%</td><td>8%</td><td>35%</td><td>54%</td></tr>
<tr><td>Other mineral waste</td><td>2%</td><td>-</td><td>0%</td><td>0%</td><td>-</td><td>-</td><td>0%</td><td>9%</td><td>-</td></tr>
<tr><td>Total mineral waste</td><td>67%</td><td>84%</td><td>40%</td><td>17%</td><td>33%</td><td>68%</td><td>80%</td><td>75%</td><td>70%</td></tr>
<tr><td>Asphalt</td><td>26%</td><td>12%</td><td>24%</td><td>9%</td><td>-</td><td>-</td><td>4%</td><td>5%</td><td>27%</td></tr>
<tr><td>Wood</td><td>2%</td><td>2%</td><td>-</td><td>-</td><td>41%</td><td>-</td><td>-</td><td>4%</td><td>-</td></tr>
<tr><td>Metal</td><td>1%</td><td>0,20%</td><td>-</td><td>40%</td><td>14%</td><td>-</td><td>4%</td><td>3%</td><td>-</td></tr>
<tr><td>Gypsum</td><td>-</td><td>0,30%</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>0,2%</td><td>0,4%</td></tr>
<tr><td>Plastics</td><td>-</td><td>0,10%</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>2%</td><td>-</td></tr>
<tr><td>Miscellaneous</td><td>7%</td><td>2%</td><td>36%</td><td>34%</td><td>12%</td><td>32%</td><td>12%</td><td>12%</td><td>3%</td></tr>
</table>

Source: BIO IS, 2011.

Figure 2.18 indicate that **the largest known fraction in C&D waste is concrete**, although the relative volumes per country and year differ substantially. Based on the more detailed waste material analysis in the BIO IS report, asphalt and masonry, together with concrete seem to cover the bulk of the inert C&D waste generated. Wood, glass and metals are also present in smaller quantities.

When trying to take uncertainties into account and instead present a possible range, the total C&D waste in 2010 is **estimated to be around 850 million tonnes (including soil and excavation material)** per year in EU27, equalling to 1.72 tonnes per capita and year in the EU27, however there are substantial differences between European countries as the following figure illustrates.

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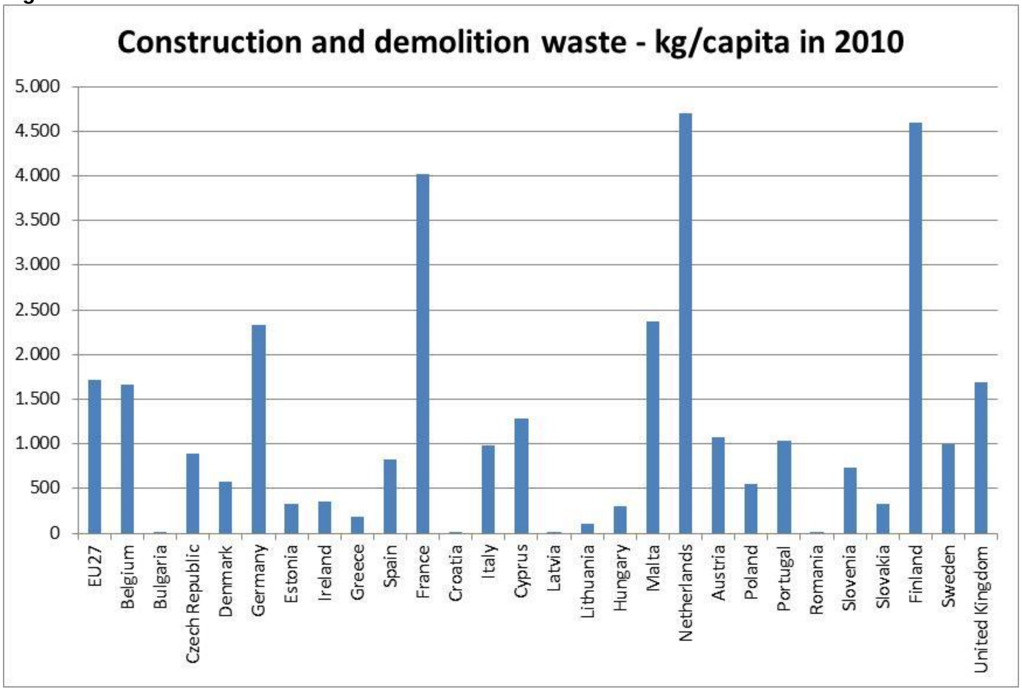
31 PE North West Europe, 2011. Background Report. Project No. 10148/10- Thermal Insulation and the EcoDesign Directive: A Review for the European Insulation Platform.

32 BIO IS, 2011 Service contract on management of construction and demolition waste, Final report.

33 http://www.umweltbundesamt.de/publikationen/umweltwirtschaftsbericht-2011

Figure 2.19



Source: Eurostat.

However, **approximately a third of the total waste (**Error! Reference source not found. **and Figure 2.19) reported is soil and other excavation materials**: building on the most recent consolidated data and applying corrections related to **exclusion of excavated materials** when possible and data filling when data was assumed to be incomplete, the generation of C&D waste is estimated to 0.94 tonnes per capita (BIO IS, 2011). This amounted to a total of approximately 461 million tonnes in 2005, but it must be stressed that the uncertainty is high.

It can be assumed that some differences in the amount of waste from construction and demolition activities derive from differences in building tradition and differences in geography/geology, but the economic activity within the sector will also influence waste generation (ETC/SCP, 2009). The building tradition in each country plays an important role, as most of the C&D waste originates from demolition activities of buildings that have exhausted their life span. Moreover, the building tradition is strongly correlated to the geological availability in each country, since building components require large amounts of materials which are difficult to transport from across borders (e.g. more wood would be expected in C&D waste from the Scandinavian countries). Another geological factor is related to the structural properties of a country's grounds (e.g. a country with frequent earthquakes has to rely on different materials than other countries). The economic activity in the construction sector influences not only the construction waste generation but also the demolition waste since often new constructions replace old ones, especially in urban areas.

There is a similar problem with the availability of data for waste management of C&D waste, which is further distorted by the fact that some countries include soil backfilling in the definition of recycling. However, the data availability is expected to improve soon, as each country will have to start monitoring their progress towards the target set for recycling C&D waste in the Waste Framework Directive.

Data shows that **most of the old EU member states have a recycling rate of over 60% while other European countries generally do not reach 50%** (ETC/SCP, 2009). A recent study[34] has

[34] Implementing EU waste legislation for green growth, DG ENV 2011.

tried to consolidate existing national data, excluding soil backfilling and filling gaps when needed. It arrives at a broad estimation with high uncertainty of an average recycling rate for EU27 of 46%.

BIOIS, 2011 estimated that **the recycling levels for the EU27 as a total are around 47%.** At national level the differences estimated are the following:

Recycling rates	Countries
Above 70%	Denmark, Estonia, Germany, Ireland, UK, The Netherlands
60-70%	Austria, Belgium, Lithuania
40-60%	France, Latvia, Luxembourg, Slovenia
Below 40%	Cyprus, Czech Republic, Finland, Greece, Hungary, Poland, Portugal, Spain
No data	Bulgaria, Italy, Malta, Romania, Slovakia, Sweden

Source: CRI compilation based on BIO IS, 2011.

2.3.9 Land use

75% of Europeans live in urban areas[35] (EEA SOER2010) and the built environment equals about 0.06 hectares per person in Western Europe and 0.04 hectares per person in Eastern Europe[36]. The artificial area is expanding. Between 2000 and 2006, the percentage of Europeans living in urban areas increased with 0.61% per year to be compared with the rate between 1990 and 2000 of 0.57% per year in 36 European countries studied. Housing, services and recreation accounted for 43.2 % of the increase in land area between 200-2006, with areas “under construction” responsible for a further 21.4 % of new land take. Industry and commercial sites were responsible for a further 15.5 % of new land take over the same period. The type of land that was taken by these uses varies significantly between European countries, but at a European level, arable and pasture lands were the most predominant land type converted, accounting for just under 78 % of all land take in the period[37]. However, artificial land took up more forests, natural grasslands and open spaces between 2000 and 2006 than in the previous decade, leading to a higher loss of natural ecosystems.

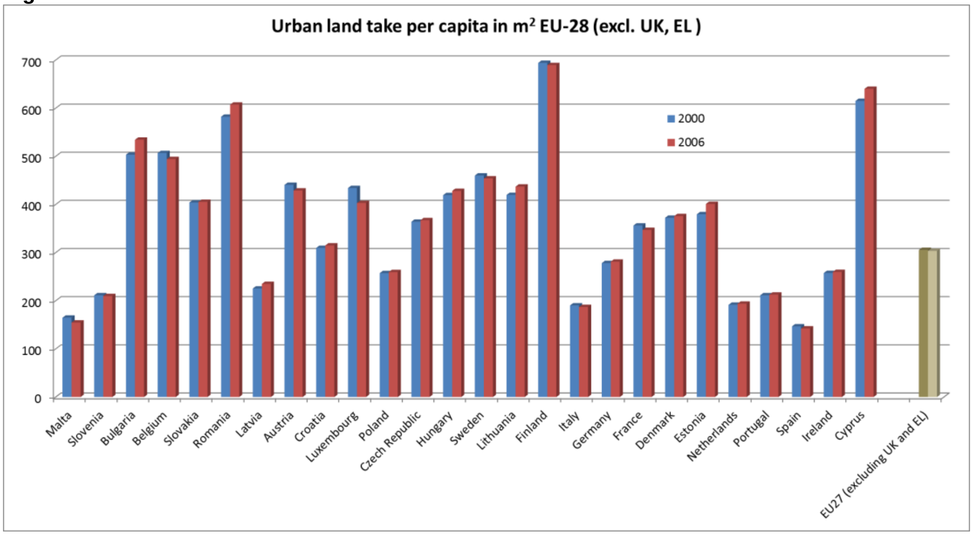
In total, new urban and other artificial development in 38 European countries, as identified by the CORINE land cover, amounted to approximately 636 900 hectares in the six years between 2000 and 2006 with discontinuous urban fabric, industrial commercial units, mineral extraction sites, construction sites and sports and leisure facilities accounting for about 90% of the increase[38].

Total urban land cover (continuous urban fabric and discontinuous urban fabric) in the EU (excluding Greece) increased by approximately 1.7 %, about 235 000 hectares, between 2000 and 2006. The vast majority of this was discontinuous urban fabric.

Figure 2.20 provides an indication of the population density of the urban landscape in Europe. Finland and Cyprus have a notably sparse urban landscape, enjoying over 600m^2 per person. At the other end of the scale people in Italy, Spain, Malta and the Netherlands each have less than 200m^2 of urban space, one third less than the European average of around 300m^2 per person. There are a multitude of historical, social, economic and geographic reasons for the ways in which different urban centres have evolved, including the amount of space available, security and protection, development of transport infrastructure, and land prices, titles (ownership paradigms) and development regulations.

35 EEA, 2010. SOER2010 Land use — SOER 2010 thematic assessment.
36 EIO Thematic Report, 2011. Resource-efficient construction. The role of eco-innovation for the construction sector in Europe.
37 EEA Indicator CSI014.
38 EEA Indicator CSI014.

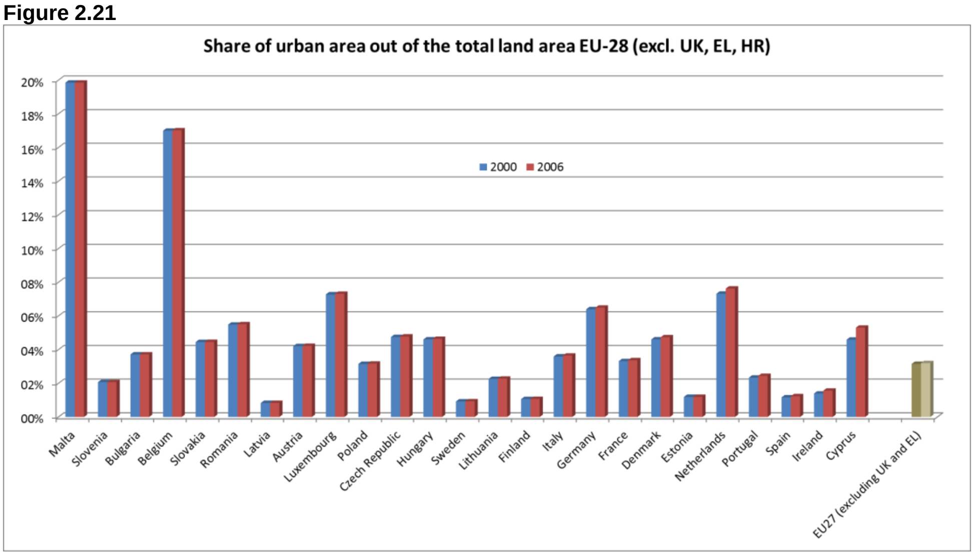
Figure 2.20



Source: CRI calculations based on CORINE and Eurostat.

Figure 2.21 shows how much of the land in European countries is given over to urban development. Unsurprisingly, small countries with high populations have a higher share of urban area than those with smaller populations and large land areas. The disparity between the extremes is large (nearly 20% of land in Malta is urban land, while Finland, Sweden and Latvia have only around 1 % of their territory covered by urban land). Around 3.2 % of the European land area is covered by urban development.

Figure 2.21



Source: CRI calculations based on CORINE and Eurostat.

2.3.10 Water use in buildings

Buildings use substantial amounts of water. United Nations Environment Programme (UNEP) for example estimates water use in buildings to 25% of water available globally and[39] in Europe, public water supply represents about 21% of total water use of which the majority is used in buildings.[40]

39 UNEP (2012) http://www.unep.org/sbci/AboutSBCI/Background.asp.

40 BIO Intelligence Services (2012) Water performance of Buildings, Final report prepared for European Commission, DG Environment.

Water use in the construction sector and buildings can be divided into **operational** and **embodied** water.

- *Operational water* encompasses the consumption of water once the building is in use.
- *Embodied water* comprises 'direct' (where only the water used as input to the production process is accounted for) and 'indirect' (water used in the extraction of materials etc.) water use in the construction of the building, product assembly and manufacturing of the material[41] and can be defined as the cumulative quantity of water used to produce a product through the supply chain.[42]

Data and accepted methodologies for measuring water use in buildings are scarce. Neither Eurostat nor the European Environmental Agency (EEA) has datasets on, for example, the use of water per household over time. However, Eurostat offers some data that can be used as proxies for water consumption in buildings (see below). For embodied water, data availability is even poorer. New concepts such as 'water footprinting' and 'virtual water' have been introduced over the last decade to overcome the data gap and improve the understanding of water use during the entire life cycle of a product, however, they are not yet ripe for use at a European level. This is unfortunate since emerging research suggests substantial amounts of water may be going into buildings if one takes the whole supply chain into account.[43]

Finally, **high water use is not necessarily a problem or a good indicator for environmental pressure.** If the water embodied in a product is abstracted over time in geographical regions where water is abundant and quality is safeguarded throughout the process, water-use might not pose a problem. Yet, if water is abstracted in water-scarce regions, it could exacerbate water stress in vulnerable areas. Water abstraction rates in the buildings process should therefore be linked with water stress data in order to be relevant for resource efficiency policy.

Operational water use

Based on a recent study for the European Commission, the average European citizen uses approximately 160-173[44,45] litres per person per day (L/pp/day). Taking into account the upper bound (173 L/pp/day), **the total consumption equals 30 198 million m^3**, per year [46] which represents around **9% of total European annual freshwater abstraction**.[47]

The (operational) water use in buildings divided by residential and non-residential buildings corresponds to 72% and 28%, respectively. In residential buildings, the use can be further disaggregated by category: showers and baths (35%), toilet flushing (25%), washing clothes (14%), dish washing (8%), drinking and cooking (5%), room cleaning, irrigation and car washing (5%) and other (8%).

The amount of water used heavily depends on the number of people in a household, which differs significantly per EU Member State. In non-residential buildings, toilet flushing in WCs and urinals represents 75 – 90% of the water use (except for hotels where the use patterns are similar to

41 Crawford, R. and G. Treloar (2005) An assessment of the energy and water embodied in commercial building construction. Peer reviewed paper presented at the 4th Australian LCA Conference, February 2005, Sydney.

42 Anderson, J. & J. Thornback (2012) A guide to understanding the embodied impacts of construction products. Study by PE International for the Construction Products Association.

43 WRAP. (2011) Direct and indirect water use at Heathrow Terminal 2B. http://www.wrap.org.uk/sites/files/wrap/Heathrow_T2B_FINAL.pdf.

44 BIO Intelligence Services (2012) Water performance of Buildings, Final report prepared for European Commission, DG Environment.

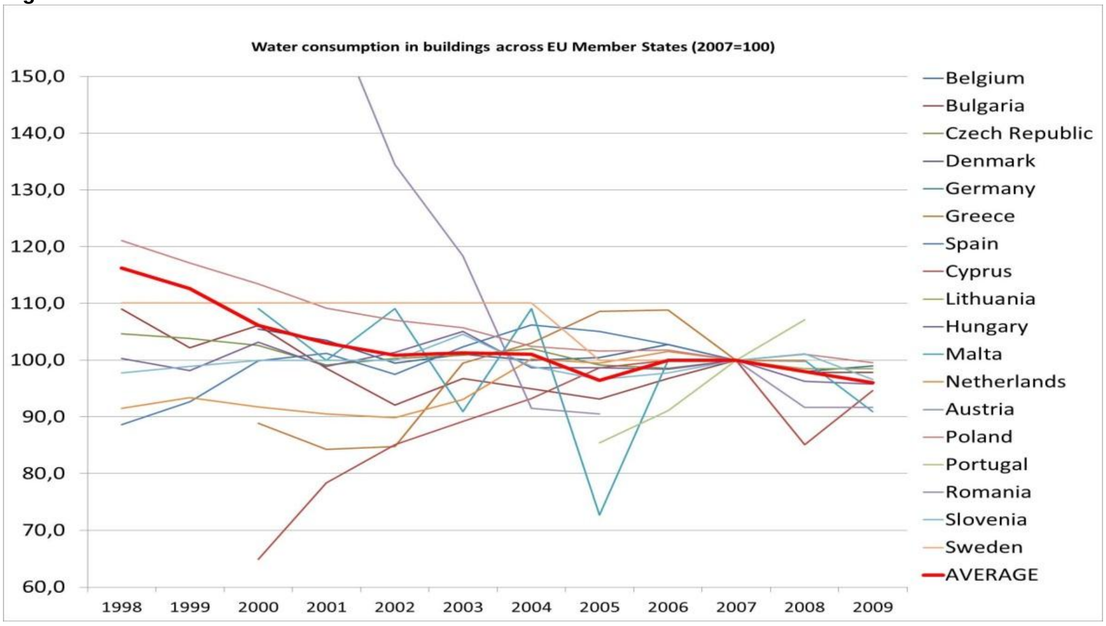
45 The lower bound is from BIO Intelligence (2012) and the upper bound from JRC, IPTS, AEA (2011) ECOTAPWARE. Task 2: Economic and market analysis, Task 3: User behaviour.

46 JRC, IPTS and AEA (2011) ECOTAPWARE. Task 2: Economic and market analysis, Task 3: User behaviour.

47 Own calculations based on 2008, EEA figures suggesting that 350 km^3 water is abstracted annually in the EU (http://www.eea.europa.eu/themes/water/water-resources/water-abstraction).

residential buildings).[48] Figure 2.22 shows the water consumption in buildings across the different EU Member States, based on Eurostat data and indexed to consumption in 2007, and demonstrates the large differences in trends in water use in buildings among different EU Member States.

Figure 2.22



Source: data on use of water from public water supply by services and private households from Eurostat, used as a proxy for water use in buildings, based on BIOs study on Water performance of buildings (2012).

On average, the trend in the EU is decreasing water consumption in buildings (approximately 20% decrease in water use in buildings on average in the EU during 1998-2009). Based on this data, Romania had the largest decrease in water consumption (approximately 135% decrease during 1998-2009), while Slovenia the lowest (only 1% decrease during this period).

On the other hand, for example Cyprus increased its consumption by 31% during 2000 and 2009. The data for some Member States do not cover the entire period, hence these trends need to be interpreted with caution.

Embodied water use

To define water use in the construction phase, we have decided to use ‘embodied water’, which means all water that goes into the life cycle of *building materials* during the extraction, manufacture, construction, and dismantling phase. It also connotes to the more developed concept of ‘embodied energy’ in products which has become highly relevant in energy efficiency discussions and ‘embodied carbon’ which has become part of climate mitigation efforts in for example international trade. **As already mentioned above, the data available on embodied water is even scarcer than data on water use in the operational phase**.

With respect to water footprinting (as a way to measure embodied water), this concept was introduced a decade ago to highlight the amount of water used throughout the supply chain of a product. It divides water use into Green water (rainwater evaporated or incorporated into a product), Blue water (surface water or groundwater evaporated, incorporated into a product or returned to other catchment or the sea) and Grey water (polluted water). All three waters need to be included to create a comprehensive water footprint. Furthermore, the footprint needs to incorporate both direct and indirect use of water in the construction phase.

48 JRC, IPTS and AEA (2011) ECOTAPWARE. Task 2: Economic and market analysis, Task 3: User behaviour.

Based on these emerging methodologies, to properly calculate the embodied water in buildings one could look at:

1. Quarried products such as sand and gravel where water is used in the extraction of raw material phase (‘indirect water’ use);
2. Manufactured products such as concrete mixes where water goes into the production phase (‘direct water’ use).[49] Embodied water (or water footprint) is then calculated by:

$$Embodied\ water = Water\ used\ (m^3) \div Quantity\ of\ product\ t$$

In a case-study reported by the Waste and Resources Action Programme (WRAP) in the UK[50], the embodied water of constructing the Terminal 2B on Heathrow outside London was calculated using a water footprinting tool developed by Parsons Brinkerhoff (part of Balfour Betty, the company responsible for building the terminal) based on the methodologies introduced by the Water Footprint Network. The tool was created to support Balfour Betty’s sustainability plan that requires assessments of the most significant areas of water use in the products and manufacturing phase. The initial analysis of embodied water use showed 18 596 m^3 water in direct use (embodied water used on-site) and 652 236 m^3 in indirect use (embodied water used for procured products and materials). **This indicates that indirect water use corresponds to approximately 97% of the total embodied water of a building (and around 3% corresponds to ‘direct’ water use).**[51] The most water intensive parts of the building were found to be flooring materials (wood, ceramic tiles, stone, etc.), quarried materials, such as sand and gravel, and metals. This suggests that for a construction company the large majority of water use comes from procured products and materials instead of from the building site itself.

2.3.11 Impact of buildings on biodiversity

The impact of buildings on biodiversity may be the most difficult indicator to quantify. Biodiversity is in itself cumbersome to measure and it is problematic to isolate the effects of one activity, such as the construction of buildings, on biodiversity, which makes it difficult to establish a causal chain of events. Nevertheless, the following paragraphs attempt to map the effects from buildings on biodiversity in a largely qualitative way.

Buildings and construction could have negative impacts on biodiversity in many different ways. On the most general level, extraction, manufacturing of construction products, construction, buildings use and demolition all pose different threats to habitats such as species disturbance, habitat loss, dust smothering of vegetation, alien species introduction and spread, sediment run-off, habitat fragmentation and other.[52] It is not only the actual construction of buildings that has impacts, also the sourcing of materials. Quarrying, foresting, and water use, for example, may have similar large impacts on biodiversity, such as the ones described above for construction.

Based on our own judgement, the following impacts are most likely to be relevant for biodiversity impacts linked to buildings:

Table 2.4 Overview of impacts on biodiversity

49 Hardisty, M. (2011) Water footprinting in the construction industry. Presentation for Parsons Brinckerhoff and Balfour Betty.

50 WRAP. (2011) Direct and indirect water use at Heathrow Terminal 2B. http://www.wrap.org.uk/sites/files/wrap/Heathrow_T2B_FINAL.pdf.

51 Hardisty, M. (2011) Water footprinting in the construction industry. Presentation for Parsons Brinckerhoff and Balfour Betty.

52 http://www.saiea.com/cbbia/html/guidance/partf.html.

		Impact on biodiversity	Extraction	Product manufacture	Building construction	Use & maintenance	Demolition & waste
Resources	Biodiversity loss	Disturbance of species at the local level	x		x		x
		Local loss of habitat*	x		x		
		Dust smothering of vegetation	x	x	x		x
		Introduction of alien species	x		x	x	
		Sediment runoff	x				
		Sedimentation of streams, rivers		x	x	x	x
		Pressure/ loss of access to ecological goods and services			x	x	x
		Habitat fragmentation	x		x		

Based on: http://www.saiea.com/cbbia/html/guidance/partf.html.
Note: * local loss of habitat might have a variety of reasons, e.g. may be due to habitat fragmentation.

There is no common established indicator or method to assess the impact of buildings or construction on biodiversity.[53] Attempts to create such indicators use for example land-use, ecotoxicology, human health and habitat fragmentation. Data availability to measure biodiversity is in general scattered and/or scarce. For example, the Ecological Footprint developed by Global Footprint Network, is a measure of how much biologically productive land and water an individual, population or activity requires to produce all the resources it consumes and to absorb the corresponding waste, all using prevailing technology and resource management practices.[54] In other words, it looks at the bio-capacity of ecosystems to supply us with natural resources. However, even this indicator does not properly measure the impact on biodiversity and has data constraints.

Another example is the biodiversity indicators being developed within SEBI (Streamlining European Biodiversity Indicators), launched in 2005. However, these look mostly at the current state of biodiversity (e.g. number of sites under the EU Habitats and Birds Directive, number of certain species, etc.) and do not as such assess directly the impact on biodiversity, particularly not of buildings or construction. A central and potentially highly destructive effect of buildings on biodiversity is the expansion of urban areas through land-takes. The EEA has collected data (indicator CSI 014) on land-take for the period 2000 – 2006.[55] The bulk of land-take is made from conversion of arable land and pasture to artificial land development. It is thereby not pristine, natural land or forests that are lost but mainly semi-natural lands. Due to a lack of other good data sets, land-take may be the best proxy for biodiversity degradation linked to the construction sector.

2.4 Conclusions on the resource use and environmental impacts of buildings

The use of materials for building construction represents a significant share of our total use of abiotic materials. The environmental impacts associated with the extraction and use of these materials is a result of the quantities used and the impacts per unit material.

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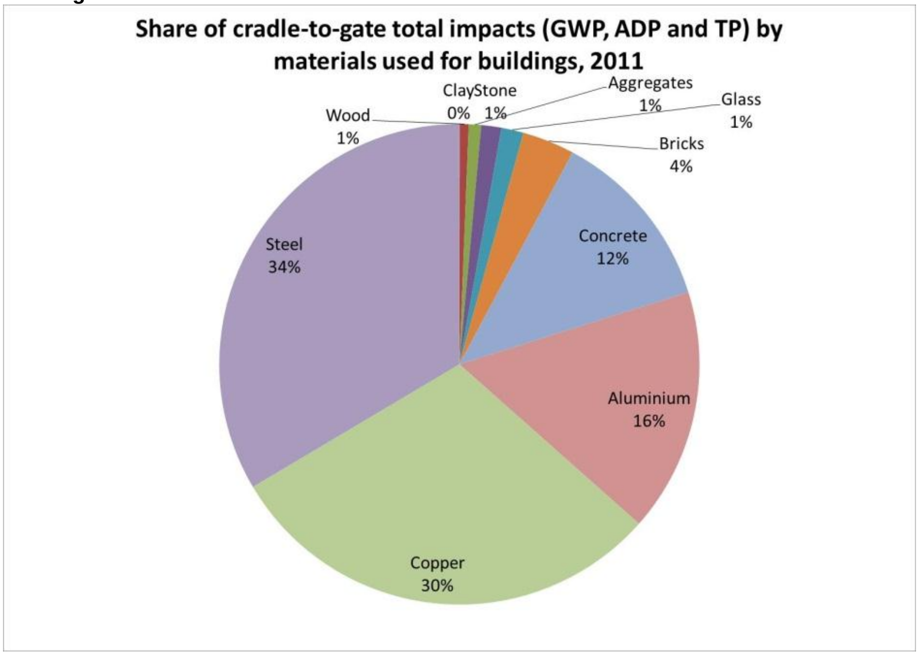
53 http://www.eebguide.eu/?p=1817.
54 http://www.beyond-gdp.eu/download/Ecological_Footprint.pdf.
55 http://www.eea.europa.eu/themes/biodiversity/indicators#c10=&c5=all&c7=all&c13=20&b_start=0

The figures presented above are subject to a series of assumptions, particularly with respect to consumed quantities, recycled contents and the factors used to calculate environmental impacts and embodied energy. The assumptions represent the best available data and are clearly stated where they occur in the analysis above. The following conclusions do not re-state these assumptions as a matter of rule.

Aggregate materials and concrete are the predominant building materials by weight used in Europe. Concrete is also responsible for the largest share of GHG emissions stemming from buildings (excluding operational energy use during occupation), particularly when recycling of metals is taken into consideration (which minimises the contributions of other high-emission materials like steel and aluminium), as well as a significant portion of abiotic depletion. However, looking at the split of total aggregated impacts (Figure 2.23) from the materials used in buildings, it is clear that **steel, copper and aluminium dominate**. **These three metals are collectively responsible for about 80% of all impacts** stemming from the (cradle-to-gate) production of the studied materials, even despite the fact that benefits of recycling for these materials are included in the calculations.

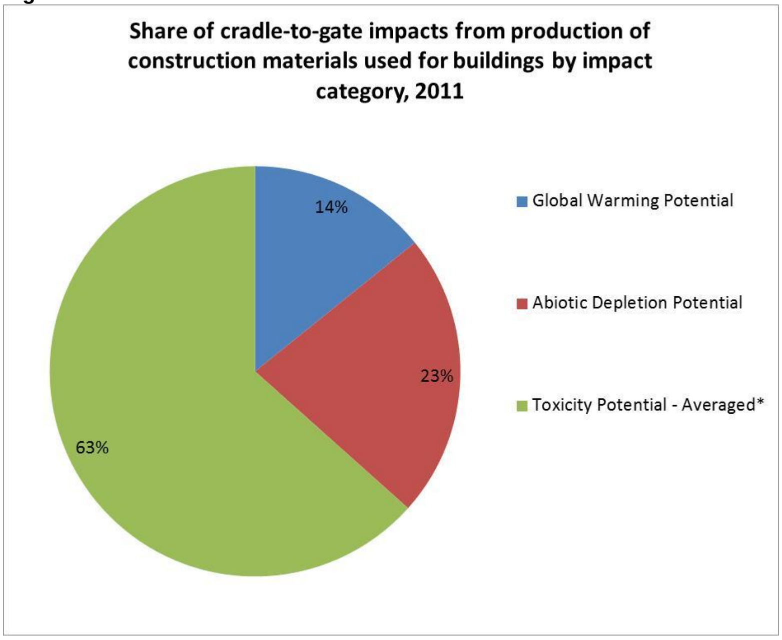
Figure 2.23



Source: CRI calculations.

This is, in large part, because metals are responsible for the vast majority of the averaged toxicity impacts from buildings and 63% of all impact categories taken into account (GWP, ADP and averaged TP) from building materials fall into the toxicity (TP) category as the following figure illustrates.

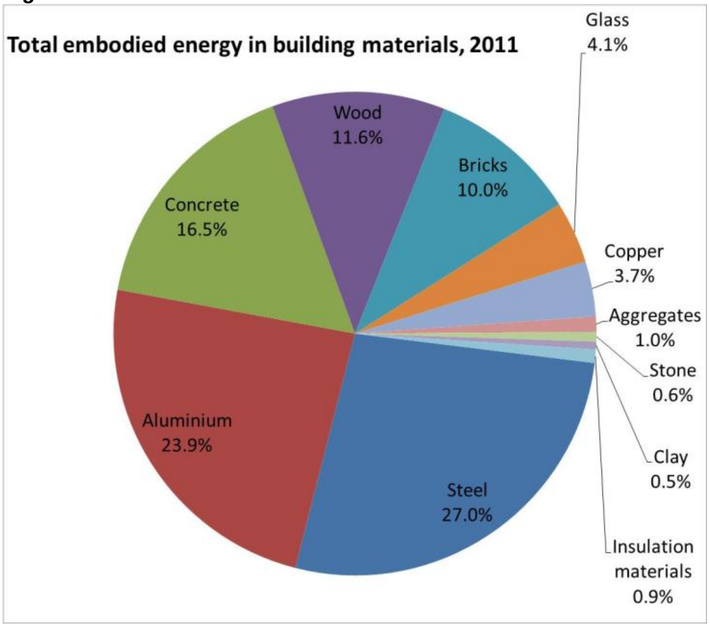
Figure 2.24



Source: CRI calculations.

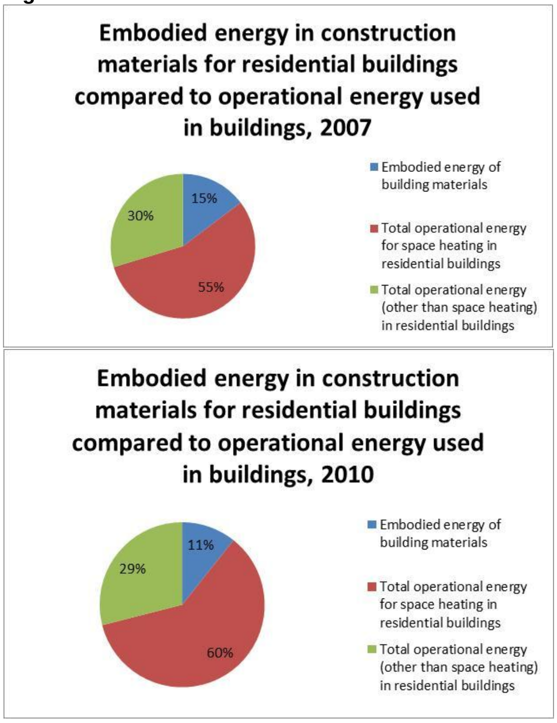
The estimated total amount of **embodied energy in building products is estimated to be 1.9 Million TJ (2011). Steel and aluminium together are responsible for approximately 51 % of the total embodied energy** in building materials (Figure 2.25) used in European construction in 2011 (as above, this calculation includes the average recycled content of these materials), with another 17 % of the total embodied energy being in concrete.

Figure 2.25



In 2010, nearly 7 times more operational energy was consumed in *residential* buildings (a benchmark proxy best available) alone than was embodied in all newly produced building materials (Figure 2.26). Although **in 2007, at the height of the building boom, just 4.5 times** as much energy was used in residential buildings as was embodied in all new building materials produced. This was due to the larger production volume (in 2007) and thus embodied energy and **not because of a lower energy use in buildings**.

Figure 2.26



There is considerable **uncertainty about the composition of construction and demolition** (C&D) **waste**, although the total quantity has steadily increased between 2004 and 2010. Similarly, the exact level of recycling of C&D waste is difficult to ascertain, primarily because there is currently non-uniform reporting of the management of C&D waste within EU Member States. It is not possible to even speculate to which extend buildings are being refurbished rather than demolished and replaced.

Urban land cover has increased according to the limited data series available covering Europe, and this trend is anticipated to continue. The majority of this land take has been from productive agricultural land, rather than wild land[56].

Data on **the use of water in buildings** is sparse and less than robust. However, the average EU citizen consumes about 170 litres of water per day, which represents about 9 % of the total fresh water abstraction in the EU. The amount of water used in the extraction of materials, manufacturing of products and during construction, as well as during demolition and treatment of waste is also difficult to accurately assess; emerging methodologies are not yet sufficiently robust to provide reliable figures. However, it is anticipated that the quantity of water used throughout these processes is significant; with one estimate proposing that including “indirect” water use (water used in the extraction of materials etc.) can increase the water footprint of a building by 90 % compared to a measure using “direct” water use (where only the water used as input to the production process is accounted for).

Buildings **impact biodiversity** along the entire life cycle, and the impacts can take a variety of different forms, from the local and sometimes temporary disturbances caused by material extraction, to the long-term loss of the land the building stands on, and the fragmentation of habitats caused by both buildings and their supporting infrastructure.

56 EEA Indicator CSI014.

In summary, the use of steel, aluminium and copper in buildings is responsible for the majority of pollutant and climate change emissions stemming from building construction, although concrete is also a major contributor, particularly to GHG emissions, due to the high volumes used. The impacts tend to take place during the extraction and processing of materials and the production of building products used in building construction, while the construction process itself, demolition and waste management cause relatively few environmental impacts [57].

However, the demolition of buildings and their disposal, rather than the re-use or recycling of material, leads to a loss of material that could, in many cases, substitute or negate the need for virgin materials. In this way, the management of the end-of-life buildings, and indeed, how one arrives at the decision that a building has reached its end-of-life, has important consequences for the overall resource use and environmental impacts of buildings.

2.5 Review of existing policy on sustainable buildings and resource efficiency in buildings in Europe – for developing the baseline scenario

There is already a wide range of policy instruments in place in Europe that cover areas directly or indirectly related to and affecting the sustainability of buildings. In order to provide a solid base for a new policy, it is essential to scope the existing policy landscape to identify where and at what level the policy has been implemented.

The policy landscape has been mapped at the European (EU) and national level, drawing on existing reports and surveys of policies at the national level and a thorough search of European policy and initiatives.

2.5.1 Policy at the EU level

Strategic overarching policy

At a contextual level, several pieces of EU initiatives provide the regulatory framework and strategic direction that affects the sustainability of housing in Europe. **The Resource Efficiency flagship initiative of the Europe 2020 Strategy (2011)** puts work on resource efficiency into the wider context of European policy, while the **Roadmap to a Resource Efficient Europe (COM(2011)571)** provides the overall strategy for improving resource efficiency in Europe. The **Thematic Strategies**, on **Sustainable use of Natural Resources (COM(2005)670)**, and on the **Urban Environment (COM(2005)718)**, also both provide background framework conditions for more sustainable buildings by influencing the extraction and utilisation of natural resources and the processes involved in building development in the urban environment.

The **7th EAP** provides a framework for environmental policy, and includes *boosting resource efficient low-carbon growth* and *enhancing the sustainability of EU cities* among its nine priority areas. The **Raw Materials Initiative (COM(2008)699)** and the subsequent **Raw Materials Strategy (COM(2011)25)** address sustainable access to raw materials both within and outside the EU, as well as resource efficiency and recycling.

The **Waste Framework Directive (2008/98/EC)** is the overarching piece of legislation on waste management in the EU, and holds particular importance for construction and demolition waste. It sets a recycling, recovery and reuse target of 70 % of C&D waste by 2020. The **Registration,**

[57] The definition of life cycle phases for "buildings" is complicated by renovation. Some studies place material use for renovation in the use phase, while others place it in the construction phase.

Evaluation, Authorisation and Restriction of Chemical substances (REACH) regulation (Regulation (EC) No 1907/2006) also affects the use of chemicals in the building industry, during extraction of materials, production of building products and installation. For example, the use of HBCD (hexabromocyclododecane), a flame retardant used in polystyrene insulation, has been severely restricted from August 2013 under Annex XIV of the REACH regulation[58].

Buildings

More specific legislation directly dealing with the sustainability of buildings at the European level mainly focuses on energy consumption during occupancy – indeed, the majority deals with energy used for space heating during occupancy. In particular, the recast **Energy Performance of Buildings Directive (2010/31/EU)** is a key EU legislation in this area, which inter alia, mandates national implementations of energy certificates, as is the **Energy Efficiency Directive (2012/27/EU)**, which requires the annual renovation of 3 % of public buildings owned and occupied by National central governments. The recast **Eco-design Directive (2009/125/EC)** also holds implications for basic services in buildings. While it deals more prominently with heating (water and space) apparatus and components, and energy efficiency in other appliances, it also addresses lighting: the gradual phasing out of incandescent light bulbs was implemented under the auspices of the Eco-Design directive. The Eco-design directive also sets minimum requirements on products and applies energy labels to energy using and energy related products.

Construction Products Regulation (Regulation (EU) No 305/2011) aims to ensure reliable performance information on construction products by providing a common technical language and offering uniform assessment methods of the performance of construction products. While primarily concerned with functional quality, one of the basic requirements for construction works is the sustainable use of natural resources. The process of defining the basic working requirements of the construction products regulation is still in progress.

The introduction of new **European Standards for Aggregates** in 2004 introduced a principle focusing on fitness for purpose and not discriminating between different resources. This means that the same standards apply to aggregates from natural, recycled and manufactured materials. These standards have been transposed by national standards bodies.

The Communication on the Sustainable Competitiveness of the Construction Sector (COM(2012)133) directly addresses key action areas in moving towards improved resource efficiency and environmental performance. While this places heavy focus on the framework conditions for the construction industry and how these can be adapted to favour more sustainable construction, it also calls for the development of harmonised rules on the declaration of the performance characteristics of construction products in relation to a sustainable use of natural resources in the context of the Construction Products Regulation.

The European Commission's **Lead Market Initiative (COM(2007)860)** identified sustainable construction as one of six Lead Markets and in its Annex 1 describes an Action Plan for Sustainable Construction. This emphasizes the importance of LCA approach to sustainable buildings, and calls for environmental performance to be included in building regulations, (particularly with regard to energy efficiency), but also in improving the opportunities for GPP in construction and for multiple action on standardisation, labelling and certification. The Lead Market Initiative succeeded in creating a network of public authorities[59], as well as mapping building regulations in EU member states. This report has informed section 2.5.2 on national policy for sustainable buildings below.

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[58] In Early May 2013, the Stockholm convention on persistent organic pollutants agreed a worldwide ban on the substance with a five-year exemption for expanded and extruded polystyrene.

[59] http://www.sci-network.eu/.

The Lead Market Initiative also initiated work on integrating sustainability criteria into the Eurocodes structural design standards.

The recent **Blueprint to Safeguard Europe's Water Resources (COM(2012)673)** addresses water use in buildings. In particular, it calls for the development of a voluntary EU Ecolabel and GPP criteria for key water related products and the inclusion of water-related products in the Eco-design Working Plan.

The **European Eco-label (Regulation (EC) No 66/2010**) includes criteria for some product categories that are relevant to the sustainability of buildings; particularly in decoration and finishing, but also flooring. Nearly half of all registered products under this scheme fall into the categories "hard floor covering" and "indoor paints and varnishes"[60]. Timber is addressed directly in the Timber Regulation (2010), which aims to exclude illegal timber from the EU market. Recycled timber is excluded from the EU **Timber Regulation No 995/2010**, as including it would place an unnecessary burden on the industry.

Commission Communication **Public Procurement for a Better Environment (COM(2008)400)** and the **Eco-Management and Audit Scheme (EMAS)**[61] both seek to foster sustainable buildings and sustainability respectively by creating a positive market environment for sustainable products, service, organisations and practices. The former identified construction (covering raw materials, such as wood, aluminium, steel, concrete, glass as well as construction products, such as windows, wall and floor coverings, heating and cooling equipment, operational and end-of-life aspects of buildings, maintenance services, on-site performance of works contracts) as the first of ten priority sectors for GPP, and notes that this sector often accounts for a major share of annual public authority budgets. To date, GPP criteria have been developed for 21 product groups/ sectors, of which eight fall within what could reasonably be termed "buildings": construction (as mentioned and outlined above), plus furniture; windows doors and skylights; thermal insulation; hard floor coverings; wall panels; indoor lighting and; sanitary tapware. The Commission provides an online guide to these criteria and their application, to aid Member States integrating them into tendering procedures. The uptake of these criteria is discussed under the national policies in section 2.5.2.

The EU Eco-Management and Audit Scheme (EMAS) is a tool through which companies and organisations can evaluate, report and improve their environmental performance. It does not contain specific requirements for buildings, but can be applied by construction companies to improve their environmental performance. It is also important to note that improvement options for companies and organisations could also involve improving the building within which they are housed.

A large number of policy initiatives are already underway at the EU level, covering different resources and some initiatives specific to the building and/or construction industry. These tend to focus on energy efficiency in the occupancy phase of a building's lifecycle. There is far less focus on embodied energy or other life cycle impacts of buildings. However, several initiatives point to the need for assessment frameworks, building, product or material certification and implementation of these assessments, with a focus on a lifecycle approach which incorporates a wider spectrum of resource uses and environmental impacts.

2.5.2 Policy at the National Level

At National level, a wide variety of policies influences the sustainability of buildings.

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60 http://ec.europa.eu/environment/ecolabel/facts-and-figures.html.

61 http://ec.europa.eu/environment/emas/index_en.htm.

Building regulations

Building regulations, present in all Member States, directly control what can be built and how. Certain aspects of environmental sustainability do appear in building regulation.

The LEAD Market Initiative on Sustainable Construction mapped Member State building regulations and assessed the sustainability criteria contained therein[62]. Generally, energy consumption in the occupancy phase (presumably driven at least in part by the EPBD), waste prevention (presumably driven by the WFD 70% target) and the protection of biodiversity (again, driven by EU legislation) are the most common sustainability criteria present in Member State building regulations. However, water conservation/efficiency and resource use/resource efficiency receive significantly less attention: the Netherlands, Finland and Austria were considering the inclusion of criteria on the minimisation of use of resources in their building codes.

The UK has undertaken a revision of its Housing Standards[63], although it is difficult to highlight any specific conclusions or activities that have arisen from the process. However, some interesting aspects of the consultation include:

- The consultation includes provisions addressing space standards (in terms of adequacy, not energy consumption impacts);
- Water efficiency standards;
- Energy efficiency standards;
- The proposition that material standards should be left to the market to lead on;
- Two possible implementations options are proposed; to function alongside building regulations or be integrated in building regulations.

The Netherlands introduced a new requirement to the Dutch Building Decree[64], which came into force in January 2013. Article 5.9 demands that two environmental impact indicators – embodied emissions of greenhouse gases and the depletion of resources – are calculated for new residential buildings and office buildings with a floor area of more than 100 m². The calculation method is based on LCA principles and the former NEN8006 for environmental product information (which has been superseded by NEN-EN150804). The decree does not include energy in the use phase.

These indicators provide useful information to prospective purchasers, but must be used in tandem with energy performance certificates to form a more rounded understanding of total environmental performance. For example, near zero-energy buildings, which tend to require a higher material input (for example, in the form of insulation) than traditional buildings, will appear to perform less-well in these indicators than traditional buildings, despite lower building lifetime impacts due to reduced energy consumption during occupation. This problem will, however, be at least partially alleviated once the majority of new buildings become near-zero energy.

EPDs

Environmental Product Declarations or briefly called EPDs provide standardised information about the environmental performance of a given product or material, and are used extensively for building products and materials. They allow the environmental performance of products to be traced up-stream and facilitate more transparent and easier environmental declarations of intermediate and final products (like, for example, buildings). However, there is currently a proliferation of different EPDs throughout Europe, which means that product manufacturers must often prepare multiple EPDs for a given product to access different markets or satisfy different customers.

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[62] PRC Bouwcentrum International, (2011).

[63] https://www.gov.uk/government/consultations/housing-standards-review-consultation (accessed 30/09/2013).

[64] http://www.bouwbesluitonline.nl/Inhoud/docs/wet/bb2012/hfd5/afd5-2/art5-9.

The European Standard EN 15804:2012, developed as part of the work on CEN-350, provides core product category rules for the application of EPDs to construction products. It describes a suite of 24 indicators, and their methodological background, that must be provided (seven environmental impact indicators; ten resource indicators; three waste indicators and four output flow indicators) for compliance. Together with EN 15978 (calculation method for the environmental performance of buildings) it provides a consistent method of measuring and reporting on the impacts. These standards are not assessment tools in themselves, but describe the methodology which tools should follow to be interoperable.

Market forces should lead to European companies providing EPDs based on the EN15804:2012 standard as the information contained within a compliant EPD can be used in further upstream analysis, regardless of specific implementation. However, some Member States have now passed national legislation to regulate the environmental declarations on construction products in line with the EN 15804:2012 standard. For example France and Belgium have enacted legislation that demands mandatory compliance with EN15804:2012, where environmental declarations are made for construction products.

A new network and collaboration platform (ECO Platform) has been established to coordinate the implementation of Europe-wide EPD for construction products that will be based on ISO 14025 and will be consistent with EN15804[65].

Materials legislation

Some countries do currently have a regulatory framework that explicitly addresses the sustainable use of raw (building) material. In particular, Austria, Finland, Germany and Estonia have overarching legislation providing strategic direction on increasing the efficiency of use of raw materials. In addition, Denmark, the Czech Republic, Estonia, France, Latvia, Sweden, UK and Cyprus all have some kind of market based instrument (most commonly taxes on extraction) on the use of raw materials. Although the materials covered varies across the different policies, all cover at least aggregates, while Estonia, Denmark and Latvia have more comprehensive material coverage, also including soil and peat.

Impacts of these taxes are varied and depend on both the details of implementation and the additional/other measures that impact extraction of materials. For example, the tax in Denmark has, in combination with voluntary industry agreements and a landfill tax, helped to reduce the excavation of aggregates. The UK tax also seemed to have led to a slight reduction in aggregate sales, and a slight increase in use of substitution materials from waste[66].

To support recycling and in response to the 2004 EU Aggregates Standards, Member States have transcribed the quality standards for specific aggregates into national standards. These ensure that aggregates conform to specific standards regardless of origin; placing recycled and recovered aggregates on the same footing as virgin aggregates.

The UK has recently launched a quality standard for recycled wood: BSI PAS 111:2012[67]. This aims to bolster the market for recycled wood and to further reduce wood going to landfill. The standard was developed jointly by WRAP and the Wood Recyclers Association.

65 www.eco-platform.org.
66 http://ec.europa.eu/environment/enveco/taxation/pdf/ch11_aggregated_taxes.pdf.
67 http://www.wrap.org.uk/content/bsi-pas-111-processing-wood-waste.

Waste legislation

The National Waste Management Plans of Austria, Belgium, Finland, Germany, Italy, Liechtenstein, Lithuania, Poland, Romania, Slovakia and Slovenia have specific strategies addressing C&D waste aiming to meet the 70 % recycling target of the WFD. Austria, Belgium, Bulgaria, Czech Republic, Estonia, Finland, Germany, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Netherlands, Poland, Romania, Slovakia, Slovenia all have specific objectives and targets regarding C&D waste although only Belgium (Flanders and Brussels Capital Region), Finland, Ireland, Lithuania, the Netherlands, Poland and Slovenia have defined targets for C&D waste to meet or exceed the 2020 C&D waste target.

In 2010, the situation in the MS regarding progress toward the Water Framework Directive or WFD target was as follows:

- 6 countries report recycling rates that already fulfil the WFD target (Denmark, Estonia, Germany, Ireland, the UK and the Netherlands);
- 3 countries report recycling rates between 60 % and 70 % (Austria, Belgium and Lithuania);
- 4 countries report recycling rates between 40 % and 60 % (France, Latvia, Luxembourg and Slovenia);
- 8 countries report recycling rates below 40 % (Cyprus, Czech Republic, Finland, Greece, Hungary, Poland, Portugal and Spain);
- 6 countries lacked data (Bulgaria, Italy, Malta, Romania, Slovakia and Sweden)[68].

Public procurement

As mentioned in section on EU policy above, Green Public Procurement is promoted at the MS level and, to date, criteria for eight different product groups / sectors have been developed that are directly relevant for buildings. So far, 22 of the EU27 countries have a national action plan or equivalent on GPP: Estonia, Greece, Hungary, Luxembourg, Romania are the exceptions. Of these 22, the majority include criteria covering construction and/or buildings[69]. The LEAD Market Initiative sci-network of public authorities provides a platform for the dissemination and sharing of good practice on GPP of buildings and construction.

Sweden, UK, Denmark, Germany, The Netherlands, France and Austria have reported to be conducting “some form of Life Cycle Costing analyses” or “derivatives of it” in the procurement/commissioning of new energy-efficient buildings and/or the refurbishment of existing buildings, especially heat, light and ventilation systems/units and building management systems[70]. One example is the UK’s updated “The Green Book”[71], a guidance document for public procurement. This describes not only the steps taken to ensure the lifecycle costs of procurement are used in evaluation, but also describes an approach for valuing non-market impacts.

The uptake of these and other sustainable criteria by member states has been investigated in relation to the target of 50% GPP by 2010 in the Communication *Public Procurement for a Better Environment* (COM(2008)400) by a 2012 project undertake for the EU Commission[72]. This found that while there seems to be a high uptake of including at least one core GPP criteria for public tenders involving construction (around 62 % of those tenders involving construction included *one* of five criterion covered by the survey), very few tenders for construction used all 5 of the core criteria investigated (3 %). As such, construction is one of the areas where GPP significantly lags behind and falls significantly short of the 50% by 2010 target. The same survey revealed, however, the

68 BIO IS (2011).
69 http://ec.europa.eu/environment/gpp/action_plan_en.htm accessed 2/07/2013.
70 http://ec.europa.eu/environment/gpp/pdf/WP-LifeCycleCosting.qx.pdf Life Cycle Costing: A Question of Value, IISD White paper.
71 The Green Book: Appraisal and Evaluation in Central Government, HM Treasury 2011.
72 CEPS (2012).

only 53 % of tenders included “any” green criteria; a lower percentage than included one of the EU core green criterion for construction. This discrepancy is attributed to the subjective nature of the understanding of “green” by the survey participants; i.e. some respondents to the survey did not consider all of the EU GPP criteria to be “green”.

An earlier survey conducted for the European Commission in 2009 into the practice of GPP in seven Member States (Austria, Denmark, Finland, Germany, the Netherlands, Sweden and the UK) found the prevalence of GPP related to buildings was still limited[73]. The exception here was the UK, where over 50% of contracts, and over 75% of contract value applied either core or comprehensive GPP criteria for buildings. Sweden also applied core or comprehensive criteria to GPP in just over 40% of their contracts. It is important to note that, both these studies focused on the *last* contract passed by the answering authority, not on all of the contracts in a given time period.

For a complete overview of the policy that affects the sustainability of buildings, please see annex A.

2.5.3 Assessment Frameworks

While policy provides a regulatory framework within which the construction of sustainable buildings can take place, more specific measures have been taken by both public and private actors to provide methodologies or frameworks for assessing the sustainability of buildings and building products. To a large extent, these provide the market with a current working definition of a “sustainable building”. These are more or less comprehensive and each places emphasis on different environmental criteria.

The three most actively used schemes are BREEAM, HQE and DGNB, although national implementations of the American LEED system are also in use by many (although not all) European national Green Building Councils (GBCs). The latter are national NGOs recognised by the World Green Business Council, with the overarching goal of promoting a transformation of the built environment towards one that is sustainable. They provide resources, stakeholder networks and education to improve the built environment, often in conjunction with assessment and certification according to one of the above methodologies. Although differentiated by membership level (from “Associated Group” through “Prospective” and “Emerging” to “Established” members), UK, Turkey, Sweden, Spain. Romania, Poland, Netherlands, Germany, France (all Established members), Italy, Hungary, Finland, Croatia, Bulgaria, Austria (all Emerging members), Czech Republic, Greece, Ireland, Latvia Slovenia, Switzerland,(all prospective members) and Slovakia, Portugal, Norway, Luxembourg, Lithuania, Iceland, Estonia, Denmark and Bosnia have Associated groups. Only Belgium, Cyprus and Malta, within the EU27 do not currently have some form of GBC.

An overview of these frameworks can be found in Annex A.

2.5.4 Conclusions on current policy affecting the sustainability of buildings

There is a comprehensive range of policies at EU and Member State level addressing energy efficiency in buildings. These policies are not only driven by environmental concerns around climate change, but also economic concerns and energy supply concerns, and as such are well established and subject to a variety of implementing mechanisms. The promotion of sustainable buildings has not benefited from such prolonged policy action, although policies do exist at both the EU and Member State level that directly and indirectly influence the sustainability of buildings, either

[73] Collection of statistical information on Green Public Procurement in the EU Report on methodologies PwC (2009) http://ec.europa.eu/environment/gpp/pdf/statistical_data.pdf.

through support for improvements certain parts of the building lifecycle, by targeting materials that are used in buildings, or as policy strategies encompassing the wider urban environment.

The practice of measuring and communicating the resource use and environmental impacts of building materials, products, and buildings (and at a larger scale, developments) though the use of EPDs and assessment, verification and disclosure schemes has gone from nascent, merely 20 years ago, to increasingly common today. The proliferation of different methodologies and requirements surrounding these practices means that there is fragmentation of the market for sustainable buildings and sustainable building products. As such developers and final consumers must consider an array of overlapping certification possibilities, while material and product manufacturers must comply with information requirements in multiple forms. Similar schemes have been used on a smaller scale to certify recycled material (for example the UK recycled timber initiatives).

Although the majority of these existing assessment schemes are private and fall outside the traditional scope of "policy", there is often a public-support element in their initial development, the verification/certification process or on-going aid and recognition. In addition, it is entirely conceivable to make policy in this area (whether or not policy currently exists), and so the scoping of existing initiatives is relevant to policy development for sustainable buildings.

2.6 Baseline Scenario

The existing policy that impacts and influences the sustainability of buildings at the EU and Member State level forms the policy background for the baseline scenario. This is the overall policy framework from which the current trends in socio- economic- and environmental indicators stem.

This section uses a selection of indicators with projections to 2020 and 2030 to set a baseline for the BAU scenario used for the assessment. These cover drivers, environmental impacts and resource use, as well as economic impacts.

The indicators are supplemented by **qualitative** treatment where data is insufficient to provide a reliable projection. Note that where projections are included, they are simple **statistical best-fit extrapolations** from the existing data, rather than based on a modelling approach. Some of these indicators were also used to describe the recent trends in material use and environmental impacts of buildings in the previous section of this report. However, many of those indicators are not suitable for extrapolation. In particular, those with short or fragmented data series are not included in the BAU scenario, neither are those for which an extrapolation would be disproportionately distorted by the effects of the financial crisis starting in 2007/8. Given the central role that buildings and construction played in the crisis in some countries and the considerable financial resources required for construction of buildings, the building sector has taken a particularly hard hit from the crisis. The result of this is that the BAU scenario draws on a considerably smaller set of environmental and material indicators than were used to describe the current impacts of buildings in the Problem Definition in chapter 1.

This simple approach cannot account for the complex interactions of policy and/or commercial, technological or macro-economic factors. Where possible, these are addressed qualitatively. For example, regulation promoting energy efficiency in buildings will affect the quantity and type of materials used to construct buildings. However, other factors, like technological breakthroughs, macro-economic conditions, political actions and changes in public perceptions could also lead to a change in the demand for buildings and the type and quantity of material used in building construction.

The use of materials can also be affected by their price. However it is worth noting that material costs typically constitute **only between 15% and 20% of total construction costs** (depending on a variety of factors, not least whether the building or components are factory built or constructed entirely on site)[74]. As such, small changes in the costs of individual materials, have only a **marginal impact** on the overall costs of construction.

The indicators included in the BAU and for which we have prepared projections to 2020 and 2030 are:

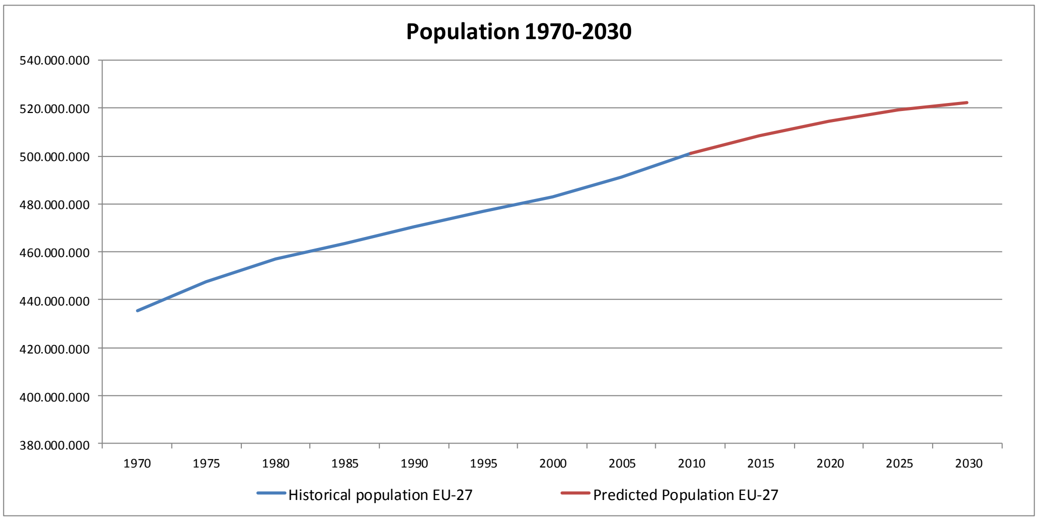
- Drivers:
  - Population;
  - Household size;
  - Floor area of buildings;
  - Housing deprivation rate.
- Material use and Environmental Impacts:
  - Gross material use and gross GHG emissions associated with construction materials (to gate);
  - Steel and cement consumption for buildings;
  - Land use;
  - Water use;
  - Construction and demolition (C&D) waste.
- Economic Impacts:
  - Gross Value Added (GVA) in the construction sector;
  - Gross Fixed Capital Formation (GFCF) in the construction sector;
  - Employment in the construction sector.

2.6.1 Drivers

Population

While no criterion can reasonably be influenced by sustainable building policy, population is the key factor driving the demand for new buildings of all types.

Figure 2.27



SOURCE: Eurostat.

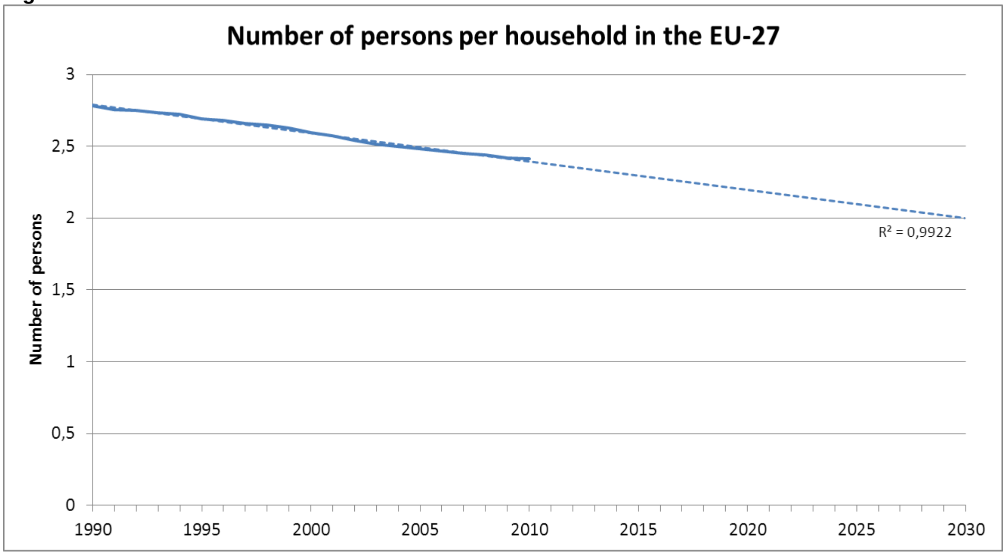
74 BWA (2006).

This is the only indicator presented in this paper for which we use a solid "modelled" projection towards 2030. It indicates that the European population will continue to grow throughout the period. By 2020, Europe will have approximately 13 million more inhabitants than in 2010, and by 2030, Europe will be home to 21 million more inhabitants than in 2010. These inhabitants must be housed and must have access to services, which inevitably leads to an ongoing demand for buildings and a potential expansion of the built environment. This indicator, while part of the baseline scenario, is not one anticipated to be affected by the policy options suggested and analysed in later sections.

Household size

Household size also provides key information about the demand for buildings, specifically dwellings. The size of households is a result of many long-term social and demographic trends (aging population, increased divorce rate, changing population, fertility rates etc.)[75]. Figure 2.28 shows that the trend over the last two decades has been unequivocal and constant: a gradual reduction in household size (persons per household). The statistical extrapolation of this trend comes, therefore, with a high degree of confidence.

Figure 2.28



SOURCE: Odyssee, Eurostat.

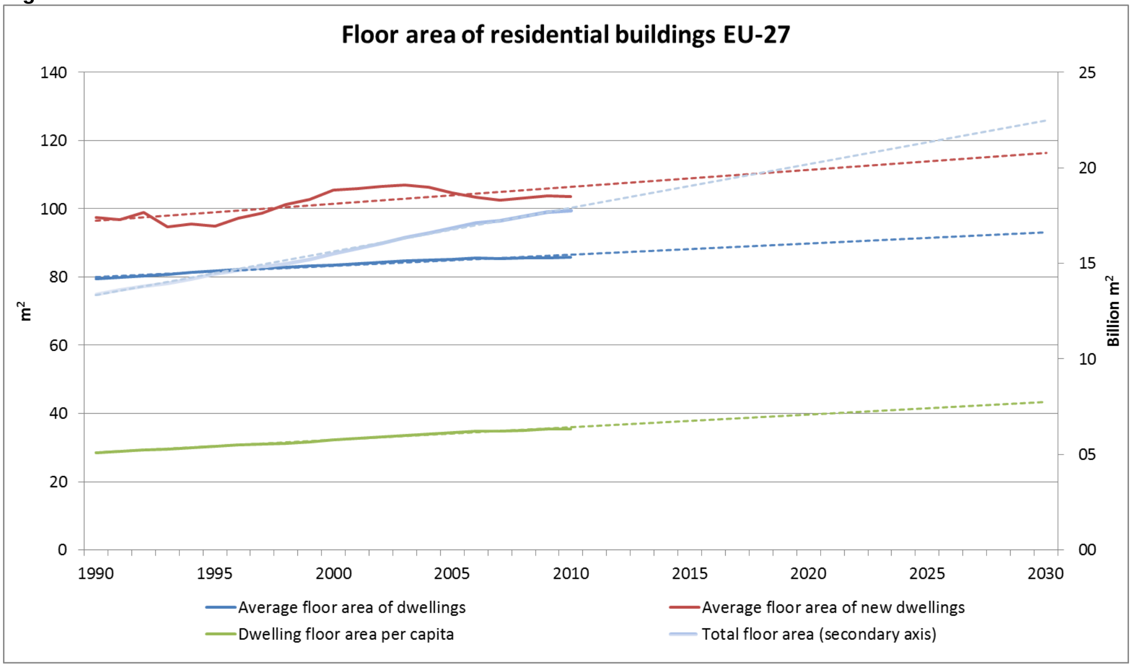
Together, Figure 2.27 and Figure 2.28 provide information on drivers for the demand for buildings. These are highly unlikely to be influenced by changes in the conditions for sustainable buildings described in the Communication as they are heavily influenced by a variety of social, political and economic factors.

Floor area of buildings

Figure 2.29 is a compound indicator for residential buildings. It shows the development in total residential floor area in the EU27 from 1990 up to 2030; the development of the average floor area of new residential buildings; the average floor area of all residential buildings; and the floor area per capita.

75 ETC/SCP, 2013. Housing assessment. ETC/SCP Working paper 4/2013.

Figure 2.29



SOURCE: Odyssee.

Generally, the extrapolated trend lines exhibit a close fit with existing trends. However, the trend in average floor area of new buildings has been more variable and as such provides a less certain projection.

The **total floor area**, with units on the right-hand axis is a very **useful proxy for overall demand for (residential) buildings**. There is a clear trend here towards ever more floor space, driven both by increase space per capita and an overall increase in population (Figure 2.27). The average size of new residences is also around 20m^2 larger than the average for the existing building stock. The trend in **size of new residences appears to have peaked around 2004**, considerably before, and therefore not as a consequence of, the financial crisis. This could suggest that there is **saturation point** in the amount of space demanded by home purchasers. It is worth noting here, also, that there is a considerable variation between countries in all of these variables: Generally, the EU-12 countries have considerably smaller average residence size and significantly fewer square meters per capita. However, the size of new build residences is approximately the same as for the rest of Europe[76].

Increasing the renovation rate and reducing the number of new build residences (i.e. making the existing building stock more desirable rather than creating new, larger building stock) could, potentially, slow the overall growth in residential floor space. Financial measures effecting the ownership or purchase of larger residences could also reduce demand, as could planning measures that favour smaller residences.

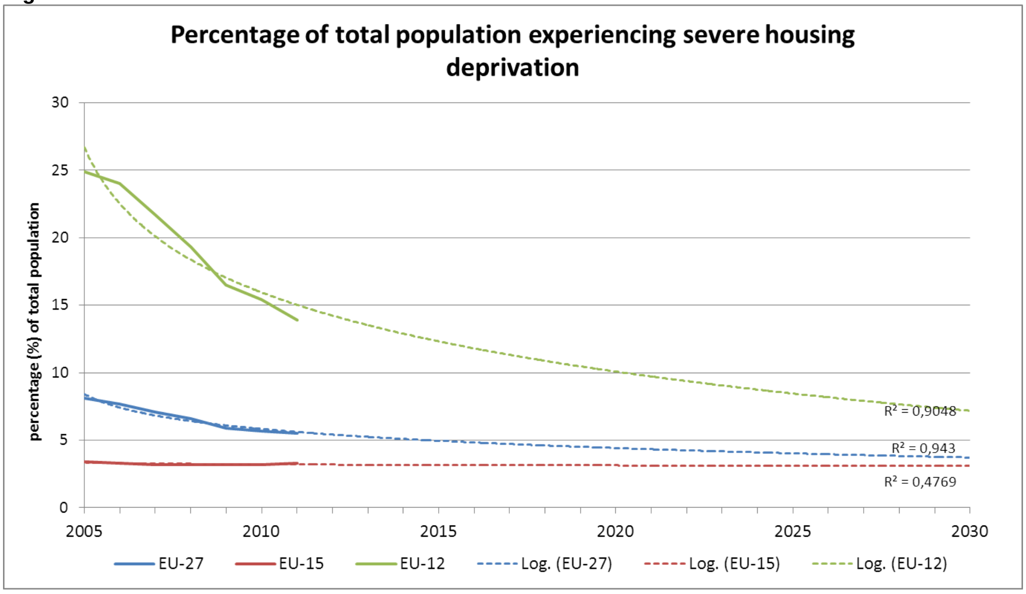
Housing Deprivation

Renovation is also a key issue in the reduction of the level of sever housing deprivation in Europe. Eurostat defines the severe housing deprivation rate as “the percentage of the population with is considered overcrowded”, while also exhibiting at least one of the housing deprivation measures (leaking roof, no bath/shower/ no indoor toilet, high level of darkness in dwelling). Overcrowding is defined by Eurostat as “households which do not have a minimum number of rooms equal to: one room for the household; one room per couple; one room for each single person aged 18 or over;

[76] ETC/SCP, 2013. Housing assessment. ETC/SCP Working paper 4/2013.

one room for each single person between 12 and 17 years of age; one room per pair of children under 12 years old". Sustainable building policy could negatively influence the housing depravation rate if it severely restricts the expansion of space per capita, particularly in the EU-12.

Figure 2.30



Source: Eurostat.

2.6.2 *Material use and Environmental Impacts*

Gross Material Use and Gross GHG Impacts

Figure 2.31 shows an estimation of the **development of total construction material use** together with associated GHG emissions. This is based on the long-term trend (1990-2010) projection figures on cement and steel, which provide an annual average increases of 0.5885% for cement use and 0.1014% for steel consumption for buildings towards 2030[77]. **The average of these growth figures is used (0.34495%)** for projecting annual increase of material use (see Figure 2.32 below**).**

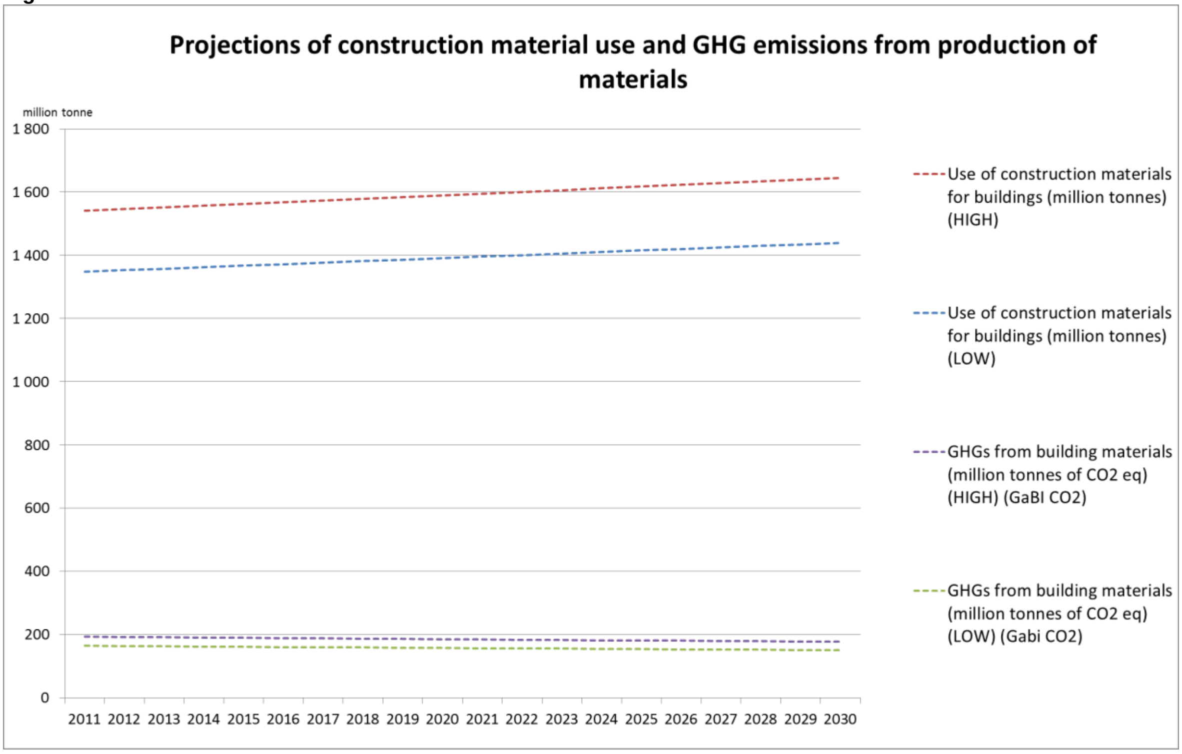
The associated GHG emissions are calculated using the projected average per annum GHG intensity decrease of **0.75% a year for steel production and 0.85% for cement production**. Based on this, an average GHG intensity decrease of 0.80% per annum is then applied to the total GHG emissions for all materials – taking a point of departure in the GHG emissions calculated in Figure 2.10 for 2011. The increase in material quantities and increase in efficiency is then applied for successive years.

GHG emissions are used as a proxy for all environmental emissions. This has the advantage of providing a solid base for comparison, and for key materials (notably steel) this assumption also holds true[78]. In case of energy-intensive processes, this is often a very accurate proxy for the overall environmental impacts.

[77] See figure 2.34 for the origins of these growth rates – based on long term trends in material *production* and projections to 2030.

[78] The percentage savings in GHG emissions from recycled steel compared to virgin steel is approximately the same as the mili-eco-Point savings from recycled steel compared to virgin steel. For more information on Eco-points see section 2.3.4.

Figure 2.31



Source: CRI calculations.

Figure 2.31 includes a high and low projection of material consumption for buildings. This is done to reflect the influence of the economic crisis on current trends in the use of building materials. The "high" projection takes a point of departure in the average material consumption over five years from 2006 to 2011. The "low" projection takes a point of departure in the actual material consumption in 2011 (as calculated in the previous sections). The "high" and "low" emissions projections reflect these two approaches to projecting material consumption.

Our projections suggest a **slight increase in the production of construction materials** (in both high and low scenarios – as the annual percentage increase is the same), and a **slight reduction in the resultant total GHG emissions**. This is because the annual increase in efficiency is expected to be greater than the annual increase in the quality of material used and suggest that GHG emissions have, on the estimations presented here, been decoupled from material use.

This is a rough estimate based on a projection of aggregated construction material production, and applies a compound of the predicted efficiency improvements for two of the most prominent building materials (steel and cement), to the total gross use of materials to arrive at a net GHG emissions for these materials.

As such it does not include any future change in the material mix used in building construction. While this is a rather arbitrary assumption, we have no data that can be used to provide an understanding of likely changes in material mix. For that short time series that we have for *all* materials, the only trend that can be inferred is that, while use of most of the materials has decreased in more or less predictable trends since 2007 (the start of the economic crisis)[79], the use of glass has been remarkably robust, and has increased over time (see Figure 2.4). Extensive utilisation of glass panels is often a feature of buildings designed for high energy performance. With

79 While our calculation found a decrease of total material used in building construction (and a projection of which would lead to an ongoing reduction in material use in building construction) this was not felt to be representative of the longterm trends. As such, the growth indicated in figure 33 is, as stated, based on predicted growth of use of cement and steel in construction as noted in the paragraphs preceding Figure 2.33.

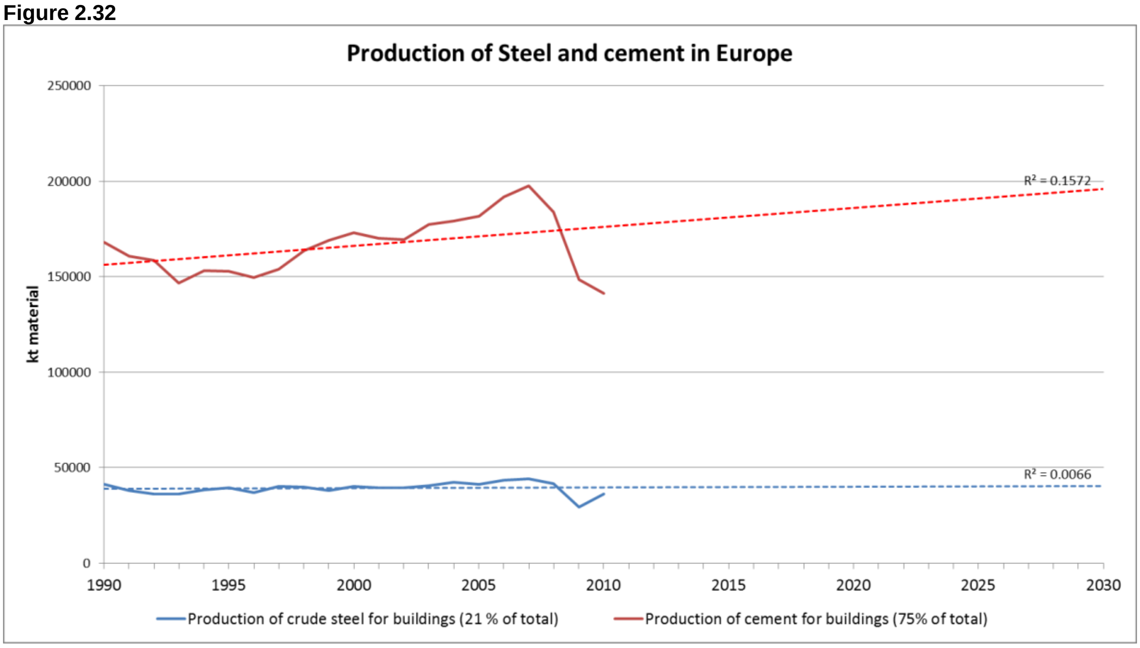
promotion of these buildings expected to continue, one could infer that the use of glass in buildings is also likely to potentially increase at the expense of other materials used for wall panels, such as brick and concrete. Change in the mixture of materials used in buildings has, to date, been driven by many factors, including legislation (particularly demands on increased energy efficiency), but also material and design innovations and cultural and aesthetic factors (including planning and heritage regulations).

Steel and cement

Cement and steel are two of the core materials used in the construction of buildings (steel is the largest non-mineral component in buildings, and cement is an ideal proxy for mineral use) and for which we have a relatively long time series on which to base an extrapolation to 2030. These will be presented in two indicators. The first provides absolute quantities of material production. The second indexes these values to 1990 and compares them to an industrial production index for construction.

These figures focus on production of material rather than use of material, and so do not take into account the effect of imports and exports. While this is not a significant issue for cement (where around 3% of European production is exported and 7% of consumption imported[80]), it does pose more of a data-quality issue for steel. The projection of steel and cement in Figure 2.32 is used to provide a single compound figure for annual growth rate for total material use in Figure 2.31.

Figure 2.32

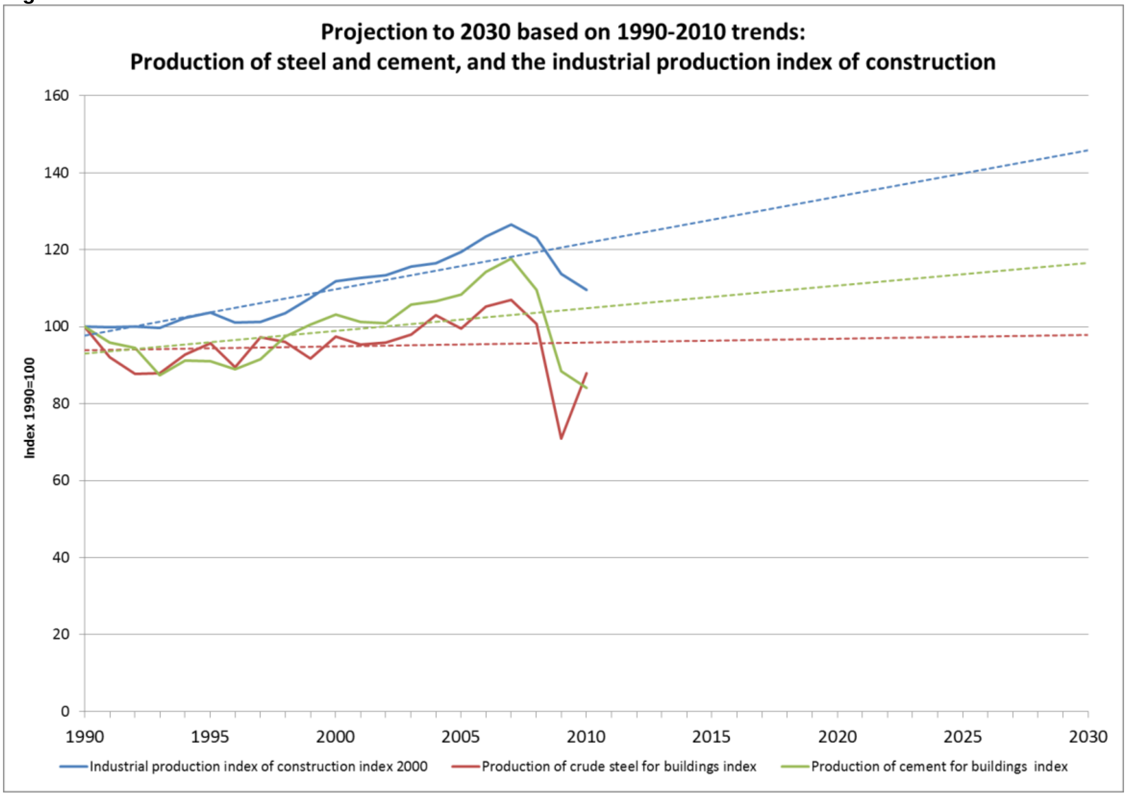


Source: CRI calculations.

Further, and unsurprisingly, they both exhibit a similar production trend as the industrial production index for construction. Figure 2.33 includes all three variables (production of cement and steel for buildings, and industrial production of construction) indexed to 1990 to allow comparison of trends. It shows that, particularly for cement, (the European consumption of which is mostly satisfied by European production) the industrial production index is a reasonably good proxy (albeit with a less amplified trend) for material use. This could be useful given that we currently have very short time series for the consumption of most of the materials used in building construction. It also reinforces our belief that the trends in the use of cement and steel for buildings is a useful proxy for the trends in use of total building materials (as applied in Figure 2.31).

80 http://ec.europa.eu/enterprise/sectors/metals-minerals/non-metallic-mineral-products/cement/index_en.htm.

Figure 2.33



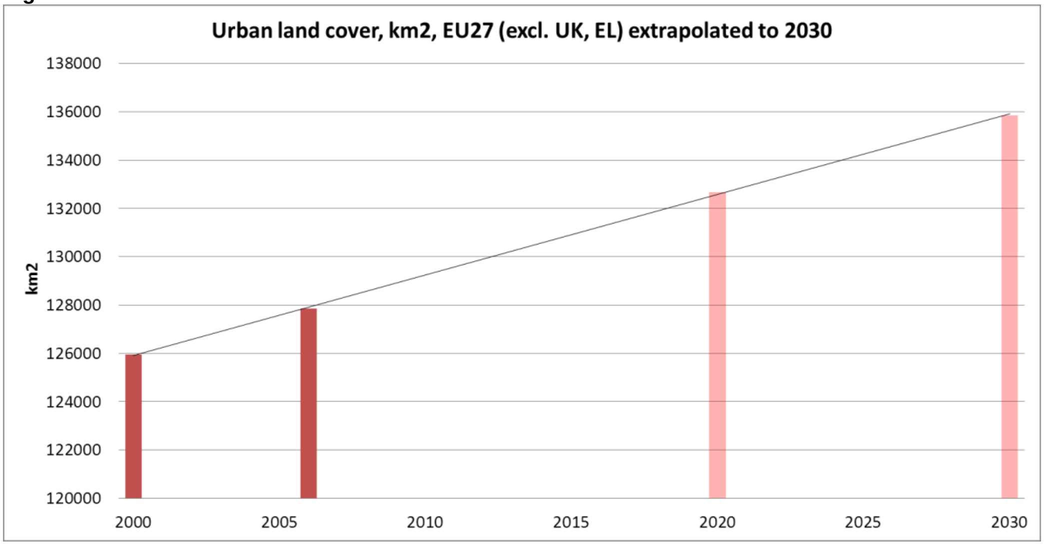
Source: ODYSSEE.

The industrial production index for construction includes all construction activities, including new buildings, renovation of existing buildings, and infrastructure. Increasing the share of renovation within construction could partially decouple trends in the use of materials and financial indicators such as the industrial production index of construction. This is because less material is required per square meter for renovation of existing buildings than for construction of new buildings. However, the extent to which renovation can meet the demand for new housing (from the demand for greater floor area and the increase in population) is unlikely to be large, as it is dependent on the conversion of non-residential (i.e. primarily industrial) buildings to residential or office space (the latter not included in the indicators on growth in floor space). Where residences are renovated, no additional new residential function is created, and so no additional demand for residential space can be satisfied. Often, in fact, renovation of residential buildings can result in an *increased* floor area per dwelling and per capita (as small apartments are combined to form larger ones), and this, in turn, can create demand for new residences.

Land use

Expansion (or, theoretically possible, contraction) of urban land cover is a useful indicator not only of the quantity of building construction activity, but also of the type of building construction and as such a proxy for the potential impacts to biodiversity. Unfortunately, only two data points exist (2000, 2006) although a third (for 2012) is currently under production. This makes projection less certain. Nevertheless, direct projection of the trend between 2000 and 2006 leads to a total urban land cover of 132 665 km^2 in 2020 and 135 867 km^2 in 2030. This is equivalent to a total increase of 6,25 % between 2006 and 2030. This is the same order of magnitude as the anticipated increase in population over the same period (approximately 4.6 %), although significantly below the projected rate of increase of total floor area (approximately 25 %).

Figure 2.34



Source: EEA CORINE.

While increased population and increase in the average floor area per capita of buildings tends to drive this increase, one could expect that increasing urbanisation will lead to a lower growth in total land cover than if the increase took place in extra-urban areas. Another study which focused on changes in global land cover, predicts an annual increase in urban land cover of 2.50 % to 2030 in Europe[81].

Urban land take (the increase in land cover) towards 2030 will have an impact on biodiversity in Europe, but the impact depends greatly on the local environment of individual developments. As noted earlier in this report, arable and pasture lands represent around 80 % of the land taken by urban environment between 2000-2006. Despite this, more forests, natural grasslands and open spaces were absorbed by artificial land cover than in the previous decade. This meant a higher loss of natural ecosystems in 2000-2006 and a higher threat to biodiversity.

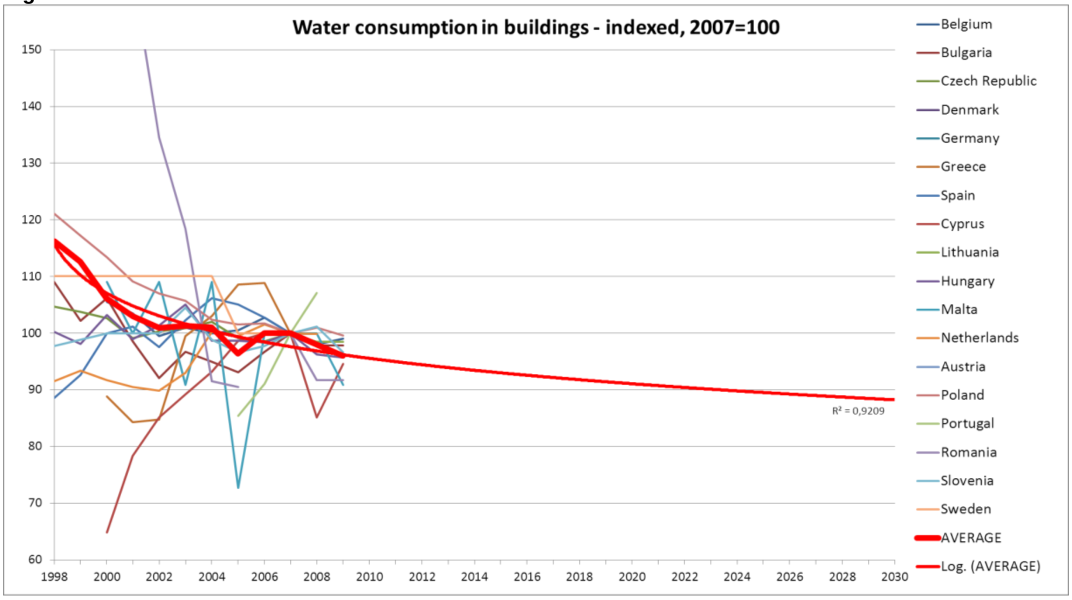
Water

Water is one of the key resources used during both construction and occupation of buildings. The importance of that resource use, however, varies significantly based on the availability of local water resources. While limited data is available for the use of water in buildings, which can be used to describe an indicator (below), there is insufficient data available to form an indicator on water used in the construction of buildings and the production of building materials and products. This situation is not expected to improve in the near future. There is no definitive methodology for performing “water footprints” of products. An added complication to the calculation is that the majority of “consumed” water is often used, cleaned and returned to the eco-system.

However, the indicator below can be used to discuss the impacts of policy options in the context of this report as many of them will have an impact on the amount of water used in the occupation phase of buildings.

[81] Seto et al, 2011.

Figure 2.35



Source: based on Eurostat and BIOIS.

The national data seems noisy given that the indicator is indexed, which would suggest that there is either significant annual variation in water consumption, or that there are quality issues with the underlying data. However, the data seem to be improving, with less variation in the years after the index year (2007) than in the preceding years. Given that water saving has become an issue in the years covered by the indicator, and that water saving technology and initiatives are gradually being introduced, it is a reasonable assumption that extrapolated residential water use to 2030 illustrated here is a close approximation to eventual water use in the absence of further policy.

A recent study[82] on water performance of buildings estimates that the residential water consumption today is 160 l/person and day and it further predicts that, without further policy intervention, the water consumption in buildings will decrease by 5% from 2010 to 2050.

Construction and Demolition (C&D) waste generation

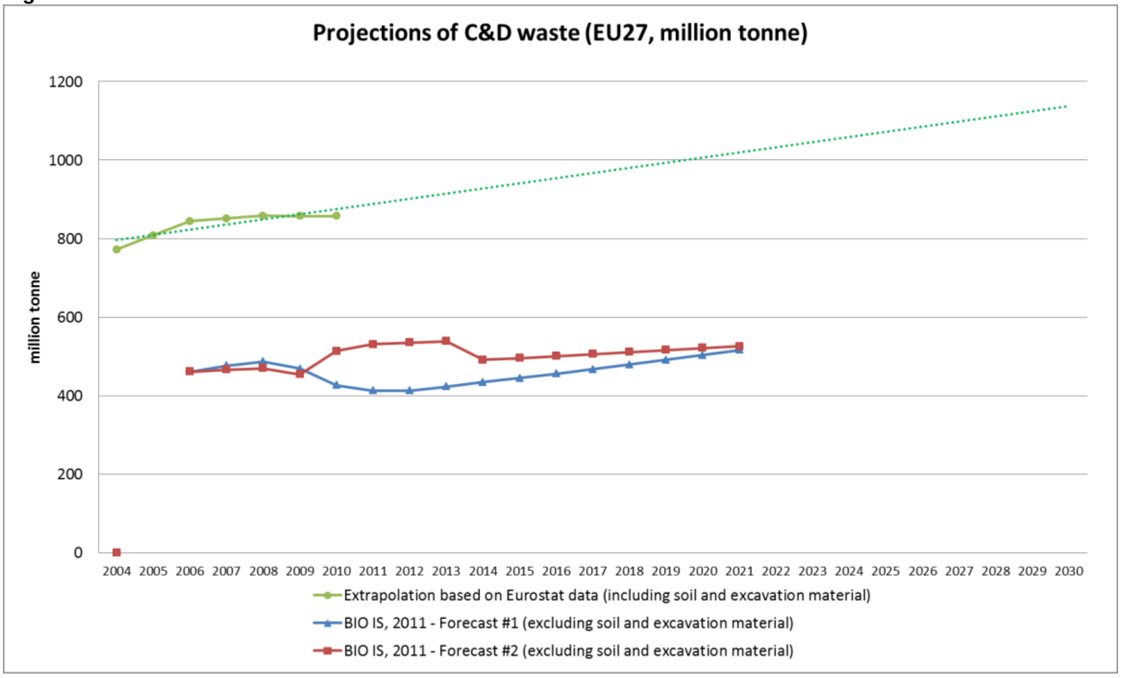
Figure 2.36 provides projections for the generation of C&D waste towards 2030. Two sources have been used, providing three different projections:

- one based on Eurostat data; and
- two drawn from a study by BIO IS for the Commission on construction and demolition waste[83].

[82] Study ssupporting the Impact Assessment for the Water Blueprint.

[83] BIO IS, 2011.

Figure 2.36



SOURCE: BIO IS (2011); Eurostat.

Only 4 years of data on C&D waste generation are available from Eurostat's Waste Data Centre: 2004, 2006, 2008 and 2010, and none of these data points is particularly reliable. The Eurostat data (and therefore projection) include excavation material. The projection of Eurostat data leads to about 1.13 billion tonnes of C&D waste generated in 2030 (including excavation material).

BIO IS for DG Environment[84] calculated the projected C&D waste toward 2020. This projection takes a point of departure in a calculated quantity of C&D waste generated in 2005 and uses economic trends and forecasts as proxies for construction activity to provide the trends in C&D waste generation towards 2020. Two forecasts were produced, using two sets of assumptions, both excluding excavation material:

- **Forecast #1** is based on the production index of the construction sector (EUROSTAT data series from 2005 to 2009, industry estimates from 2009 to 2013, and gross Business as Usual (BAU) estimates for the period 2014-2020);
- **Forecast #2** is based on assumptions for the rates of new constructions, renovation and demolition from 2005 to 2020. For this forecast, the following assumptions were made[85]:
  - Stable demolition rate at 0.1 % per year over the considered period;
  - BAU new construction waste of 1 % per year, with a slight decrease in 2008, 2009 and 2010 due to the economic crisis;
  - BAU renovation rate of 1.2 % per year, with an increase in the period 2009 to 2011, due to stricter energy efficiency targets;
  - C&D waste arise from demolition (25 %), renovation (60 %) and new construction (15 %).

The report states clearly that these forecasts are highly uncertain and should be treated with caution. The figures from the BIO IS report are considerably lower than those produced from Eurostat data for the period 2004-2010, and further in the projection/extrapolation. This is because the figures from BIO IS do not include excavation material, which has been removed because it cannot contribute toward the 70% target set by the Waste Framework Directive.

84 BIO (2011).

85 BIO (2011): pp 24.

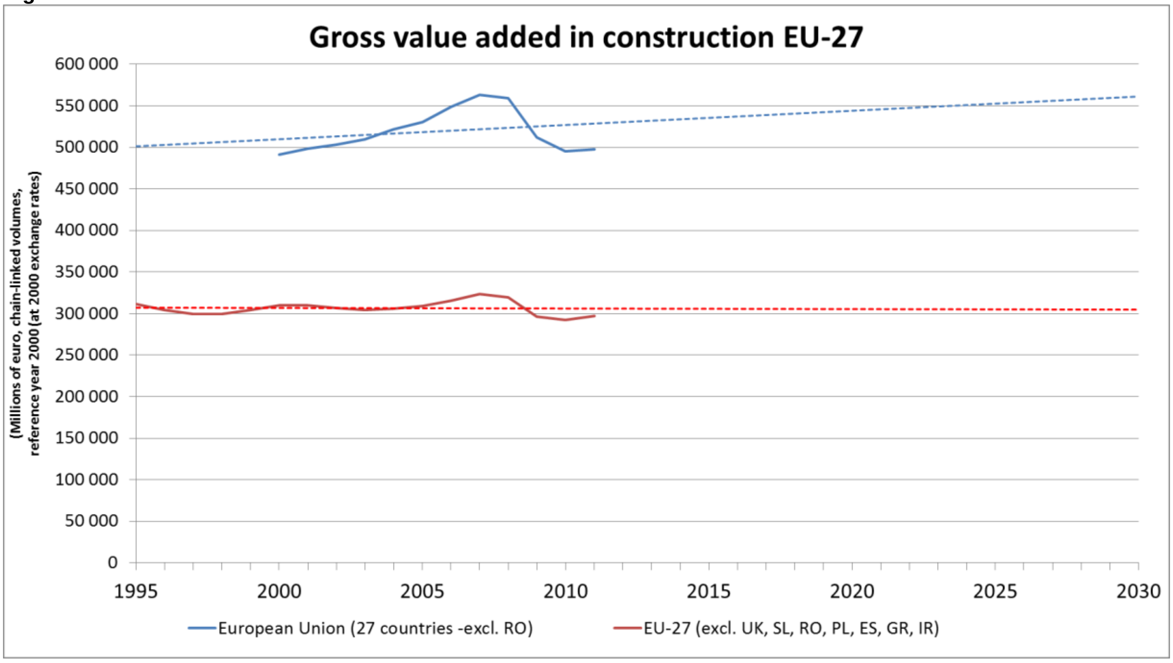
Increasing the rate of renovation compared to demolition and subsequent new build, could potentially decrease future levels of C&D waste generation. This would be in line with the principles of the waste hierarchy, which places waste prevention as the first step in waste management.

2.6.3 *Economic impacts*

Gross Value Added (GVA) in the construction sector

Ideally, we would use Gross Value Added (GVA)[86] in the construction sector to describe activity in building construction. However, the available data time series make this problematic: Eurostat only has data from 2007-2011 for the majority of the EU27. The time series can be extended back to 1995 by excluding the UK, Slovakia, Romania, Poland, Spain, Greece and Ireland. However, these countries represent a significant share of the GVA in construction. Further, the building sectors in Ireland and Spain were very strongly affected by the financial crisis, and removing them significantly decreases the effects of the crisis on the long-term trend. This, of course, has advantages and disadvantages, but we feel that, on balance, it is not an ideal solution.

Figure 2.37



Source: Eurostat.

Gross fixed capital formation (GFCF)[87]

Gross fixed capital formation – a measure of the value of acquisitions of new or existing fixed minus the disposals of fixed assets – also provides an overall indication of activity in the construction industry. Data here is available in a longer time series for the whole EU27, and follows a very similar trend. Further, the extrapolations for gross fixed capital formation have a considerably tighter fit to existing trends than those for GVA. As such, it is an excellent proxy for total economic activity in the construction of buildings.

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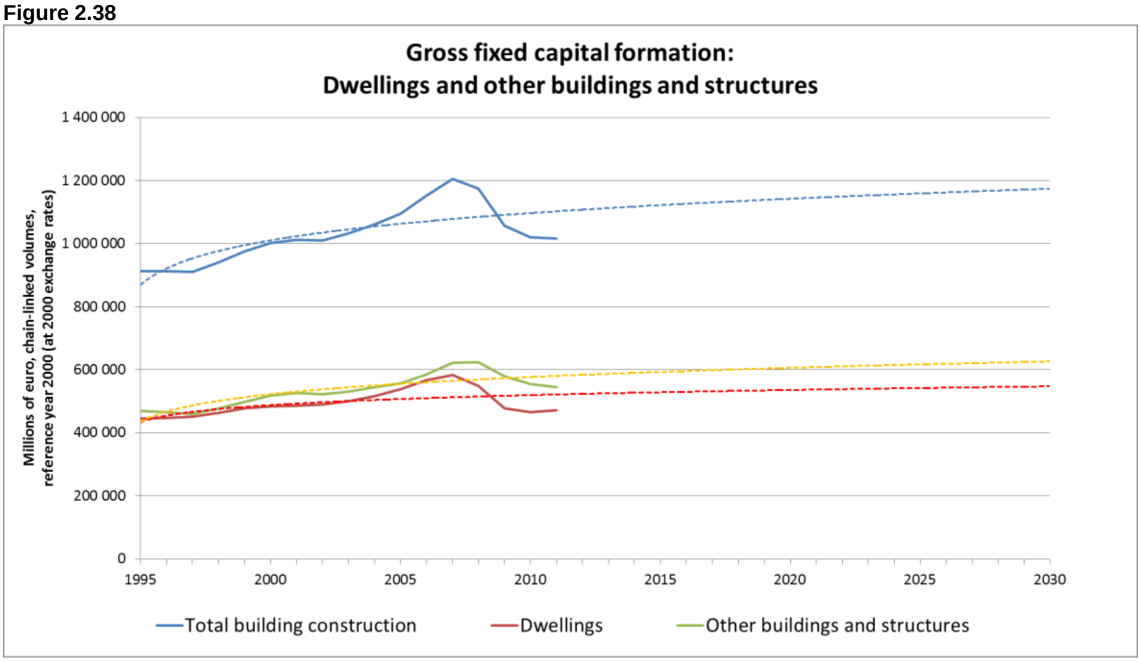
86 **Gross Value Added (GVA)** is the net result of output valued at basic prices less intermediate consumption valued at purchasers' prices. **Output** consists of the products created during the accounting period**. Intermediate consumption** consists of the value of the goods and services consumed as inputs by a process of production, excluding fixed assets whose consumption is recorded as consumption of fixed capital. The goods and services may be either transformed or used up by the production process. GVA is calculated before consumption of fixed capital.

87 **Gross fixed capital formation - GFCF** consists of resident producers' acquisitions, less disposals, of fixed assets during a given period plus certain additions to the value of non-produced assets realised by the productive activity of producer or institutional units. **Fixed assets** are tangible or intangible assets produced as outputs from processes of production that are themselves used repeatedly, or continuously, in processes of production for more than one year. **Disposals of fixed assets** are treated as negative acquisitions.

Figure 2.38 disaggregates GFCF for building construction into that from “dwellings” and that from “other buildings and structures”. It is interesting to note that GFCF from “dwellings has been hit harder by the economic crisis that from “other buildings and structures”. The baseline projections in Figure 2.38 can be used to assess the potential impacts of policy options that increase or decrease activity in the construction of buildings and can help illustrate where any given benefit will take place (between “dwellings” and “other buildings and structures”). Of course, it cannot be used to identify whether any given policy initiative will provide a net benefit.

Figure 2.38

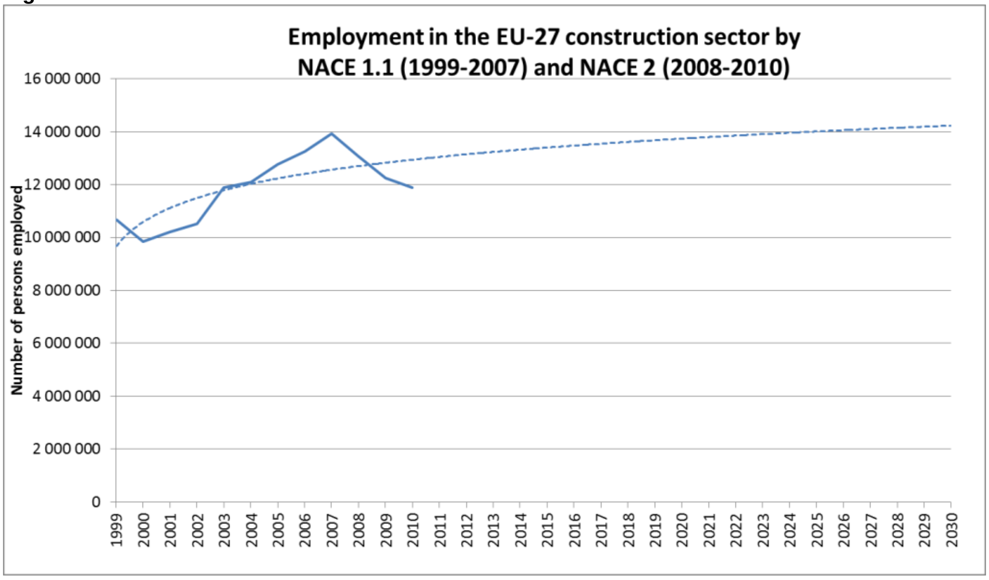


Source: Eurostat.

Employment

The construction industry is a significant European employer and given the current economic crisis, the ability of the Sustainable Building Communication to increase employment is critical. Employment is therefore an important part of the baseline scenario. The time series for employment within the construction sector run from 1999-2010 and vary significantly during this period. In addition, the change in NACE classifications coinciding with the financial crisis (2007/2008) also introduces an element of doubt, and makes ascertaining the roles of each in the overall trend difficult. As such, the extrapolation provided in Figure 2.39 can only be assumed to give a very approximate baseline indication of employment in the construction sector in 2030. However, increasing the sustainability of buildings should influence employment in the construction sector, so despite the limitations of this projection, we felt that it was a necessary component for an assessment of policy options for sustainable buildings.

Figure 2.39



Source: Eurostat.

2.6.4 *Baseline Conclusions*

The above indicators and qualitative analysis provide a baseline scenario towards 2030 and can be used in the assessment of the policy options presented later in the report.

The principle drivers for the demand for buildings in Europe are a **growing population** and the **increasing floor space per capita**. This is compounded and affected by the **decrease in average household size** created by a complex combination of social, political and economic factors. New residences tend to be, on average, larger than existing residences, and there will be **an additional 21 million Europeans demanding all kinds of buildings by 2030**. Decreasing the housing deprivation rate is also a driver for new (residential) buildings and renovation, particularly in some EU-12 countries. Total building floor area looks set to keep on increasing towards 2030 in the absence of policy intervention. The impacts of this expansion in floor area depend largely on the form that these buildings take, how and where they are built, and how they are used.

While projections of individual materials would have been ideal, this was, on the one hand, severely limited by the length of time series and quality of the available data on resource consumption. On the other hand, it would also be in opposition to the Commission's stated desire (in the context of this project) not to favour any given material – a position that would be severely undermined by the comprehensive inclusion of individual materials in the baseline scenario. Projections for steel and cement have, however been included, as they provide a useful indication of how current trends in material use could carry on into the future (as a more stable and longer time series was available), and have been used as proxies for total material use. They are well suited to this, as both materials are used extensively in buildings and are responsible for a large degree of the impacts from building materials. The average growth rates of cement and steel were used to provide a compound growth rate for all materials.

The projection of total material use in the construction of buildings does not incorporate any change in material mix. While we are certain that there will be some alteration of the total material mix in buildings, there is no way to predict what this change could be. Anecdotal evidence suggests that the push for better energy performance in buildings will lead to an increase in the use of glass and insulation material, although the extent to which this change has already taken place (for new buildings, and therefore reflected in the most recent figures for material consumption) is difficult to assess.

The projected increase in total material use has been supplemented by projections in gross GHG emissions from the production of these materials. These have been derived from the quantity of material use and the anticipated compound efficiency improvements in the production of cement and steel. This would suggest that, in the absence of additional policy intervention, **GHG emissions from the production of materials in buildings will decrease by approximately 8.25% by 2030**. Please note that this projection is highly uncertain and subject to all of the caveats mentioned previously in this report.

The improvements here are solely the net result of (predicted) efficiency improvements in the production of construction materials (derived from an average of the predicted efficiency improvements in steel and cement production) and the change in projected material consumption over time (derived from an average of the predicted activity in the steel and cement industry). That is to say, it does not specifically account for improvements in the design of buildings with the goal of increasing sustainability. This is partly because any improvement induced by the initiatives mentioned in section 2.5 are either assumed to be reflected in the trends of material consumption described above or are still too new to inform the analysis. The impact of the economic crisis severely complicates the identification of any material efficiency improvements in building construction.

The environmental consequences of sustainable construction/buildings assessment frameworks mentioned in section 2.5.3 are also difficult to identify. Limited information is available about the particular savings that the frameworks create in specific building scenarios, but also, as existing frameworks are voluntary, the use of frameworks reflect a desire of the developer to take on the responsibility to make those savings (that can be calculated and aided by frameworks) rather than the impact of the frameworks themselves. These savings could have been achieved (and in many cases probably have been achieved) in the absence of an assessment framework if the developer is intent on producing a sustainable building. That is to say, while it is theoretically (although generally not practically) possible to assign a specific improvement potential over an industry standard building, it is not conceptually possible to assign a specific (nor any) improvement potential over a building that is developed with the aim of being sustainable (or energy efficient) that does not conform to, or take place within, a specific assessment framework.

The economic indicators presented provide a snapshot of the importance of construction to the European economy. They provide a baseline against which potential improvements can be measured on the macro scale, and provide a useful gauge of the relative size of any costs anticipated to be incurred by initiatives to improve the sustainability of buildings.

2.7 Objectives

The policy objectives of the draft Communication on Sustainable Buildings have been defined largely by the Commission, with input from the consortium on the strength of the problems identified jointly by the Commission and the Consortium.

The analysis above highlights that the majority of environmental impacts from buildings (excluding the consumption of energy during occupancy) are linked to a relatively small group of materials. While these are more or less regulated through national and regional strategies, existing environmental regulation and in terms of material quantities and qualities, often by building regulations themselves, the communication for sustainable buildings is not a suitable policy forum to address these materials directly (and the ability of policy to make significant changes to the environmental profile of these materials without simultaneously and fundamentally changing the market for those products seems weak).

However, it is possible to influence the utilisation of these, and indeed all, building materials indirectly by seeking to change the demand and supply dynamics for buildings generally and sustainable buildings in particular. For example, reducing the need for and expansion of the built environment (through policy that seeks to improve the efficiency of use of space, for example) indirectly influences the demand for *all* building products (including those that we have highlighted as particularly resource and environmentally intensive). Similarly, the facilitating better information collection and provision about the environmental impacts of products and buildings can influence the way in which product and building designers approach their work and developers specify building attributes. These factors that influence the market for sustainable buildings represent the best leverage point to improve resource efficiency and reduce the environmental impacts of buildings.

As such, policy interventions addressing the supply of sustainable products, buildings and developments, as well as policy influencing demand parameters (both the demand for sustainable buildings and the wider demand for interior space), are more useful in this context. Initiatives in this area can potentially provide framework conditions that can drive more efficient use of these key impact materials.

In cooperation with the Commission, the following short list of key objectives was established. These address the key issues briefly described above:

- Raise awareness of and demand for better environmental performing buildings, among private consumers, developers and public purchasers;
- Improve knowledge and information regarding resource use and related environmental impacts in relation to buildings in order to support decision making among designers, architects, developers, construction companies, construction product manufacturers, investors, consumers etc.;
- Remove the barriers created by different sets of requirements concerning the environmental performance of buildings;
- Improve material efficiency, including the prevention and management of construction and demolition waste;
- Support more intensive use of buildings in order to reduce the need for further built environment (e.g., use empty buildings instead of new building new ones, use buildings for more than one purpose when suitable, build flexible buildings to be adapted to new functions or changing needs when appropriate).

Together, these five objectives provide a basis for the exploration of potential policy options that could be applied at EU or national level to help improve the sustainability of buildings.

3 Policy Options

3.1 Background to the analysis

The analysis focuses on certification systems for commercial and residential buildings present and used in the EU27. This concerns mainly private and public voluntary sustainable schemes and the energy performance certification system used under the Energy Performance of Buildings Directive (EPBD). This section of the report describes the current state of development of these certification systems.

3.1.1 Overview of voluntary sustainable certification schemes for buildings in Europe

From the screening and analysis of the existing market for certification schemes for buildings (both energy and sustainable schemes) in the EU, it can be concluded that EU27 can be roughly divided into two blocks:

1. countries where voluntary sustainable and energy certification schemes have been developed (some of which are used internationally) in addition to the Energy Performance Certification (EPC) rating system under the EPBD certification, and
2. countries where own voluntary certification schemes have not been developed, and which to a large extent utilise the mandatory EPC certification scheme system implemented under the EPBD and make limited use of additional voluntary sustainable certification schemes.

Countries where sustainability certification systems have been developed include (and an example is given):

Country	
The United Kingdom - BREEAM France - HQE Germany – DGNB, DE-BREEAM Denmark – DK-DGNB Sweden – Miljobyggnad, SE BREEAM Italy – Casa Clima Portugal - Lider A	The Netherlands – NL BREEAM, Spain – ES-BREEAM, Verde Czech Republic – SBTool ICZ Austria – AT-BREEAM, OGNI Belgium – Valideo Finland – PromisE assessment tool

An overview and comparison of the main schemes used in Europe is provided below. However, these schemes are mainly developed and used for commercial buildings. The large stock of residential buildings in Europe is not certified yet and only a few countries in Europe have to our knowledge developed sustainable certification schemes largely used for residential buildings. These countries include the UK, France and Sweden. These schemes are also described below.

In the rest of the EU, we found little evidence of additional voluntary sustainable certification schemes developed at the national level, and public and private users of such schemes rely primarily on the mandatory certification system developed under the EPBD, which contains certification only related to energy performance or have the possibility to use one of the existing schemes in other countries (for commercial buildings). However, in these countries, internationally used schemes, such as LEED or BREEAM, are used to a very limited extent as the data suggest. Tables 1 and 2 below show the use of the main schemes per MS for commercial buildings.

The limited use is due to the high costs of the international schemes, low market demand for such schemes (e.g. a small country, stagnating construction sector, etc.), and/ or little resources at the national level to develop and run these schemes. Low awareness of the advantages of these schemes has been mentioned also as one potential reason.[88] In these countries, the leading schemes are mainly used by international and European actors operating in multiple countries, investors, developers and industry to reward the best performers. For the residential sector, there is still a gap in the market for sustainable certification schemes across the majority of EU countries.

Voluntary sustainable certification schemes are mostly private schemes developed by the national Green Building Councils, independent organisations, institutes, agencies and other private initiatives as well as in-house by large private companies. In terms of public schemes, there is a GreenBuilding voluntary scheme developed by the European Commission (JRC operated), however, it focuses only on energy performance. This GreenBuilding Programme was initiated by the Commission in 2005 to enhance energy efficiency in the non-residential buildings of both existing and new buildings. However, this programme has not gained momentum yet.

For **commercial buildings**, an overview of the most important voluntary sustainable schemes used in Europe is presented in the table below:

Table 3.1 Overview of voluntary sustainable schemes in the EU27

Name	Country origin	Year creation	Other countries*	Owner	Public vs private
BREEAM	United Kingdom	1990	> 10 countries	BRE	Private
CasaClima Nature	Italy	2008	1 - 2 countries	Agenzia CasaClima	Public
DGNB	Germany	2007	> 10 countries	DGNB	Private
GPR Gebouw	Netherlands	1995	None	W/E adviseurs (company)	Private
GreenCalc+	Netherlands	1996	None	NL Green building council (was Sureac Foundation operations)	Private
HQE	France	1992	5-10 countries	Assocation HQE	Private
Klima:aktiv	Austria	2009	1 -2 countries	Klima:aktiv	Private
LEED	United States of America	1998	> 10 countries	U.S. Green Building Council	Public
Miljöbyggnad	Sweden	2005	1 - 2 countries	Swedish Green Building Council	Private
OGNI	Austria	2009	5–10 countries	ÖGNI; DGNB Partner	Private
SBTool ICZ	Czech Republic	2010	None	Technical and testing centre Prague	Private
TQB2010	Austria	2009	1-2 countries	ÖGNI	Private
Valideo	Belgium/ Luxembourg	2008	1–2 countries	SECO, BCCA and BBRI	Private
VERDE	Spain	2002	None	Spanish Green Building Council	Private

Source: Study prepared by Triple E Consulting for DG ENER (ongoing)

* Other countries means rest of the world

Based on the current data on the number of certifications for commercial buildings by several leading schemes in Europe (Table 2), it can be seen that BREEAM is leading the European market. According to the new RICS survey Going for Green, which includes pre-certificates and certificates for commercial properties (office, retail, logistic, hotels, etc.), BREEAM accounts for more than 80% of all sustainable building certificates in Europe. [89] In numbers, BREEAM has issued around 7829 certificates across EU28 (for new/ refurbished as well as existing commercial buildings) out of a total of 9669 sustainable certificates in EU28 under BREEAM, DGNB, LEED and HQE. The

[88] Discussions during an expert meeting for a common EU voluntary certification scheme for energy performance of non-residential buildings, part of on-going project for DG Energy

[89] RICS, “Going for Green, Sustainable Building Certification Statistics Europe”, September 2013

numbers per Member State are presented in the table below. RICS 2013 survey is the most up-to-date and comprehensive source.

Table 3.2 Overview of key leading schemes and their approximate market share among commercial certified buildings

Country	BREEAM		LEED		DGNB		HQE	
	Retrofit and New Build	Existing Stock	Retrofit and New Build	Existing Stock	Retrofit and New Build	Existing Stock	Retrofit and New Build	Existing Stock
Austria	2	2	5	1	43			
Belgium	39	72	2				5	
Bulgaria	1		2	1	2			
Croatia								
Cyprus								
Czech Republic	11	19	7	2	1			
Denmark		1	3	2	8			
Estonia			1					
Finland	13	5	27	10				
France	83	51	11				955	125
Germany	9	85	46	11	349	5	1	
Greece	1		1					
Hungary	14	12	6	2	2			
Iceland	4		1					
Ireland	22		2	1				
Italy	9	11	32	3			1	
Latvia								
Lithuania		2						
Luxembourg	9	4			7		7	1
Malta	1		1					
Monaco	1							
Netherlands	25	138	5	1				
Norway	3		1	1				
Poland	38	80	14	2				
Portugal	2		2					
Romania	10	8	2	1	3			
Russia	7	6	6					
Serbia		2						
Slovakia	2	6	2		1			
Slovenia	1							
Spain	9	18	35	4				
Sweden	13	10	33	5				
Switzerland	1	8	9		2			
Turkey	17	14	34	3	1			
Ukraine	1							
United Kingdom	6940	51	38	1				
Total	7288	605	328	51	419	5	969	126

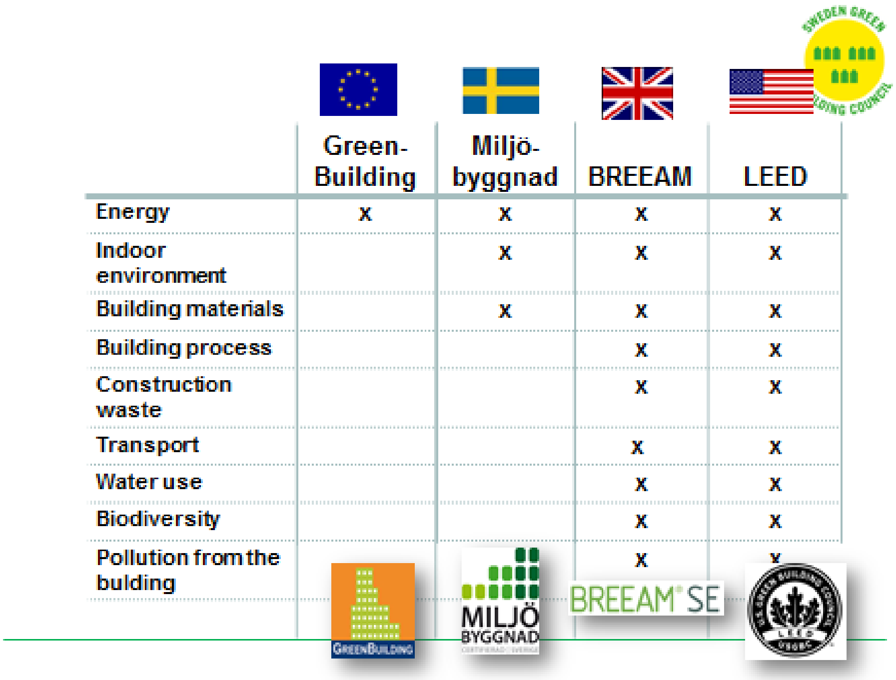
Country	BREEAM		LEED		DGNB		HQE	
	Retrofit and New Build	Existing Stock	Retrofit and New Build	Existing Stock	Retrofit and New Build	Existing Stock	Retrofit and New Build	Existing Stock
Total all schemes = 9791	7893		379		424		1095	
% share	80.6%		3.9%		4.3%		11.2%	
EU 28								
Total	7254	575	277	47	416	5	969	126
Total all schemes = 9669	7829		324		421		1095	
% share of all schemes	81.0%		3.4%		4.4%		11.3%	

Source: RICS (2013) 'Going for green' report, the cut-off date of the survey is March 31, 2013, if no information provided, field left blank; the survey includes pre-certificates and certificates for commercial properties (office, retail, logistic, hotels, etc.) but no certificates for residential properties

Hence, in total the four major schemes account for approximately 9669 certifications (EU28). There are several minor additional schemes but these are small in terms of numbers. In these cases, one certification typically assumes one building.[90]

The main difference between these schemes is the environmental and energy aspects they cover (see for example figure below) and the weight they give to different environmental categories (description and comparison of the main schemes is described in Annex A. This makes benchmarking or comparison between schemes difficult as their bases, scope and indicators differ.

Figure 3.1 Overview of aspects covered in four schemes



Source: Swedish Green Building Council

For **residential buildings**, the situation regarding certification is different. BREEAM reports to date 17 353 certified projects under the Code for Sustainable Homes and Ecohomes, which corresponds to over 418 000 individual dwellings.[91] The description of the Code for Sustainable Homes and its

[90] Interview with BRE
[91] Interview with BRE

latest developments can be found in Box 1. HQE reports 245 648 certified residential 'units' under their scheme.[92] In total, this gives an estimate of 673 317 certified commercial and residential buildings in Europe at a minimum for the UK and France**.** Swedish Miljöbyggnad scheme also targets residential buildings. For example, two very large nation-wide owners of apartment buildings (HSB and Riksbyggen) have taken the decision to certify all their new and renovated buildings. The market is said to be booming.[93]

In France, the HQE for residential buildings started off as a mandatory requirement for social housing in order to get government's financial support – this is similar to the UK CSH. Since 2005 it is however, voluntary for social housing. After that they started to develop slightly different schemes for different kinds of residential buildings. Today, 90% of social housing is certified. Public authorities operate these houses and are thus interested in quality and low operating costs. In addition, public authorities receive financial support for the construction of certified homes. 40% of residential buildings of private developers are certified as well. In the latter case the drivers are financial or environmental interest. As for individuals, there are very few certified homes as they do not have an investment strategy and financial aspects are less clear to them. The drivers in this case are financial incentives for energy performance but also to sell better. Most of the French certificate schemes are multi-criteria, i.e. include a wider environmental approach. The energy request push for certification in the first place and the other criteria come along with the help of the multi-criteria approach.

In Germany, the DGNB also has a system for new residential buildings such as apartment blocks, as well as a system for new small residential buildings for less than 6 units or single-occupation homes. Amongst other things, the latter has been used to certify some prefabricated single-occupation house types. However, the DGNB does not currently have a system for existing residential buildings

Box 1: The Code for Sustainable Homes (CSH) and its latest developments

The Code for Sustainable Homes (CSH) is linked to all housing built with Government funding. It is an environmental assessment method for rating and certifying the performance of new homes based on BRE Global's EcoHomes scheme and is a major tool in the Government's target for all new homes in England and Wales to be zero carbon by 2016. The Code is voluntary in the private sector, but since May 2008, most building control departments have adopted it.

In 2010 the Government announced the need for an industry-led examination of housing standards, to simplify and rationalise them. The examination started in 2011 and the results were reported in June 2012. The main outcome was that rationalisation is possible and as much material as possible should be transferred to the national Building Regulations. The objectives of the restructuring were the establishment of a clearer divide between planning policies and technical regulations and the transformation of carbon and energy targets in the Building Regulations[94]. The three options presented in the Department of Communities and Local Government (DCLG) review[95] are:

A. whether government should develop a nationally described standards set which would operate in addition to the Building Regulations (rigorous local needs and viability testing indicated support for this option);

[92] Information provided by the World Green Building Council
[93] Interview with the Swedish Green Building Council
[94] Department of Communities and Local Government (2013) Housing Standards Review. Consultation.
[95] Department of Communities and Local Government (2013) Housing Standards Review. Consultation.

B. whether government should develop a nationally described standards set as a stepping stone en route to integrating standards into Building Regulations at a future date *(option preferred by the Government)*;

C. whether the government should move now to integrate standards directly into building regulations, as functional tiers, and no technical standards would remain at all outside of the Building Regulations system, recognising that this will take time and may require legislative change.

After the publication of the Consultation Review disagreement was voiced by different stakeholder groups and associations because standards are likely to be lowered. Some of the arguments include:

- economic effects could hit building material manufacturers in the UK as they use the Code as a green quality standard when they sell their products abroad;
- higher costs and delay in the planning and design phase due to the shift of the planning standards to local councils which could lead to different local or regional planning and design requirements;
- concern that the ability of local planning authorities to adopt proactive strategies will be restricted[96] and that national and local government may no longer set prescriptive requirements for developments to meet sustainable rating tool standards[97]
- concern that the Code has not been properly deconstructed and thus key elements that should be retained are included in other standards, absorbed into badged guidance or explicitly taken out of any regulatory regime;
- concern regarding the lack of co-ordination between the relevant regulatory and non-regulatory regimes and the potential confusion emerging by that.

A recent discussion about 'The future of rating tools' organised by the UK-CBG provided a valuable insight on the view of developers and users of schemes about current advantages and criticism in the sector. One suggestion was that economic and social sustainability should also be included in the assessment in order to make the tools relevant to a wider section of society and encourage high quality design that takes into account the needs of the wider population. Another proposition was that rating tools should focus on the outcomes, and not on the process. Furthermore, there was wide agreement that the existing rating tools need to be revised and that the inclusion of the industry is vital for this process.[98]

3.1.2 Share of certified commercial and residential buildings in Europe

To estimate the share of certified commercial and residential buildings in Europe by voluntary certification schemes, we applied the following methodology:

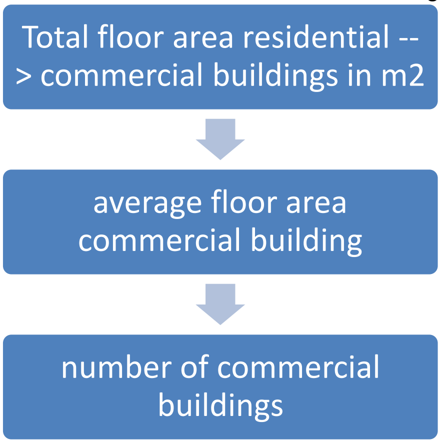
For the number of **residential buildings** in the EU27 (single and multi family houses in 2013), we made use of the Odyssee database, which reports on this data (as well as on the average floor area of a dwelling). The Odyssee database is maintained by Enerdata and contains public and private data about energy related issues in industry, transport, housing and services, as well as related economy-wide indicators. The data is drawn from a wide variety of public and private sources, and Enerdata do not publish the methodologies used to compile the data. This means that it is not possible to scrutinise or directly validate the data. However, the Odyssee database is regularly used by European institutions, including the EEA, and is considered a reliable data source. ODYSSEE reports 205 million dwellings in 2011. To estimate the number of dwellings in 2013, we made a projection based on the gradient of the best fit line (historical time series 1990 – 2011), which amounted to 208.7 million dwellings.

[96] Environmental Audit Committee (2013) Code for Sustainable Homes and the Housing Standards Review, p.11
[97] UK-GBC Debate: The Future of Rating Tools
[98] UK-GBC Debate: The Future of Rating Tools, http://www.ukgbc.org/document/uk-gbc-debate-future-rating-tools-write

To calculate the current number of **commercial buildings**, we used information on the total floor area split between residential and non-residential buildings (assuming the majority of non-residential buildings correspond to commercial buildings as public buildings cover approximately 12% of the total building stock, see section 2.1.1of this report) and an assumption on average floor area for commercial buildings, both based on the information provided by BPIE. Organisations such as BPIE collecting such information report building stock statistics only in terms of floor area (m2). They do have data on number of buildings/dwellings for few EU countries (2-3), however, there is not enough information to draw the European overview.[99]

The methodology applied is graphically presented in Figure 1-2.

Figure 3.2 Calculating the current number of commercial buildings



The total floor area is approximately 75:25 between residential and non-residential buildings (based on the split reported in the BPIE report).[100] The total residential floor area has been calculated by multiplying the number of dwellings by the average floor area of a dwelling (based on data from Odyssee). For the average floor area per dwelling we used the most recent value from 2011, i.e. 87m2 and extrapolated it to 2013 based on the gradient of the best fit line, resulting in 88m^2 in 2013. This gives an estimate of a floor area of 18.4 billion m^2 in 2013. Cross-checking with data provided by BPIE, the latest estimates of the total floor area for residential buildings was 18.8 billion m^2.[101]

Since the floor area for non-residential buildings is approximately one third of the area of residential buildings (see 75:25 reference above), this gives an estimate of 6.1 billion m^2 floor area used for non-residential buildings in 2013. We use this estimate as a proxy for the floor area of commercial buildings as we know that only limited part of this goes to public buildings. To estimate the average floor area per commercial buildings, we made use of the BPIE information.[102] This states that the majority of commercial buildings have a floor area in the range of 200 – 1000 m^2. For the purposes of this analysis we assume average floor area of 250 m2 per commercial building. Based on this assumption, this results in an estimate of 24.4 million of commercial buildings in EU27 in 2013.

In total, we can estimate approximately 233 million residential and commercial buildings in the EU27 in 2013.

[99] Information provided by BPIE
[100] BPIE (2011) Europe's buildings under the microscope
[101] Information provided by BPIE
[102] BPIE (2011) Europe's buildings under the microscope

Table 3.3 Overview of current number of residential and commercial buildings

Current situation	
Residential buildings	
ODYSSEE data # residential buildings (million)	208.7
Average floor area per residential building in 2013 (m2)	88
Residential buildings floor area (million m2) based on ODYSSEE	18,366
Residential buildings floor area (million m2) based on BPIE	18,773.4
Commercial buildings	
Commercial buildings floor area (million m2)	6,102
Average commercial floor area (m2)	250
Number of commercial floor buildings (million) based on ODYSSEE	24.4
Total residential and commercial buildings (million)	233.1

Source: Floor area data based on BPIE and ODYSSEE, number of residential buildings based on ODYSSEE, number of commercial buildings own calculations

To calculate the share of certified commercial and residential buildings in 2013, we used the data presented above on the number of certifications and the calculated number of buildings above. For residential buildings, we used the information on certified residential buildings from the UK and France to assess the number of certified residential buildings in Europe. This is an underestimate as it does not include statistics from for example Sweden, however, this is the best estimate we can derive at this stage.

Based on this, we derived the following estimates:
- Share of certified commercial buildings equals to 0.04%;
- Share of certified residential buildings equals to 0.32%.

Regarding the change in certifications for retrofit and new build between 2011/2012 and 2012/2013, there has been an increase of approximately 3,120 certifications for commercial buildings during this time in Europe. This is mainly due to the significant increase in the use of BREEAM in the UK (amounting to an increase by 2,761 certifications within this year).[103] Unfortunately the statistics do not report on the share of new buildings that are being annually certified.

3.1.3 Generation of data and awareness

Due to the differences in schemes, currently no comparable data is generated across the EU. Even within a single scheme, it is often difficult to produce aggregated figures.[104]

3.1.4 Current state of implementation of the EPBD

The adoption of the Energy Performance of Buildings Directive (Directive 2002/91/EC,EPBD), first published in 2002, required all EU countries to enhance their building regulations and to introduce energy certification schemes for buildings. The recast EPBD in 2010 (Directive 2010/31/EU) introduced mandatory certification of new and existing buildings (constructed, sold or rented out to a new tenant) along with periodic certification of public buildings.

The MS still have until 2020 to implement the measures introduced by the recast EPBD. Concerted Action provides the following update on the progress so far (by March 2013):

[103] RICS Going for Green reports, 2012 and 2013.
[104] Interview with DGNB

- 6 MS have their national application of the NZEB definition legally fixed and another 6 MS are ready but have not yet published the national application of the NZEB definition in a legal document.
- 12 MS had provided the EC with their national plans for increasing the number of NZEBs
- Several countries use public buildings as lighthouses for the general development of high performance buildings.[105]

Pilot and demonstration projects of NZEB have been realised in the MSs and promotion and subsidy programmes support their market implementation. These kinds of projects and programmes should be continued and extended to all European countries. Experience in some MS shows that the state investment in financial incentive programmes is a win-win situation because of the payback by the increased number of jobs and taxes.[106]

Table 3.4 Estimates on the number of EPCs issued for some countries[107]

Country	No. EPCs issued new buildings	No. EPCs issued existing buildings	
		Residential	Non-residential
BE - Brussels	430 (2011 - 2012)	60 000 (as of Nov 2012 for houses and apartments)	3 million m2 offices covered
BE - Flanders	90 000 (since 2006)	> 532k (since 2008)	6 563 (2009 - 2012 for public buildings)
BE - Walloon		> 150 000 (since 2010)	
Croatia		> 3 000 (since 2010)	> 2000 (since 2010)
Cyprus		> 12 000	1 600
Czech Republic	Around 40 000 in total		
Denmark	Around 160 k residential, around 14k commercial		
Estonia	Around 8200 in total		
France	> 5 million in total		
Greece	Around 210 k residential, around 30 k non-residential		
Ireland	Around 334 k residential, around 11 k non-residential		
Italy	Around 1.3 million in total		
Lithuania	Around 7 k residential, around 3 k non-residential		
The Netherlands	New and existing buildings	> 2.4 million (2008 - 2012)	15k (2008 - 2012)
Portugal	111k (2007 - 2012)	444k (since 2009 - 2012)	
Romania		Around 16k (until 2012)	Around 4k (until 2012)
Slovakia	Around 23 k	Around 10 k	
Sweden	Around 420 k in total		

Source: Concerted Action EPBD (2013), Implementing the EPBD: Featuring country reports 2012; some countries do not report this information as no system in place (e.g. BG, PL)

3.1.5 Summary implications

As presented above, the current market for certification schemes for commercial and residential buildings consists of the mandatory EPBD system (only energy performance) and several competing voluntary (mostly sustainable) multi-criteria certification systems assessing the energy and environmental performance of buildings. As such two implications can be made:

[105] Concerted Action EPBD (2013), Implementing the EPBD: Featuring country reports 2012
[106] Concerted Action EPBD (2013), Implementing the EPBD: Featuring country reports 2012
[107] Concerted Action EPBD (2013), Implementing the EPBD: Featuring country reports 2012

1. There is no mandatory multi-criteria system in place at a European level measuring environmental (not only energy) performance of buildings; and
2. The market for voluntary assessment frameworks for measuring environmental performance of buildings is fragmented (as can be seen from the relatively high number of (competing) sustainable schemes) and limited, i.e. the share of buildings assessed is very small as explained in section 1.2.3.

3.2 Policy options

3.2.1 Introduction

To improve the environmental performance of buildings in Europe, and as such to increase the number of assessed buildings, it is essential to have a complementary assessment framework in place which is simpler and less costly than existing commercial schemes, and which would push the whole building stock towards higher sustainability performance, including buildings in markets that are lagging behind. Moreover, a tool at the European level would provide a basis to collect reliable, accurate and comparable data across the EU MS, which is currently lacking. Such a framework would furthermore facilitate and support the uptake of environmental aspects in Building Information Modelling (BIM) tools. With such automated systems available to calculate the impacts at building level, assessments will be made more readily, resulting in more buildings than today being assessed.

With a framework available, sufficient uptake could be more easily supported via different policy measures.
The following three options are analysed:

1. No policy change (Business as Usual)
2. A voluntary framework consisting of core indicators to be used for the assessment of the environmental performance of buildings (Option 3.1)
3. A mandatory framework consisting of core indicators to be used for the assessment of the environmental performance of buildings (Option 3.2)

3.2.2 "Business as Usual" (Option 1)

The Business as Usual (BAU) scenario assumes no common European assessment framework is developed and implemented. The market would rely on the EPBD system for energy and multiple voluntary sustainable certification schemes across the MS. A change in EU policy in this domain is viewed as important and potentially effective by all respondents in the public consultation linked to this initiative. Only a small minority (less than 5 %) was in favour of the 'no change' option.

3.2.3 A voluntary framework consisting of core indicators (Option 3.1).

Option 3.1 is defined as **a voluntary framework consisting of core indicators to be used for the assessment of the environmental performance of buildings**. A voluntary use of identified core indicators will mainly attract the best performers, much like existing commercial schemes do today. The advantage will lie in data being comparable. Analysis would conclude if it can be considered useful to develop a full-fledged scheme, such as the Ecolabel, or if a set of core indicators to be used by existing and future schemes together with their own individual ones would be sufficient. Regardless, the voluntary use of core indicators will serve to inspire the best performers and pull the upper part of the green building market.

While the mandatory option (see below) is preferred by most respondents in the public consultation, the voluntary option is supported as well.

3.2.4 A mandatory framework consisting of core indicators (Option 3.2).

Option 3.2 (**a mandatory framework consisting of core indicators to be used for the assessment of the environmental performance of buildings**) requires all new built and major renovation to include an assessment based on identified core indicators. The existing energy efficiency certificates could be expanded to include a limited number of additional indicators in order to provide the demand side a more complete picture of the environmental performance of buildings and to generate more data across the market, including the laggards to increase the awareness.

In the public consultation, there is a clear majority among the companies, individual persons, research institutions and public authorities which consider a mandatory European framework consisting of core indicators and, eventually, a set of benchmarks as an effective option; NGOs find it somewhat effective. Associations are less favourable of this option – more than half of these respondents did not consider it an effective option.

4 Analysis of impacts and comparisons of options

4.1 General remarks and methodology

This chapter assesses and compares the economic, social, and environmental impacts of the policy options described in the previous chapter in relation to the baseline scenario. To the extent available and relevant, the analysis includes the various cost elements, impact on SMEs, job creation, resource use, and other environmental effects.

4.2 "Business as Usual" (Option 1)

The Business as Usual (BAU) scenario assesses the development of Building assessment schemes (BAS), how they evolve in terms of scope, share of total certified buildings as well as their projections for commercial and residential buildings respectively.

Firstly, we will estimate the number of certificates issued for commercial and residential buildings as well as the number of residential and commercial buildings in EU27 in 2020 and 2030. Secondly, we will look at the economic, social and environmental impacts expected under the BAU.

4.2.1 Estimating the uptake of certifications in 2020 and 2030

To estimate the development of the certification systems for commercial and residential buildings in 2020 and 2030, we first estimate the number of buildings. Second, we make projections on the number of certified buildings based on evidence we collected from secondary sources and interviews. We then assess the projected share of certified buildings in the EU in 2020 and 2030 for commercial and residential buildings respectively.

To estimate **the number of commercial and residential buildings in 2020 and 2030**, we used historical data on the residential building stock from the ODYSSEE database, and again the most recent data point (2011) and the gradient of the best fit line to make projections. We applied similar methodology to estimate the number of commercial buildings as for 2013, described in section 1.2.2. To derive the average floor area per dwelling, the values for 2020 and 2030 are based on a projection from 2011 (most recent data point in the ODYSSEE database) from the gradient of the best fit line. This corresponds to values 91m2 and 94m2 for 2020 and 2030, respectively. Assuming an average commercial building in 2020 and 2030 will have a similar floor area as in 2013, i.e. 250 m2, this implies approximately 26.5 million commercial buildings in 2020 and 29.5 million in 2030.

To cross-check the estimates for residential buildings, we made use of the Preparatory Study for the Recasting of the Energy Performance of Buildings Directive (EPBD) 2002/91/EC, which estimated the number of dwellings in the EU27 building stock in 2020 and 2030.[108] Based on this study, around 250 million dwellings are expected in 2020 and around 270 million in 2030.

This leads to an estimate of 248 million residential and commercial buildings in 2020 and 270 million in 2030.

All the values are reported in Table 5 below.

[108] Ecorys (2008)

Table 4.1 Estimation of future building stock

Forecast	2020	2030
Total residential buildings (million) (ODYSSEE)	221.7	240.3
Total residential buildings (million) (Ecorys 2008)	250	270
Average floor area per dwelling (m2)	91	94
Total residential area (million m2)	19,894	22,161
Total commercial floor area (million m2)	6,631	7,387
Average commercial floor area (m2)	250	250
Total commercial buildings (million)	26.5	29.5
Total residential and commercial buildings (million)	**248.2**	**269.9**

Source: ODYSSEE, own calculations

To forecast the number of certified commercial and residential buildings in 2020 and 2030, we will first look at the historical trends for a number of leading voluntary certification schemes.

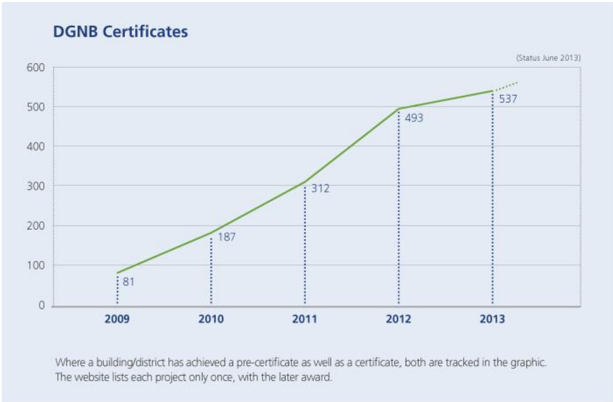
Box 2 below shows the development of a number of **voluntary certification schemes** used mainly for **commercial buildings** (all schemes except HQE show aggregate numbers for both, residential, usually a minor number, and commercial buildings). This, together with the historical trend of HQE certification scheme used for residential buildings shown further below, will be our departing point for the projections on the number of certified buildings.

Box 2: Historical trends of the major voluntary certification schemes for commercial buildings

BREEAM Project certifications 2008 – 2012

Source: BREEAM

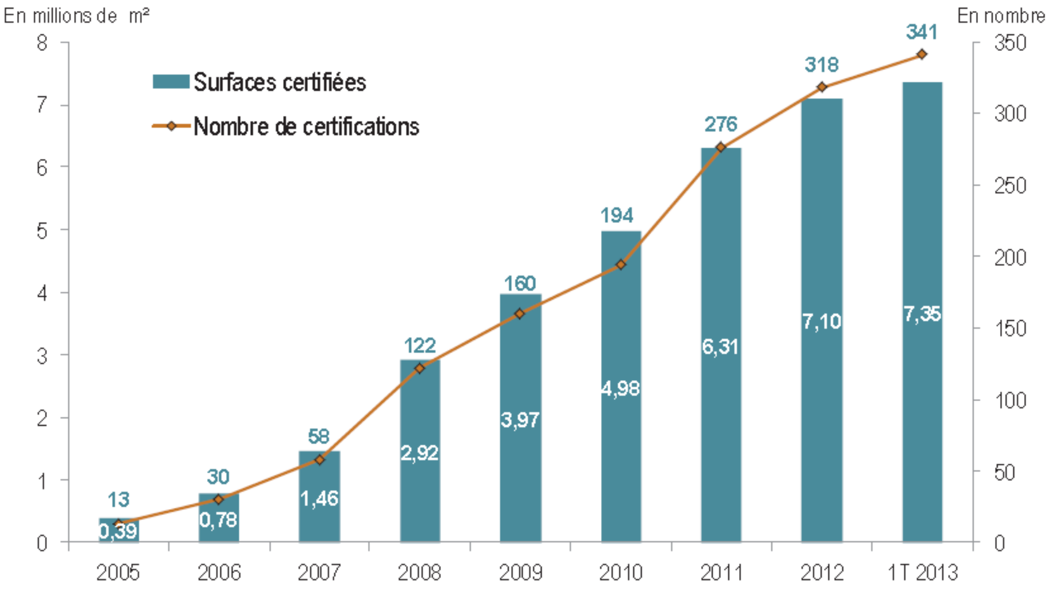
DGNB certificates 2009 - 2013



Source: DGNB

For BREEAM, a clear increasing (almost linear) trend can be seen between 2008 and 2012. Moreover, the number of certifications almost doubled (from 8 000 to almost 16 000) in those five years. Similarly, for DGNB, there is a clear (almost linear) increasing trend; however, the increase in certifications has been sixfold over these past five years. In both cases, the trend shows slightly diminishing returns, i.e. the trend line gets flatter with time. The numbers take into account all certifications, including those for residential buildings, which form a minority; hence the numbers differ compared to the RICS estimates in Table 3.2 which shows data only for commercial buildings.

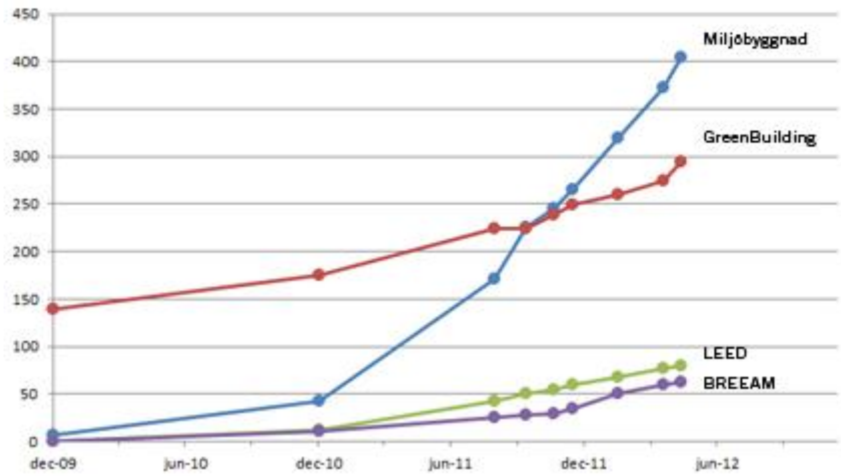
Figure 4.1 Evolution of the cumulative number of HQE[109] offices in Ile-de-France 2005 – 2013



Source: HQE, Jones Lang LaSalle, Certivea and Immostat

For HQE, the number of certifications in France has been rising steadily, with most certifications taking place in and around Paris (Ile de France - shown above). As the figure above for the Ile de France region shows, the trend has been increasing until the first quarter of 2013, in terms of the certified floor area as well as the number of certifications.

Figure 4.2 Overview of Miljobyggnad, GreenBuilding, Leed, BREEAM, 2009 – 2012 in Sweden



Source: Swedish Green Building Council

With respect to the Swedish scheme, the rise in certification is booming. However, it is not possible to differentiate in the graph between residential and non-residential buildings. Over the last three years, the Swedish scheme went from zero certifications in 2009 to around 400 by 2012. Green Building is the energy voluntary certification scheme managed by JRC (described shortly in section 3.1). It can be seen that in Sweden, Miljobyggnad is the dominant scheme on the market.

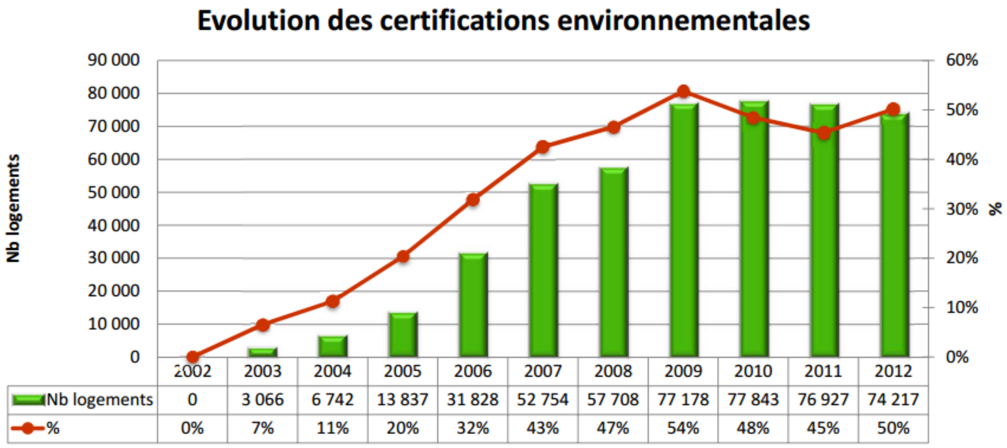
[109] Construction or renovation or exploitation for buildings completed or not

With respect to **residential buildings**, mostly the UK, France and Sweden currently use sustainable certifications also for these types of buildings. Use in other EU countries is limited. Based on the discussions with the WGBC, there are no signs of future changes.

In the UK, there have been recent developments regarding the Code for Sustainable Homes (on the latest developments see Box 1). It is expected that the Government may phase out the Code for Sustainable Homes. It can therefore be expected that the use of the Code in the UK might be limited in the future, and hence less new residential buildings might be certified.

In France, the trends show increasing share of certified residential buildings, but absolute numbers go down (as construction is declining). The share of certification is thus increasing, as the number of certified dwellings has gone down less compared to the total construction. The following graph shows the evolution of certified dwellings in France during 2002 and 2012 for all brands of environmental certification in France (HQE, Patrimoine Habitat & Environment, Habitat & Environment) out of which HQE has the largest share. As can be seen below, the market share of certified residential buildings (shown on the right vertical axis) increased significantly during this period, with a slight decrease in 2011 and 2012.

Figure 4.3 Evolution of environmental certifications in France during 2002 - 2012



Source: HQE (2013), Nb logements refers to the number of dwellings, the % refers to the percentage of certified dwellings

Moreover, DGNB expects that in 2020 around 75% of new built of commercial buildings in Germany will be certified.[110] As to the scope of existing schemes, these are expected to expand. For example, DGNB started a new scheme for existing buildings in summer 2013. Underlying drivers for it were the market demand and the fact that certifying existing stock is where DGNB could make a difference.[111]

When forecasting how the certification market for commercial buildings will develop in the BAU scenario**,** the following assumptions are made:

- We take into account assessed/ certified buildings.
- There is a linear growth[112] in the number of certified buildings up to 2030. We base this assumption on an inspection of historical trends for the major schemes as well as interviews with scheme providers.[113]

[110] Interview with DGNB
[111] Ibid
[112] Based on the evolution of certified projects under BREEAM during 2008-2012. Please note, the number of registered projects under BREEAM had an exponential growth. http://www.breeam.org/page.jsp?id=559

- The number of certified commercial buildings is doubling every 5 years up to 2030 - this means that the number of certified buildings will be twice as high compared to five years ago, or that the number of certified buildings in 2030 will be four times higher compared to 2020. This assumption is based on the recent developments in BREEAM certification as the leading scheme in Europe (see Box 2), where the number of certified buildings doubled between 2008 and 2012 (approximately five years). Moreover, based on IVG Research among European property companies,[114] the number of certified projects tripled between 2011 and 2013 in Europe. However, we do not expect such trend to continue until 2030.

Based on these assumptions and the current number of certified commercial buildings, the following estimations are made (see Table 4.2 below). We have estimated the shares also by using the projections based on ODYSSEE data. The table below shows the results.

Table 4.2 Estimated number of certified commercial buildings for 2020 and 2030

Estimated number of certifications	2013	2020	2030
Total commercial buildings (ODYSSEE)	24,409,970	26,525,704	29,548,181
Number of certified commercial buildings	9 764	72 518	290 070
% share of certified commercial buildings	0.04%	0.27%	0.98%

Source: ODYSSEE, own calculations

With respect to residential buildings, it is less clear how the market for certifications will develop under the BAU by 2020 and 2030. This seems to be due to the fact that voluntary certification of residential buildings is not common across the EU, with the exception of the aforementioned UK, France and, in the last years, Sweden. According to WGBC, there are no signs of changes, as mentioned above. According to an interview with HQE and the Swedish Green Building Council, certifications for residential buildings (or the share of certifications) are increasing, however, there is much more to be done to spur the market.[115] In addition, the situation in the UK with regard to the future for the Code for Sustainable Homes is not clear cut either. In Germany, DGNB offers a certification scheme for new residential buildings; however, the numbers are currently very low. As an example, they have certified 6 house types under the Small Residential Buildings Scheme, and a further 32 projects under the Residential Buildings Scheme. This figure does not include a further 18 Projects currently in the process of certification under these two schemes.[116]

Based on this, we do not expect significant increases in certified residential buildings by 2020. By 2030, the situation might improve, however, at this stage it is difficult to specify. Current scheme operators, such as BRE and DGNB were not able to tell us predictions about their schemes. We could expect a slight increase in the share of certified residential buildings in the EU under the BAU scenario.

One potential scenario, based on the little information available, could include the following assumption: the number of certified residential buildings will not change significantly in the future – we expect that certification of residential buildings will continue at a pace of around 70 000 dwellings per year in Europe up to 2030. It is important however to stress, that the 70.000 certified dwellings per year would be limited to very few MS.

[113] For example, DGNB mentioned that the trend is increasing and is more or less linear. According to them, in the future the trend might become a bit flatter compared to the recent significant increase in the number of certifications. This will also differ per sector as in some sectors certifications might be more common than in others, e.g. currently pre-fabricated houses.

[114] IVG Research LAB 3/2013 (2013), “Corporate sustainability in European property companies: has it arrived at an operation level?”

[115] Interviews with HQE and the Swedish Green Building Council

[116] Information provided by DGNB

The results of these assumptions are presented in the table below. Please note, to verify these results, further research on a EU28 level would have to be conducted.

Table 4.3 Estimated number of certified residential buildings for 2020 and 2030

Estimated number of certifications	2013	2020	2030
Total residential buildings (ODYSSEE)	208,731,837	221,740,637	240,324,637
Number of certified residential buildings (minimum)	673,317	1,177,317	1,897,317
% share of certified residential buildings	0.32%	0.53%	0.79%

Source: ODYSSEE, own calculations

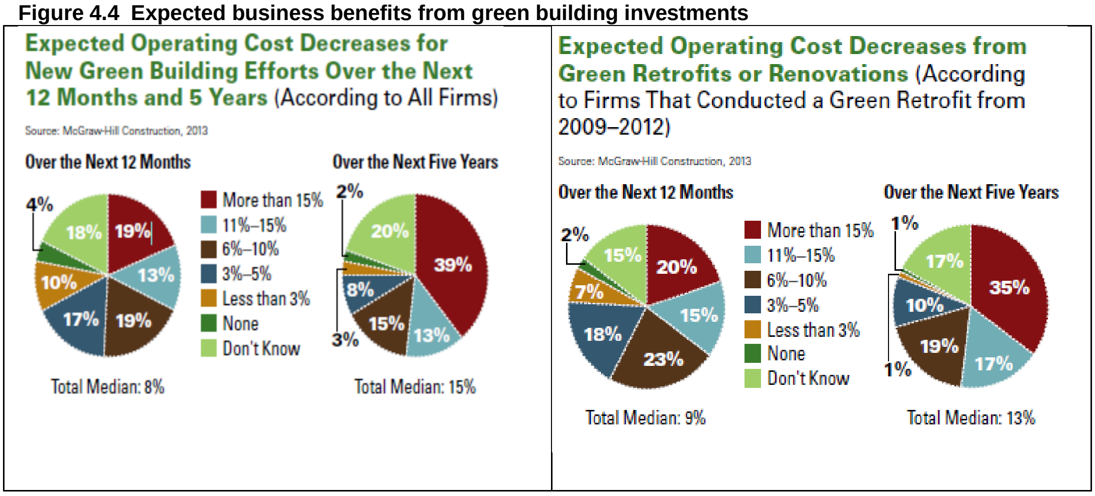
However, these numbers are highly uncertain, particularly for CSH due to the unknown future of the code. Under this code, certificates are not necessarily linked to dwellings but could be linked to buildings with e.g. numerous apartments.

4.2.2 Economic and social impacts

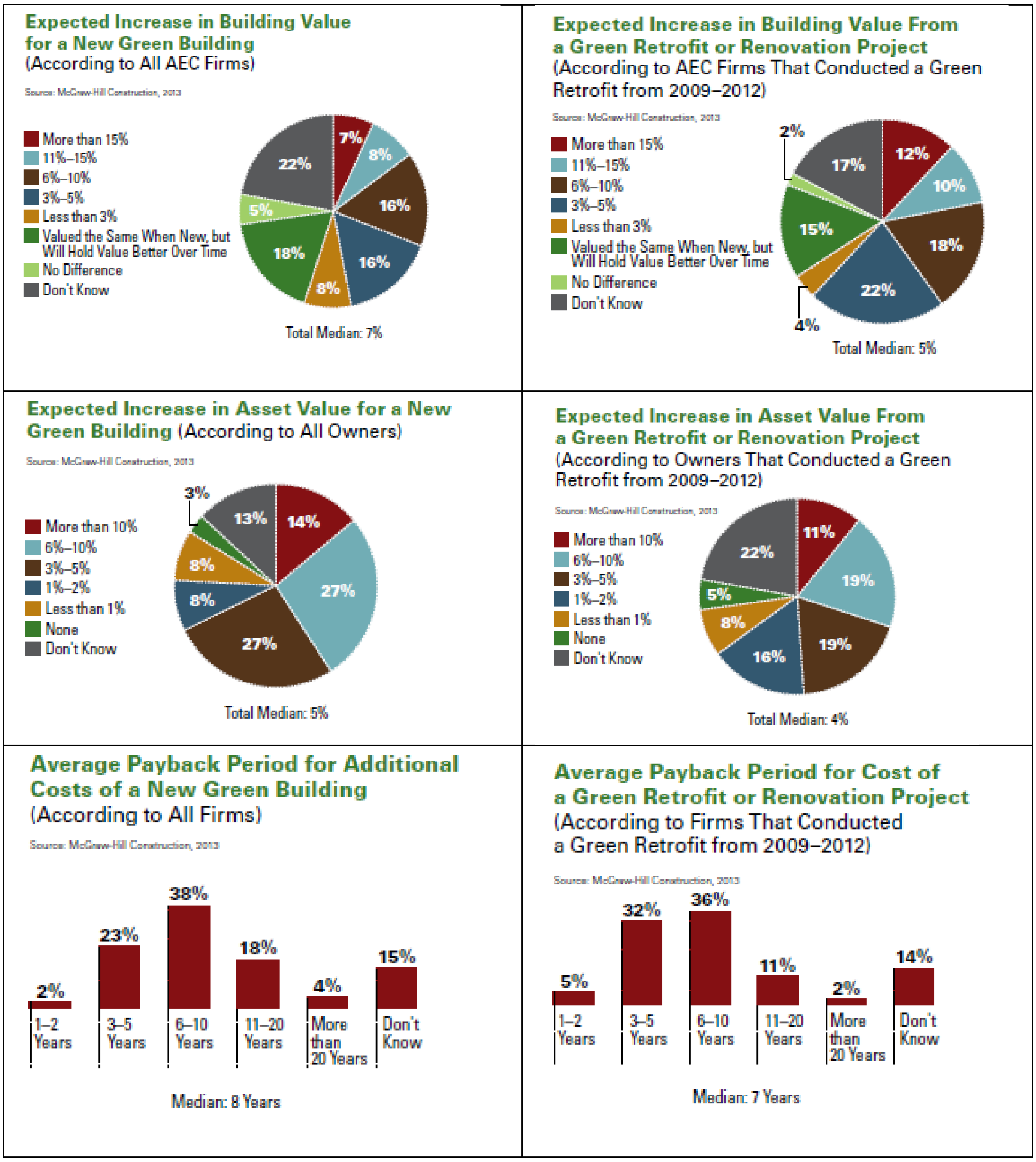
Impacts on businesses and consumers

Benefits for businesses of using a sustainable certification scheme can be estimated with respect to commercial buildings. In general, commercial users of assessment schemes agree that these provide economic benefits. A survey among 803 respondents including engineers, architects and contractor firms from 62 countries, with statistically significant results on 9 countries (Germany, Norway, UK, Singapore, Australia, United Arab Emirates (UAE), South Africa, US, Brazil)[117] shows that there are positive expected business benefits from green building investments. The results of the survey are shown in the figure below. This shows that economic benefits are expected in terms of decreased operating costs (on average by 8% over one year and 15% over five years for new green building, and by 9% and 13% for green retrofit respectively), increased building value (by 7% for new building and by 5% for retrofit on average), increased asset value (by 5% for new building and by 4% for retrofit, on average) and payback time for green investments. More details on survey results for each business benefit can be found in Box 3. However, this information is not available for Europe only.

Figure 4.4 Expected business benefits from green building investments



117 McGraw Hill Construction (2013) 'World green building trends: Smart Market Report'



Additional examples of economic business benefits are provided for BREEAM. We use this example as BREEAM covers around 80% of the certification market in Europe to date and as such can be used as a proxy to assess the overall business benefits of sustainable buildings. A survey conducted by BREEAM in January 2012 included 50 face-to-face and telephone interviews with client organisations from both public (universities and government) and commercial (owner occupiers and developers) sectors. A web survey supported this to collect a more general view (105 responses), mainly looking at the views of BREEAM assessors, other professionals and the supply chain. In total this adds up to 155 respondents of mainly professionals or clients connected to BREEAM. The results of this survey show that 67% of BREEAM client respondents indicated economic benefits were a major reason for undertaking BREEAM assessment. These economic benefits relate mainly to as in the other survey above, decreased operational costs of buildings, increased value through sale or rental. For example, more than 40% of BREEAM client respondents whose project has been certified agree it improved operational cost savings. This result is supported by the evidence on LEED. For example, it has been found that LEED certified buildings led to reduced operating costs of green buildings by 8-9% while increasing in value up to 7.5%.[118]

Other evidence suggests that many sustainable buildings also have seen increases of up to 6.6% on return on investment, 3.5% increases in occupancy, and rent increases of 3%.[119] In case of the survey for BREEAM, 40% of BREEAM client respondents whose project has been certified agree it improved return on investment.

Regarding the rental/ buying premium, a survey among BREEAM clients (described above) reports that more than 10% of BREEAM client respondents whose projects had been certified agreed it led to higher rental values. In addition, the Energy Star and LEED certified (commercial) buildings have on average a 3% higher rent, a 6% higher rental revenue (rent multiplied by the occupation rent) and a 16% higher resale price.[120] These figures are more surprising for resale values: over 31% for Energy Star buildings, over 35% for LEED buildings."[121] The resale price difference is over 6% for Energy Star, and plus 10% for LEED.[122]

In addition, almost 30% of BREEAM client respondents whose projects had been certified agreed it made it easier to let the building.

With respect to residential buildings, it has been mentioned by the HQE that there is no significant price premium on certified residential buildings. The users of these buildings rather focus on quality and the costs saved over the longer term due to a better building. However, what should be noted is the fact that the majority of certified residential buildings seem to be linked to government funded social housing. Hence the building developer receives some funding.

There are three **cost categories** for users of certification schemes:[123]

1. Certification fee – is the fee to certify the sustainability of the building. This can be done for example at the interim design stage, i.e. between the end of the detailed design stage and the beginning of operations on site (relying on 'as designed' evidence), or at the final stage, i.e. toward the end of operations on site and handover of the building (relying on 'as built' evidence).[124] This fee is also related to the project size and goes to the certificate issuer.
2. Project coordination and assessment costs – these costs are related to the (pre-) assessment of the building, registration, coordination by a consultant or an auditor of the project (e.g. putting all the documentation together, project team meetings, translations, reporting, communication, etc.), auditors fee. This tends to be the largest cost component and refers to the assessment process from the conception phase to the actual operation phase.[125]
3. The costs of improvement of the building – the last category is the cost of actually making the building more sustainable, i.e. 'green' investments. This reflects all the extra measures that need to be implemented to make the building green compared to a standard building.

Different schemes and different sources define these cost categories differently or report only a subset of these costs, and hence the numbers reported vary per source. This report tried to collect as much comparable data as possible. Values have also been cross-checked by other sources and

[118] http://www.wbdg.org/resources/gbs.php
[119] http://www.wbdg.org/resources/gbs.php
[120] Eichholtz P. et al., (2009), Doing Well by Doing Good? An Analysis of the Financial Performance of the Green Office Buildings in the USA, Maastricht University and California University
121 Fuerst F., McAllister P. (2009), New Evidence on the Green Building Rent and Price Premium, Reading University
122 Miller N., Spivey J., Florance A. (2008), Does Green Pay Off? , San Diego University, CoStar Data Basis
[123] Interviews with scheme operators: DGNB, Swedish Green Building Council
[124] BREEAM, http://www.breeam.org/page.jsp?id=27
[125] An example of BREEAM assessment price list can be found here: http://www.eh-3dstudio.com/web_documents/price_list_eh-3d_packages.pdf

by interviews. Moreover, there is a large difference in costs between certifying a commercial and residential building.[126] Therefore certification costs are split for commercial and residential buildings.

For **commercial buildings**, an overview of approximate costs per category per scheme is presented in the table below. These are based on a Swedish source reporting costs for LEED, BREEAM and Miljobyggnad in Sweden, and interviews with DGNB and HQE.

Table 4.4 Estimated costs of certification schemes for commercial buildings in EUR (approx. values)

	LEED	BREEAM	HQE (commercial)	DGNB	Miljöbyggnad
Certification fee	3 000 – 25 000	6 000 – 15 000	12 000 - 25 000	5 000 – 15 000	2 000 – 6 000
Project coordination/ assessment	75 000 – 100 000 + 20 000 (calculations)	75 000 – 100 000 + 10 000 – 20 000 (calculations)	Not obligatory	50 000 – 60 000	10 000 – 20 000 + 5 000 – 10 000 (calculations)
Extra over costs of making a building green – depends on the grade attained		57 000	n.a.	Low – up to 4% of additional construction cost, < 0.5% planning costs in Germany	Low

Source: Miljöklassningsguiden by Bengt Dahlberg AB, http://omvarldsbevakning.byggtjanst.se/Artiklar/2013/september/Tips-i-miljoklassningsdjungeln/ for Miljobyggnad, BREEAM and LEED; interview with DGNB for DGNB; interview with the Swedish Green Building Council for Miljobyggnad, interview with BRE for the improvement cost of BREEAM. Calculations refer to assessing the environmental and energy performance of the design of a sustainable building. HQE (http://www.certivea.fr/home) for estimation on HQE certification.
* For HQE, certification fee includes the registration fee and the assessment cost by their auditor. The cost for the assessor/ project coordination is not mandatory under HQE non-residential since the auditor price is included in the certification fee.

Moreover, the Spanish Verde scheme is also cheaper than most of other schemes, with the registration cost of EUR 450, certification costs ranging from EUR 1 500 (for buildings with less than 4 500 m2) and EUR 15 000 for very large buildings (buildings with more than 45 000 m2) and additional costs for an accredited evaluator, which is not high.[127]

It should be noted that the schemes vary in scope (i.e. which criteria/ indicators they cover) as well as in their assessment and certification process (e.g. who can assess/ audit the building, verification procedures, etc.). For example, HQE requires stricter verification process by an external auditor while BREEAM only asks for a feasibility study and two reports made by persons in the team of the prime contracting,[128] which makes the costs of the French scheme higher.

The cost sub-categories differ per scheme, per building type and per source, and as such make the comparison between the schemes difficult. Sources confirm this issue.[129]

Nevertheless, based on the evidence collected so far, it can be concluded that the larger commercial schemes such as BREEAM or LEED can become very expensive compared to smaller schemes such as DGNB and Miljobyggnad.

[126] Interviews with DGNB, Swedish Green Building Council, costs reported under the Code for Sustainable Homes in the UK
[127] Information from the Spanish Green Building Council
[128] http://www.lemoniteur.fr/201-management/article/actualite/871078-breeam-leed-et-hqe-a-la-conquete-du-monde
[129] On the difficulty comparing BREEAM and LEED, see http://greenbuildingmanager.wordpress.com/2011/02/01/how-much-does-it-cost-leed-ebom-and-breeam-in-use/; another source reports much lower costs for BREEAM and LEED (assessment fees for BREEAM €2.500 – 12.600, for LEED up to €47.600, certification fees (BREEAM €930 - €1.890, LEED €1.400 - €14.280), see http://wordpress.hrz.tu-freiberg.de/wordpress-mu/journal/files/2010/11/dirlich.pdf

For **residential buildings**, costs could be much lower. Given the uptake of certification of residential buildings in the UK, France and Sweden, we consider costs in these countries as reference.

In the UK, the Code for Sustainable Homes recognizes two kinds of costs of complying with the Code:[130]

1. Costs of environmental improvement (extra over costs) – these are costs associated with complying with the Code, i.e. with its Code levels (explained below) and incurred by house builders in the private sector.
2. Process and administrative costs – these are costs ensuring that a development fulfils the relevant criteria of the Code through the design and build procedure. Process costs can include:
    - undertaking technical calculations, such as related to energy or water usage;
    - collating and reviewing compliance evidence, for example light fitting specifications, materials and traceability; and
    - producing specialist consultant reports, for example relating to day lighting and ecology.
    - These costs could correspond to project coordination and assessment costs discussed for commercial buildings..

The Code has six Code level ratings, starting with the Level 1 rating (fulfilment of minimum criteria) up to Level 6. Each level has certain environmental performance requirements (assessment criteria) across nine categories of environmental impact that need to be achieved to reach a certain level. These can be mandatory for certain issues, others are voluntary. The developer is free to choose how to improve performance to achieve the rating for which they are aiming. A methodology describing the assessment process and the performance levels that must be achieved for each environmental issue can be found in the Technical Guide.[131] As an illustration, the following tables show:

1. The relationship between total percentage points score and Code level – this shows the needed environmental improvement in terms of score to upgrade to a higher Code level (table 4.5); and
2. Performance requirements for mandatory standards for each environmental category. As can be seen, some increase significantly with the increase in Level. As a reference, it should be noted that Code level 3 is mandatory for social housing if a government grant is sought. Code level 4 must be achieved for schemes within London, under the London Supplementary Planning Guidance (table 4.6).

Scoring higher percentage points will require investments and hence the costs will increase. The table below shows additional percentage points needed for each Code level. This gives us an idea about the magnitude of marginal costs needed to move up one Level. For example, to move from Level 3 to Level 4 requires an increase of 11% points, while from Level 5 to Level 6 this is only 6% points.

Table 4.5 Relationship between total percentage points score and Code level

Total percentage points score (equal to or greater than)	Code level
36 Points	Level 1 (*)
48 Points	Level 2 (**)
57 Points	Level 3 (***)
68 Points	Level 4 (****)
84 Points	Level 5 (*****)
90 Points	Level 6 (******)

[130] Department for Communities and Local Government (2013), "Housing Standards Review Consultation: Impact Assessment"
[131] Department for Communities and Local Government (2010), "Code for Sustainable Home: Technical Guide"

Source: Department for Communities and Local Government (2010), “Code for Sustainable Home: Technical Guide”

Table 4.6 Code for Sustainable Homes - Mandatory requirements per environmental category and Code level

Code level	1. Energy and CO2 emissions		2. Water	3. Materials	4. Surface Water Run-off	5. Waste	6. Pollution	7. Health & Well-being	8. Manage-ment	9. Ecology
Code	Minimum % Improvement in Dwelling Emission Rate over Target Emission Rate	Fabric Energy Efficiency kWh/m2/year for apartment blocks, mid-terrace	Maximum Indoor Water Consumption in Litres per Person per Day	Environmental impact of materials mandatory for all levels	Management of Surface Water Run-off from Developments mandatory for all levels	Storage of Non-recyclable Waste and Recyclable Household Waste mandatory for all levels	No mandatory requirements	Lifetime homes	No mandatory requirements	
1	0%	n.a.	120	At least 3 of the following 5 key elements of the building envelope achieve a rating of A+ to D in the 2008 version of The Green Guide: • Roof • External walls • Internal walls (including separating walls) • Upper and ground floors (including separating floors) • Windows	Assessment criteria relate to: • Hydraulic control criteria (Peak rate of run-off, Volume run-off) • Water quality criteria (extra points) (according to the Sustainable Drainage Manual)	Assessment criteria relate to: • Storage of household waste • Storage of recyclable household waste (extra points)		n.a		
2	0%	n.a.	120					n.a		
3	0%	n.a.	105					n.a		
4	25%	n.a.	105					n.a		
5	100%	≤ 39	80					n.a.		
6	Net Zero CO2 emissions	≤ 39	80					Where all principles of Lifetime Homes, for dwelling being assessed, have been complied with or Where an exemption from Lifetime Homes criteria 2 and/or 3 is applied subject to a steeply sloping plot gradient, but all other principles of Lifetime Homes, applicable to the dwelling being assessed, have been complied with.		

Source: Department for Communities and Local Government (2010), “Code for Sustainable Home: Technical Guide”

The following table presents the estimated extra over costs associated with all standards in the CSH for the different categories of residential buildings. These costs are based on a medium sized development of 50 dwellings under the assumption that house builders will select the most cost optimal improvements to achieve each level of the Code.[132]

Table 4.7 Extra over costs associated with all standards in the Code for Sustainable Homes

Code level	Flat	2 Bedroom House	3 Bedroom House	4 Bedroom House
Code 1	£75	£0	£0	£0
Code 2	£75	£75	£75	£75
Code 3	£118	£143	£143	£143
Code 4	£1,437	£1,712	£2,147	£2,432
Code 5	£14,075	£16,050	£16,485	£16,770
Code 6	£18,010	£26,740	£27,610	£28,180

Source: EC Harris 2013: Housing Standard Review

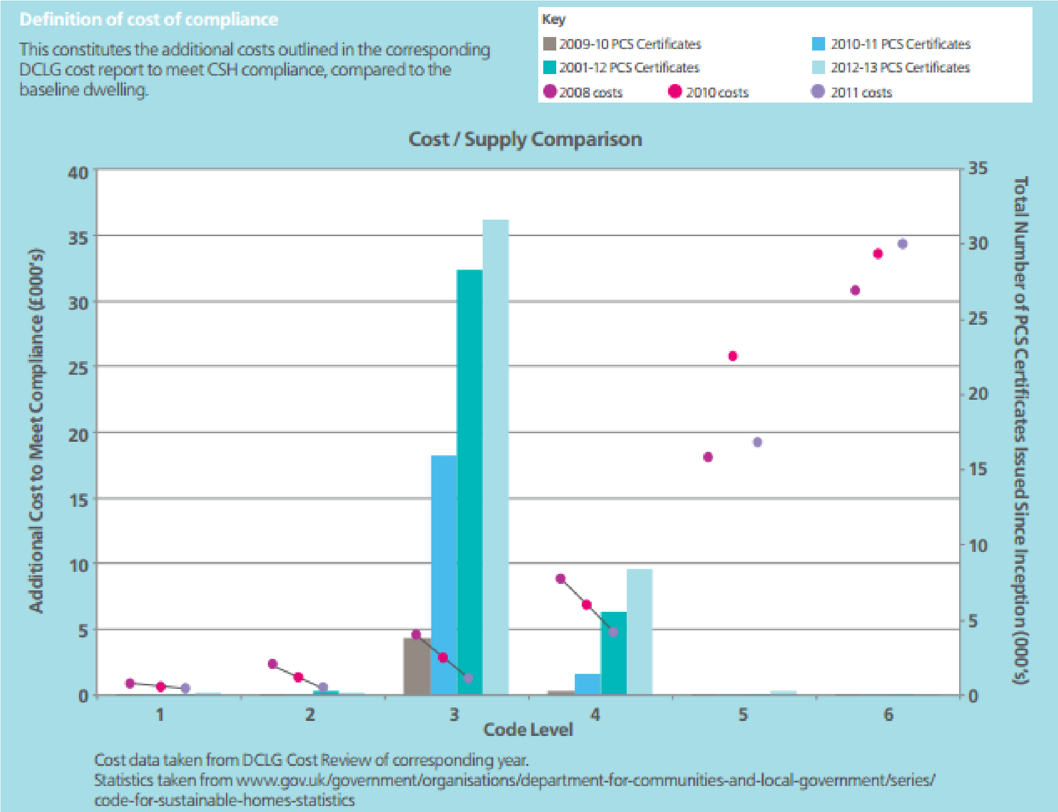
It could be seen that the over costs increase significantly when upgrading from Level 3 (e.g. required for social housing with a government grant) to Level 4 (e.g. certified buildings under CSH in London) and to Level 5/ Level 6. Evidence also shows that the majority of buildings assessed under the Code receive Code Level 3 rating. Up to end of June 2013, 75% of certificates were issued at design stage and 81% of certificates issued at post construction stage.[133] On the other hand, for Code levels 1 – 4 it has been shown that the cost of building to the Code is reducing as more Code homes are built over time and the supply chain is growing (see also figure 4.5 below).[134]

[132] Department for Communities and Local Government (2013), "Housing Standards Review Consultation: Impact Assessment"

[133] Department for Communities and Local Government (2013), "CSH and SAP ratings: Statistical Release", https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/239450/130913_CSH_Statistics_-_Q2_-_to_end_June_2013x.pdf

[134] BRE (2013), "Future of Sustainable Housing" http://www.bre.co.uk/filelibrary/pdf/casestudies/KN5211_-_Future_of_sustainable_buildings_finalsml.pdf

Figure 4.5 The evolution of the extra over cost to the Code over time



Source: BRE (2013)

With respect to the process and administrative costs, these were estimated based on hours required for various professionals to ensure compliance with the standard and hourly rates.[135] The table 4.8 shows the total process costs at each Code level based on a 50 dwelling development and the unit process cost per dwelling. For example, if a home builder builds a new home at Code level 4, the costs would be £100 for complying with the standards at this level and £37 for BRE fee, hence in total £137.

Table 4.8 Process costs of each Code level for all dwellings

Code level	Total cost (50 dwellings)	Cost per dwelling
Code 1	£4,653	£93
Code 2	£4,653	£93
Code 3	£4,653	£93
Code 4	£5,003	£100
Code 5	£9,990	£200
Code 6	£9,990	£200
BRE fee	£1,850	£37

Note: the BRE fee is paid by the house builder for each dwelling on top of the process cost it incurs depending on which level of the code the builder is aiming for

Source: EC Harris 2013: Housing Standard Review

As can be seen, the total cost and the cost per dwelling increase significantly between Level 4 and 5. This corresponds to the obligation to comply with more demanding standards.

[135] Methodology explained in Department for Communities and Local Government (2013), "Housing Standards Review Consultation: Impact Assessment"

In France, HQE certification scheme is used for residential buildings as well. The same scheme, theme and indicators apply to commercial and residential buildings. However, the benchmarks are different. The costs for residential buildings are lower compared to commercial buildings since there is a greater economy of scales (per dwelling). For example, there are typically 30 apartments per building and the certification body does not need to control each of them if they are build the same. As such, the cost per unit can be kept low. This is different for commercial buildings, which are usually unique and the cost is per m^2, as such it becomes higher.

The certification costs (assessment and certification fee) ranges from EUR 150 – 450 per dwelling in multi-residential buildings or developments with several houses. In detached houses (single house development), the cost is significantly higher, e.g. EUR1000 or more since it is impossible to make economies of scale linked to the intervention of the assessor and certification body, as described above.

With respect to the costs of improving the building, i.e. making it "green", this cost is less than 1% higher compared to a standard residential building. This cost has decreased significantly since 2003 (when it amounted to around 10%) due to more residential buildings being certified. In overall, the first time a developer or builder needs to change its practice in design and construction to make a building more sustainable for example, it is more expensive but the extra over cost goes down subsequently.[136]

In Sweden, Miljöbyggnad scheme reports that costs are much lower for residential buildings than commercial buildings, the latter amounting to approximately EUR 23 000 – 34 000.[137] There are three different grades, Gold, Silver and Bronze, whereby the latter is not requiring more than fulfilling legislation. As such, the extra over costs for improvement are negligible for the Bronze grade. To date there is no information available on the extra over cost for reaching Silver and Gold grade, however, this cost is not expected to be significantly higher.[138] Most certified buildings reach Silver grade, the second largest group Bronze grade and the smallest group Gold grade.[139]

Estimates of **future projections on certification costs** are based on the views of scheme operators only, as we have not identified any studies conducted on this topic. According to their views, costs related to certification of a building are not likely to change significantly in the future or may even decrease slightly (timeframe 2020 and 2030).[140] According to DGNB, certification fee might slightly decrease in the future but this change would not be significant. With respect to costs for environmental improvement, DGNB's opinion is that these may become cheaper in the future due to economies of scale, i.e. more certified buildings would lead to more standardised process and hence more cost-effective sustainable solutions. In addition, data could become more accessible compared to the past, which makes it easier for assessors and auditors.[141] According to BRE, improvements in IT, automation and building information modelling as well as increased take-up will help bring costs down. The market will expect to pay less of a premium for assessment in the future and will also expect the benefits and value to be clearer.[142] According to HQE, the costs, particularly the costs of greening the building are also going down as more buildings become assessed because it is mostly the initial investment into changing design and construction practices that makes the greening of a building more expensive compared to a standard building.[143] Once

[136] Interview with HQE
[137] Interview with the Swedish Green Building Council
[138] Interview with the Swedish Green Building Council
[139] Ibid
[140] Interviews with BRE and DGNB
[141] Interviews with DGNB
[142] Information provided by BRE.
[143] Interview with HQE

these practices are in place, the extra over costs decrease significantly as has been the case for residential buildings certified in France with HQE.

Based on this information, it is plausible to assume that the certification costs are not going to change significantly by 2020 and 2030, compared to the current estimates (2013). Taking into account inflation and the expected slight decrease in costs in the future, we assume certification costs to be similar to current levels in 2020 and 2030.

For **commercial buildings**, BREEAM is dominating the market for certifications (around 80% of certificates issued in EU28 according to RICS report (see table 2). Therefore, we assume that certification costs for commercial buildings for the BAU are approximately in the range of BREEAM. Given, new (cheaper) voluntary sustainable schemes are gaining importance in some countries, such as Sweden, under the BAU scenario, certification fees are assumed to be in the range of EUR 3 000 – 15 000 for both 2020 and 2030. The project coordination and assessment costs are also assumed to be in the range of BREEAM, i.e. EUR 85 000 – 120 000 for commercial buildings by 2020 and 2030.

The estimated number of certified buildings in 2020 and 2030 is 72 518 and 290 070, respectively. This would lead to total certification costs estimated at EUR 217.5 million – 1 billion in 2020 and EUR 870 million – 4.4 billion in 2030 under the BAU for commercial buildings. The coordination and assessment costs are estimated at total EUR 6.16 bn – 8.7 bn in 2020 and EUR 24.6 billion – 34.8 billion by 2030, given these assumptions. The table below presents these estimates.

Table 4.9 Certification costs for commercial buildings under BAU scenario future estimates

Year	2020		2030	
Number of certified commercial buildings	72,518	72,518	290,070	290,070
Certification fee (EUR)	€ 3,000	€ 15,000	€ 3,000	€ 15,000
Total certification fees (million EUR)	€ 217.55	€ 1,087.76	€ 870.21	€ 4,351.05
Project coordination & assessment costs (EUR)	€ 85,000	€ 120,000	€ 85,000	€ 120,000
Total coordination & assessment costs (billion EUR)	€ 6.16	€ 8.70	€ 24.66	€ 34.81

Source: Ecorys own calculations

With respect to **residential buildings**, in the UK the Impact Assessment study related to the CSH, estimates that in 2020 there would be no residential buildings assessed at Code levels 1 and 2 as these levels become more similar to Building Regulations.[144] It is expected that the majority of homes according to CSH (65%) will still comply with Code level 3 in 2020, but this trend is expected to decrease by 1% annually as more homes assessed under the Code become Level 4 and higher . This implies that in 2030, only 55% of homes are expected to be built according to Level 3. The study also expects that the percentage of home at Code levels 4, 5 and 6 will increase every year slightly, which reflects the trend that local authorities set higher standards in planning over time. Based on this, it can be assumed that extra over costs and process and administrative costs will be in the range of Code level 3 and 4 (see table 10 above) by 2020 and 2030 for the majority of certified residential buildings. However, the situation may change if the Code disappears. At this moment it is not clear how this would impact the certification of the residential market.

[144] Department for Communities and Local Government (2013), “Housing Standards Review Consultation: Impact Assessment”

Regarding the residential market in general, similar developments are expected in the UK, France and Sweden. For example, in France, extra over costs are expected to decline over time (based on interviews with HQE) while the share of certified homes is expected to increase. This will increase the total certification costs for the total stock of homes. However this increase is expected to have diminishing return.

Under the BAU, the **administrative costs** relate to operating the existing schemes, the development of new schemes under the current schemes (e.g. the new DGNB scheme for existing commercial buildings) or to extending the 'type of building' scope of the existing schemes as no new EU assessment framework is developed under the BAU.

With respect to maintaining the operation of established and self-supporting schemes, these costs can become low.[145] Regarding the development of new schemes, the costs depend on how complicated the scheme is, the cost of labour and also whether it builds on existing schemes (e.g. when an existing scheme is extended to cover other types of buildings). As an example, the cost of developing the new DGNB scheme for existing building was relatively low. This is due to the fact that DGNB is an NGO, hence people spent time and expertise for free to develop the scheme. DGNB estimates that, besides this expertise and knowledge of people, approximately 1 FTE full time/ year is needed for project management, managing the expert group of 10-20 people. Hence, in general, a tool would require around one to one and a half year to be developed, in addition to the cost of labour.[146] In Sweden, the development cost of the Swedish Miljöbyggnad has been seen as relatively cheap, and amounted to about 2.2 million EUR, with 16 indicators.[147]

Impact on SMEs

Regarding the **impact on SMEs**, it can be stated that larger companies have a greater knowledge and understanding of the business case in general. As a result, large companies usually have different drivers which may not apply to SMEs, such as CSR and its reputational risks/benefits, or certain regulation that applies to them but not to smaller companies. However, SMEs can be flexible and use flat command structures which allow them to adapt faster to new situations once they have perceived an untapped market and are trying to grow. The SME-Environment 2003 report[148] showed that a significant number of UK SMEs are already aware of the benefits that are connected to good environmental standards. 65% of the respondents answered it improves 'Good customer relations', 53% stated 'Reduced operating costs' and 48% noticed 'Improved competitiveness'. On the other side, larger product manufacturers are using more often green building or product standards than smaller ones, given the R&D often needed to systematically improve product lines. This is supported by a survey[149] of south-east European countries for the manufacturing of building material sector in which more of the half of the companies need help in dealing with their environmental standards. Most of the companies that achieved international standard (i.e. EN ISO 14001) were medium or large sized. One reason could be that larger companies can generally bear the risk or cost of innovative projects such as nearly zero-energy building better than smaller companies. At the same time SMEs can be drivers of innovation, adapting to new technologies and willing to invest in environmental and energy related innovations. There are many examples that some of the most innovative companies in the property and construction sector are SMEs as smaller companies can adapt faster to changing circumstances and grab the opportunity compared to the large companies.[150] In this context it is interesting to note

[145] Information provided by BRE

[146] Interview with DGNB

[147] Interview with the Swedish Green Building Council

[148] SME-Environment 2003, available at: http://www.environment-agency.gov.uk/static/documents/Utility/sme_2003_uk_1409449.pdf

[149] GReening business through the Enterprise Europe Network. Existing Environmental measures in support of SMEs in the Manufacturing of building materials sector: Analysis and knowledge sharing strategy

[150] Information provided by UK GBC

that the membership of the World Green Building Council (WGBC) is dominated by SMEs (more than 75% of the members).

For those SMEs who perceive green as a threat rather than an opportunity, policy certainty is a key factor for the development. These companies need time to adapt to new requirements, and seek confidence in a market opportunity, as well as help and support in learning how to deliver higher standards. This might come in the form of government sponsored training courses or pilot projects, but it also may take the form of SMEs joining together to share skills and knowledge, and partner with each other where appropriate. On the other hand, there is also evidence that SMEs can play a role in providing sustainable building solutions. However, in order to do it cost-effectively, they need project experience and guidance.[151]

In short, SMEs may have more problems with the existence of several schemes and may therefore benefit from more coordination and streamlining between the schemes.

Impact on jobs

With respect to **job creation**, current research does not provide sufficient evidence to estimate the impact of assessment schemes on job creation. According to interviews with HQE, job functions needed include:

- assistance to developers – to support them in different ways to reach the defined target
- project coordination – in particular architects and engineers, thermal engineers, maintenance professionals who need to work together from the start in a different way than what has been the tradition.

This coordination is done by "assemblers" who coordinate skills and professionals. However, the responsibility is with the developer and/or builders.

Moreover, according to BRE, certification schemes play an important role in helping to support and develop industry and innovation and therefore in-turn generate jobs. Directly, BREEAM has created and/or supported thousands of assessors and accredited professionals in the UK and Internationally (particularly in Europe) and also supports job creation through the establishment of National Scheme Operators (NSO) in different territories (at present there are six BREEAM NSO in Europe, UK, Spain, Germany, Netherlands, Sweden, Norway). Indirectly BREEAM creates demand for 'green/sustainable' products and services needed to ensure that buildings achieve the performance levels of the scheme (which go beyond what regulation requires) [152]. A report produced by the Confederation of British Industry in July 2012 stated that the UK's green business has continued to grow in real terms, carving out a £122 billion share of a global market worth £3.3 trillion and employing close to a million people.[153]

Based on this evidence, it is expected that social benefits and job creation will continue to rise in the future as more buildings are expected to be certified under the current certification schemes. At this stage, the magnitude of these benefits is difficult to estimate.

Impacts on other social aspects

The social impacts (other than jobs) reflecting the use of certification schemes are described below. The new evaluation guide for BREEAM ("BREEAM New Construction 2011"), contains nine categories, including Management, Health & Wellbeing, Energy, Transport, Water, Materials,

[151] Interview with Ana Cunha for HQE
[152] Interview with Tim Bevan for BRE
[153] Confederation of British Industry (2012) "The colour of growth: maximising the potential of green business" http://www.cbi.org.uk/media/1552876/energy_climatechangerpt_web.pdf

Waste, Land Use & Ecology and Pollution. The objective was not only to measure and evaluate the environmental performance of buildings, but also to reflect the social and economic benefits of meeting the environmental objectives covered, as well as to raise the awareness amongst owners, occupants, designers and operators of the benefits of green buildings with lower environmental impacts and a reduced material use.

The BREEAM figures in the current section are taken from a survey conducted in January 2012.[154] The research included 50 face-to-face and telephone interviews with client organisations from both public (universities and government) and commercial (owner occupiers and developers) sectors. A web survey supported this to collect a more general view (105 responses), chiefly looking at the views of BREEAM assessors, other professionals and the supply chain. In total this adds up to 155 respondents of mainly professionals or clients connected to BREEAM. This does not include residential buildings under the Code for Sustainable Homes.

In this consultation, 94% of BREEAM client respondents indicated social benefits were a major reason for undertaking BREEAM assessment. These social benefits include promotion of greater health and well-being and encouragement of sustainable business practices. Of the three elements of sustainability – environmental, economic and social – it was found that the most commonly stated benefits fell in the social category.

In particular the social benefits include:
- recognition in terms of industry standing, respectively the improved image provided by BREEAM (e.g. students prefer certain universities because of a higher ranking in the 'EcoCampus', a national Environmental Management System)
- benefits for public relations and Corporate Social Responsibility (CSR)
- improved comfort and satisfaction of the occupants (quality of a building's indoor and humidity control)

In addition, almost 30% of BREEAM client respondents whose projects had been certified agreed it improved employee retention and around 35% that it improved employee productivity. More than 70% of BREEAM client respondents whose projects had been certified agreed it improved CSR. As a result the company becomes more attractive to employees and also improves public image and thus generates more orders and most of the time higher quality. This was a further reason, as around 75% of BREEAM client respondents whose projects had been certified agreed it improved public relations and almost 80% agreed it improved recognition or industry standing.

The social impacts of environmental assessment systems for buildings also contribute, apart from image and CSR improvements, to a higher level regarding the quality of life. Around 60% of BREEAM client respondents whose projects had been certified agreed it improved occupant satisfaction and comfort[155]. This aspects is also interesting for health reasons as environmentally friendly buildings emit a lower level of VOC (volatile organic compounds), SVOC (semi-volatile organic compounds), and POM (particulate organic matter)[156]. All these substances can provoke respiratory, allergic, or immune effects and thus decrease the quality of life in a building. Green homes limit the use of chemicals that can off-gas from building materials and foster a healthy indoor

[154] Parker, J. (2012) The Value of BREEAM, A BSRIA report.

[155] http://bloomington.in.gov/green-building-benefits; http://www1.eere.energy.gov/femp/pdfs/buscase_section3.pdf; The value of BREEAM © BSRIA BG 42/2012

[156] Mendell, M. J. (2007). "Indoor residential chemical emissions as risk factors for respiratory and allergic effects in children: A review". Indoor Air 17 (4): 259–77; Articles also dealing with indoor quality; Dales, R.; Liu, L.; Wheeler, A. J.; Gilbert, N. L. (2008). "Quality of indoor residential air and health". Canadian Medical Association Journal 179 (2): 147–52; Yu, Chuck; Crump, Derrick (1998). "A review of the emission of VOCs from polymeric materials used in buildings". Building and Environment 33 (6): 357–74

environment and well-being. Moreover, green buildings have less temperature variances and use natural air circulation to keep the indoor climate stable.[157]

In case of the DGNB these comfort criteria take a large share of the 16 sociocultural and functional quality indicators. The indicators represent 22.5% of the overall weight and consist of three areas: i) health, comfort & user well-being; ii) functionality; and iii) aesthetic quality.

Also, the scheme applies criteria which involve social aspects. Two sections of the criteria deal with social impacts. First, the comfort area, dealing with thermal comfort, acoustic comfort, visual comfort, and olfactory comfort. Second, the health area, including health quality of environments, health quality of air, and health quality of water.[158]

For schemes worldwide, the figure below shows the result of 'World green building trend' of 2013. The results are based on a survey with respondents from 62 countries, with statistically significant results on 9 countries (Germany, Norway, UK, Singapore, Australia, United Arab Emirates (UAE), South Africa, US, Brazil). For the respondents, green buildings can have social impacts in both driving a larger sustainability market and delivering healthier spaces in which to live and work. Similar to the BREEAM results, the agreement on the importance of social reasons is very high. For the US, Australia and South Africa the promotion for greater health and well-being is most important. For Europe (particularly in Germany which had statistically significant number of respondents), the UAE, Singapore and Brazil the encouragement of sustainable business practices is the most important social reason for building green.

Figure 4.6 Most important social reasons for building green

Top Two Most-Important Social Reasons for Building Green (By Firm Location)

Top Reason

Most Important Social Reason	US	Australia	Europe	UAE	Singapore	Brazil	South Africa
Promotes Greater Health and Well-Being	#1 (56%)	#1 (57%)	#2 (52%)	#2 (41%)	#2 (55%)	#2 (52%)	#1 (66%)
Encourages Sustainable Business Practices	#2 (43%)	#2 (54%)	#1 (54%)	#1 (64%)	#1 (59%)	#1 (57%)	#2 (58%)

Source: McGraw-Hill Construction, 2013

Note: Results are based on respondents from 62 countries, but statistically significant results were obtained only in 9 countries (for Europe this is Germany and Norway)

4.2.3 Environmental impacts

The current low level of uptake of the above schemes means that the net effect at the building-stock level is very minimal.

In a scenario where the uptake of building certification remains rather low, we can still expect energy efficiency of buildings (as in the entire stock of buildings) to continue to improve toward

[157] Dales, R.; Liu, L.; Wheeler, A. J.; Gilbert, N. L. (2008). "Quality of indoor residential air and health". Canadian Medical Association Journal 179 (2): 147–52; Yu, Chuck; Crump, Derrick (1998). "A review of the emission of VOCs from polymeric materials used in buildings". Building and Environment 33 (6): 357–74.

158 HQE Certification applied to the reality of the civil construction industry in Brazil, available at: http://www.abepro.org.br/biblioteca/ICIEOM2013_STO_173_995_21349.pdf

2020 and 2030 as new, more efficient buildings replace older buildings and other older buildings are renovated in line with energy efficiency guidelines.

Determining whether, in this scenario, the energy embodied in the materials used to construct buildings will increase or decrease is more problematic. Two trends play against each other: i) the increase in the energy efficiency of production of these materials; and ii) the potential increase in material requirement per unit (building or m2), at least in part in response to the need to building more energy efficient buildings. The first represents a 1% improvement a year: for example, the JRC estimated that the CO_2 intensity of steel production will be improved (reduced) by 16% between 2010 and 2030[159] that corresponds to a 0.75% efficiency improvement a year. In a similar study, JRC estimated the annual improvement of CO_2 intensity to be ca. 0.85% for cement production[160]. For the latter, the decoupling between amount of materials used per m2 provided, was also limited over the long term trend as discussed in Section 2.3.2 of the final report.

Reductions in embodied energy are likely to come more from innovatively reducing material content (or changes in material type), while maintaining a push toward more efficient buildings, rather than from increases in efficiency of producing that material. This is because the primary materials used in construction are considered very mature technologies. Many of the other life cycle impacts of building materials are linked to energy use in production, although other factors limiting the use of chemicals and the uptake of eco-labelled materials (paints/finishes/flooring etc) also affect “lifecycle issues” to an extent.

The magnitude of the environmental impacts / resource use savings from buildings, certified as “sustainable”, compared to industry standard buildings is very difficult to determine. As such, it is important to note that even a wider use of a voluntary certification scheme would not necessarily mean that there would be a significant improvement in the net sustainability of buildings – as these additional buildings certified could, and possibly would, have been constructed to above industry standards in the absence of certification. This is because interest in certification is, in itself, an indication of willingness to take steps to improve environmental performance. However, it is fair to say that a low uptake of certificates can be read as a low market demand for certified buildings, which in turn could be interpreted as a low willingness to integrate lifecycle environmental concerns into building procurement.

A survey run by McGraw-Hill Construction discussed earlier, demonstrates the most important **environmental benefits** for businesses by global region. These benefits relate to reduced energy consumption, water consumption, improved indoor air quality, protection of natural resources and lower GHG emissions (see figure 4.7 below). For Europe, the most important environmental benefit reported is by far reduced energy consumption. These benefits also differ per scheme as schemes differ with respect to incorporating environmental indicators.

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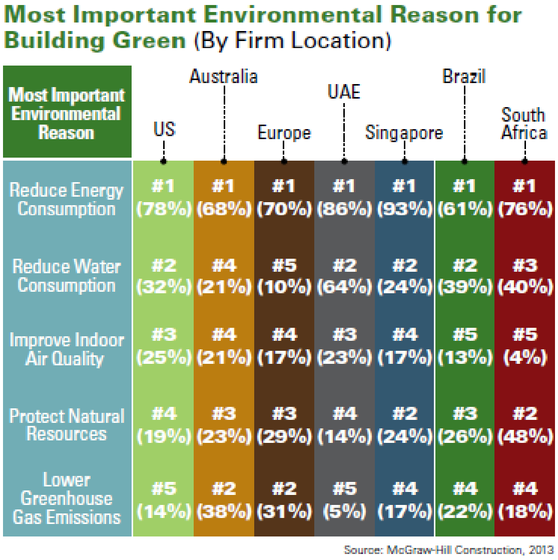
159 N. Pardo, J.A. Moya, K. Vatopoulos, 2012. Prospective Scenarios on Energy Efficiency and CO2 Emissions in the EU Iron & Steel Industry. JRC, 2012

160 J.A. Moya, N. Pardo, A. Mercier, 2012. Energy Efficiency and CO2 Emissions: Prospective Scenarios for the Cement Industry. JRC, 2012

Figure 4.7 Most important environmental reasons for building green



Most Important Environmental Reason for Building Green (By Firm Location)

Most Important Environmental Reason	US	Australia	Europe	UAE	Singapore	Brazil	South Africa
Reduce Energy Consumption	#1 (78%)	#1 (68%)	#1 (70%)	#1 (86%)	#1 (93%)	#1 (61%)	#1 (76%)
Reduce Water Consumption	#2 (32%)	#4 (21%)	#5 (10%)	#2 (64%)	#2 (24%)	#2 (39%)	#3 (40%)
Improve Indoor Air Quality	#3 (25%)	#4 (21%)	#4 (17%)	#3 (23%)	#4 (17%)	#5 (13%)	#5 (4%)
Protect Natural Resources	#4 (19%)	#3 (23%)	#3 (29%)	#4 (14%)	#2 (24%)	#3 (26%)	#2 (48%)
Lower Greenhouse Gas Emissions	#5 (14%)	#2 (38%)	#2 (31%)	#5 (5%)	#4 (17%)	#4 (22%)	#4 (18%)

Source: McGraw-Hill Construction, 2013

Source: McGraw-Hill Construction (2013)

The figure above is based on results from a survey with respondents from 62 countries, with statistically significant results on 9 countries (Germany, Norway, UK, Singapore, Australia, United Arab Emirates (UAE), South Africa, US, Brazil). They show the % of respondents that indicated a particular environmental benefit is important to them (e.g. 70% of respondents indicated reduced energy consumption as an important environmental reason for building green which makes it the number one environmental reason).

The survey conducted on BREEAM, discussed in previous sections of this paper, indicates that 76% of BREEAM client respondents indicated environmental benefits were a major reason for undertaking BREEAM assessment. In addition, almost 60% of BREEAM client respondents whose projects had been certified agreed it led to reduced construction waste and materials use, almost 60% agreed it led to reduced operational carbon, and almost 50% agreed it led to improvements for wildlife. This shows that buildings certified as ‘sustainable’ are expected by procurers to improve the environmental performance of buildings.

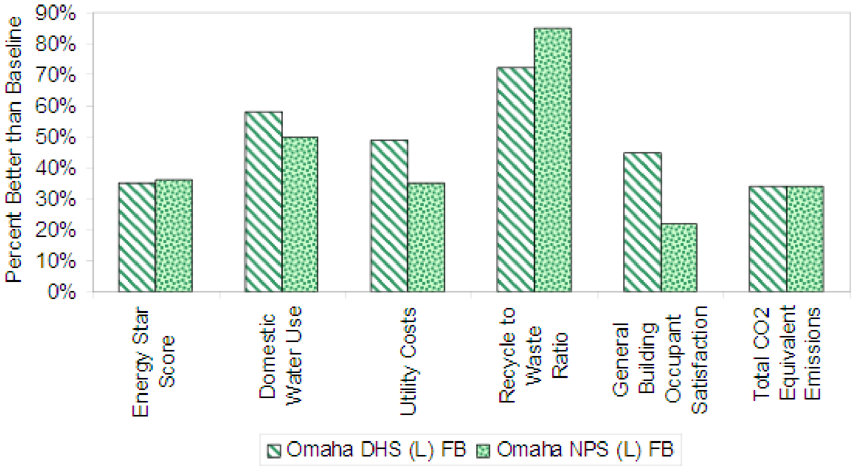
Limited information is available on the relative benefits of LEED certified buildings in the US from the Whole Building Design Guide from the National Institution of Building Sciences in the US[161]: “There are a wide range of economic and environmental benefits to sustainable design, often achieved through the use of standards, rating, and certification systems.” According to a study of LEED certified buildings, the USGBC has found that energy, carbon, water, and waste can be reduced, resulting in savings of 30 to 97% respectively.

Furthermore, a report by the Pacific Northwest National Laboratory for the US Department of Energy titled “*Assessing Green Building Performance: a post-occupancy evaluation of 12 GSA buildings*”[162] provides a little additional information on potential energy and water savings from certified buildings compared to industry averages for public buildings. This presented a mixed picture, but it does indicate that energy consumption, CO_2 emissions and the costs of waste collection would be reduced. The following graph compares two buildings certified under the LEED system with the baseline:

[161] http://www.wbdg.org/resources/gbs.php

[162] http://www.gsa.gov/graphics/pbs/GSA_Assessing_Green_Full_Report.pdf

Figure 4.8 Comparing two buildings certified under the LEED system with the baseline



Certified buildings with existing schemes typically show increased **embodied energy impacts** due to the increased insulation material use. Lack of consideration of this impact is mainly due to the fact that calculating the embodied energy takes many Environmental Product Declarations and other information. Not all materials have this and they are not always normalised. Hence, it is difficult to know what to include.[163] Increased embodied energy due to high energy efficiency of a building is also the case for some buildings certified by HQE. Comparing for example standard buildings with HQE certified buildings, it is believed that the embodied impacts for insulation in a HQE building adds approximately 10-15% to the total embodied energy of the building. Moreover, initial data indicates that a standard building neither has the embodied energy for equipment (for heating, cooling, generation of renewable energy, e.g. heat pumps, solar panels for hot water, photovoltaics for electricity) which makes up 20-25% of total embodied energy of the building (very few and new initial data are available on this so far). Lastly, 20-25% of dangerous waste from a building is linked to equipment improving the energy efficiency, and this is a negative impact that a standard building does not have.[164] Yet, in total a significant reduction in life cycle impacts can be seen. Based on this, it is expected that in BAU these environmental impacts will continue if there is no change.

However, there is an important potential for the embodied impacts to be reduced in future green buildings. The study of CSTB[165] shows embodied energy for different parts of the building (different construction products and equipment) and the spread is in several cases important, indicating that improvement potential is there and reductions can be made. For example, all materials in a building (all typologies average) have an embodied energy of about 42 kWh/m2 per year (spanning from 32 to 65). The 20% best performers have an embodied energy of 37kWh/m2 per year and the 20% worst performers have 47 kWh/m2 per year. This range shows that important improvement potential exists:

- For single houses, the average for embodied energy is 40 kWh/m2 per year with the 20% best having 37 kWh/m2 and the 20% worst having 43 kWh/m2 per year.
- For schools, the average is 44 kWh/m2 per year with the 20% best having 34 kWh/m2 and the 20% worst having 54 kWh/m2, which again shows a significant improvement potential.

[163] Interview with HQE
[164] Discussion with Julien Hans, CSTB, on the HQE performance test
[165] HQE Association, Analyse de cycle de vie des batiments at http://assohqe.org/hqe/spip.php?article283

- The waste for all typologies (non-dangerous) is 24-42 kg/m2 per year, which again shows an important range with an improvement potential.

If looking at the different parts/elements of a building, we can see the following for the embodied energy:

Elements of a building	Average embodied energy (kWh/m2 per year)	20% best and worst performers (kWh/m2 per year)
Structural parts	11	6.5 - 17.5
Windows	4	3 - 5
Insulation	2	1 - 3
Material on top of concrete slabs but under the flooring	5	4 - 6

Hence, the potential for reduced embodied impacts in buildings exists, however, it is not clear to what extent it will materialise in BAU.

The analysis provided in the problem definition for this analysis discusses the importance of recycled metals for building applications, emphasizing their environmental benefits in substituting construction materials produced from primary resources, therefore their use should be promoted.

In general, in certified buildings, material choices and improvements in terms of material use are mostly motivated by our restrictions concerning the use / content of hazardous substances. This mainly aims to reduce human toxicity and eco-toxicity impacts. [166]

In conclusion, the focus on energy efficiency risk that other resource uses and related environmental impacts are neglected. This is a reason why we need multi-criteria in an assessment framework.[167]

4.3 A voluntary framework consisting of core indicators to be used for the assessment of the environmental performance of buildings (Option 3.1)

This section firstly assesses the foreseen uptake of a common EU voluntary framework consisting of core indicators (Option 3.1) to be used for the assessment of the environmental performance of buildings in 2020 and 2030. Secondly, it evaluates potential economic, social and environmental impacts thereof compared to the BAU.

4.3.1 Foreseeing the uptake of such an EU voluntary framework

In order to estimate the uptake of this EU-wide voluntary framework, we partly relied on the results of the analysis of the current voluntary certification schemes market in the EU and primarily on the views of stakeholders. At this stage a sufficiently robust quantitative assessment is not possible.

Based on this, there are three routes foreseen for the uptake of the EU voluntary framework:

1. If existing schemes could be convinced about the benefits of this framework, they could incorporate it as a module in their systems.
2. It is expected that the EU framework on its own would have an uptake in countries where certification in general today is low, at a first stage particularly non-residential buildings.
3. It is expected that if the framework manages to be affordable enough, we could also expect it to be used for residential buildings across EU.

[166] Information provided by DGNB
[167] Interview with HQE

All these routes are qualitatively explored below.

1. Integration into an existing scheme

One potential route would be to incorporate the framework as a module in the existing certification systems. This may not directly generate more assessments, but it would add importantly to the generation of more comparable data. This in turn would support the business case and thus indirectly the demand and the number of certifications.

With respect to the incorporation of the voluntary assessment framework into the DGNB scheme, it has been noted that DGNB is based on the German government guidelines and regulations. However, when internationalising the tool, other countries' national standards and tools have to be taken into account. According to them, a potential role of the new EU framework could be in this area where it would be quite helpful to have other (a more standardised tool), e.g. with respect to LCA data which is difficult to find in other countries.

2. Countries with currently low certification

It is foreseen that the framework would be a developed tool to be used particularly in countries where certification today is generally low, without the need for Member States (and their private actors) to have to go through a process of developing an assessment framework themselves. This builds on the assumption that the EU voluntary framework would not aim to compete with the existing voluntary schemes but rather would provide an added value to the current market to for example fill the gaps. If this happens in several Member States, more comparable data than in the BAU scenario would be generated and this would support the business case for having a common EU assessment framework for environmental performance of buildings. We would thus expect more buildings than in a BAU scenario to be assessed. It is likely that under this point, the framework would be used on its own, or supplemented with some country specific indicators.

To assess the extent to which the uptake might be according to this route, we screened the voluntary certification schemes market in the EU. As discussed in the introduction (Chapter 1) on the current market for certification schemes in Europe, there are several Member States (MS) where certification of buildings is very low and/ or there is no national voluntary scheme yet. These MS primarily include:

- Baltic states - Estonia, Latvia, Lithuania
- Central and Eastern Europe - Poland, Hungary, Slovakia, Bulgaria, Romania, Slovenia and Croatia
- Southern Europe – Malta, Greece and Cyprus
- Western Europe – Ireland (due to the proximity with the UK, BREEAM scheme is used).

The low uptake of the certification market can be considered to be due to certification schemes being perceived as too complex and/or too costly, but also due to the lack of awareness of business case. Box 4 shows an overview of countries with a low uptake of certifications.

Box 4: Overview of countries with a low uptake of certifications

Baltic countries - voluntary certification schemes are used very little in the Baltic states, which is shown by the very low number of certified buildings. However, efforts are made to promote such schemes. For example, Lithuania is considering establishing a voluntary national certification scheme for the local market. The aim is to set up a scheme which is cheap and simpler in terms of registration, administration, assessment, etc. (in comparison with international schemes) and which could effectively serve private sector (both residential and non-residential). This demonstrates that market needs are not satisfied in Lithuania, i.e. international certifications such as BREEAM are too costly and complex for local companies to obtain, but local scheme with reasonable price and less complex administration could be more often used by local businesses (e.g. mainstream office buildings) and will provide them with a unique opportunity to differentiate themselves from the rest of the market).

Central and Eastern Europe - Poland, Hungary, Slovakia, Bulgaria, Romania, Slovenia - In Poland, there are three green voluntary schemes in use: LEED, BREEAM and DGNB. However, all of these voluntary schemes have a very low market share amongst non-residential buildings (below 25%). One of the reasons might be the fact that these schemes entered the market only in 2010. In Hungary, Slovakia, Bulgaria, Romania and Slovenia - International and European schemes such as BREEAM and LEED have a very marginal presence and uptake if any. The reasons may vary between low awareness of the existence of the schemes at all, low knowledge of the schemes in the real estate market as a whole and therefore little point in being certified.

Southern Europe – Malta, Greece and Cyprus **–** in these countries, voluntary certification schemes are used very little or are non-existent (e.g. Cyprus). The schemes used are LEED and BREEAM. In Greece for example, the local green building council is very active but lacks a domestic rating system.

Western Europe - Ireland - the slow growth might be due to little evidence of how environmental assessment supports national policy and what role it could have in effecting real change. There appeared to be disagreement as to whether there was actually a green premium for rent or investment associated with better environmental performance.[168]

Based on this screening of the European certification market and the fact that many EU countries do not use international green schemes, a potential could exist for the uptake of the EU voluntary framework.

Existing schemes on the markets would have the option of including core indicators (as described previously) in their systems and would thereby contribute to the build-up of comparable data, leading to better knowledge and higher awareness of and demand for sustainable buildings.
In overall, if countries where certification is low would adopt the EU voluntary scheme, this would mean that assessment of buildings would be higher compared to the BAU in the non-residential market.

3. Residential market

Screening of voluntary certification schemes also shows that certification of residential buildings is today limited to a few Member States (evidence was seen in the UK, France, Sweden and some in Germany). Even in countries which may be relatively active in certification, it is typically limited to sectors outside the residential one. If the EU voluntary framework would be affordable enough, it could push assessment to move into the residential sector. Since the residential buildings account for 75% of all floor area in Europe, there is a great potential for the EU framework to tap this market. As a result this would mean that more residential buildings are assessed compared to the BAU scenario.

Based on stakeholders' opinions, all these routes are said to be important and there is a clear belief that more buildings would be certified under such a framework than in a BAU scenario even though this is not possible to quantify.

[168] Building Environmental Assessment for Ireland. Exploratory study. Brophy, Vivienne. UCD Energy Research Group (2011). (with the Irish Green Building Council) http://erg.ucd.ie/UCDERG/pdfs/IGBC%20FINAL%20Full%20.pdf

4.3.2 *Economic and social impacts*

Impact on public authorities:

The **development cost** of the EU voluntary scheme would be borne by the EU. This cost will depend on the complexity of the framework but it could be kept low as for example in case of the Swedish Miljöbyggnad (EUR 2.2 million). This will provide a significant advantage for the Member States and their relevant private actors (e.g. Green Building Councils), namely in those countries where certification is low and a system based on national standards is not yet developed, as these would not have to develop their own systems but could use the EU framework instead. **Costs related to the running of the scheme** would be borne by the Member States or their Green Building Councils.

Moreover, several benefits compared to the BAU scenario are expected. As the public consultation mentioned:

- Current situation of having multiple certification schemes is not seen positively and a change is needed;
- Since different existing schemes provide different input and results, providing a set of core indicators should be dealt with on the EU level;
- There are not enough good indicators for green buildings and this should be also dealt with on the EU level;
- A framework with core indicators is highly rated, and should preferably be mandatory, however, a good start would be a voluntary framework.

Development of the EU framework would entail initial investment costs for the EU compared to the BAU scenario, however, once the framework would be developed, the running costs for the Member States or their national Green Building Councils are expected to be low, compared with the benefits generated.

According to the public consultation, 50% of the respondents who represent public authorities expect that with a voluntary framework, if used with benchmarks, benefits would outweigh the costs. This share is increased to 60% when taking into account those that think it would slightly outweigh the costs.

Impacts on businesses

Regarding **producers** – architects, designers, manufacturers of construction products, construction companies – these would benefit from having a more harmonised system in place, which would also provide more (comparable) data. Producers would be able to take advantage of a common framework, which would decrease the costs related to multiple reporting requirements due to the multiple assessment schemes today. Moreover, this EU framework would provide them with core indicators addressing resource use, based on which they can supply construction products and buildings taking into account resource efficiency and life cycle considerations. This will allow them to benefit from competitive advantages based on environmental grounds. This is not the case under the BAU scenario.

If the EU voluntary framework of core indicators is in place, it is expected that developers, investors and property owners would be able to take more advantage of decreased operating costs and increased assets and building value compared to the BAU scenario. This is based on the assumption that the new EU voluntary framework would result in more buildings (both commercial and residential) being assessed, and as such more benefits can be generated.

Moreover, these actors will benefit from reliable and comparable information on the environmental performance of buildings compared to the BAU scenario.

Impact on consumers

If the target group using this new scheme would be residential buildings users, i.e. particularly **individual building owners and tenants**, these benefits might be linked mainly to quality of a building in the long-term. This is based on the information provided by HQE, which states that there is no price premium on residential buildings, only on commercial buildings. For the residential buildings, the reasons for certification are more linked to quality and certainty that there will be no problem with the buildings in the future (saving costs for the future).[169]

With respect to **certification costs** under the EU voluntary framework, these will depend on the scope (commercial and/ or residential, how many indicators, etc.) and assessment process (who can assess, calculations needed and their difficulty, etc.) of this new framework. Assuming it will be a simpler and cheaper framework compared to BREEAM and LEED certification costs are expected to be significantly lower than for these leading schemes. The Swedish Miljöbyggnad could be used as an example of certification costs for commercial buildings under a simpler assessment scheme. As mentioned in Figure 4.1, Miljöbyggnad covers only three aspects, i.e. energy, indoor environment and building materials, while BREEAM and LEED cover many more. As such, this scheme can be considered simpler.

The biggest cost savings would be generated with respect to project coordination and assessment costs as can be seen from table 4.9 on the overview of certification costs for the different schemes. Regarding the over costs of making the building green, these should not be greater than in the BAU per building, but since more buildings are expected to be assessed under this option compared to the BAU, the total over costs would be higher. However, over time the over costs are expected to decrease as more buildings become assessed, as has been mentioned above. This will in turn increase demand for green buildings as the extra over costs decrease.

As such, it is expected that with the introduction of the EU voluntary core indicators the total certification costs will increase as more buildings, both commercial and residential are expected to be certified compared to the BAU. However, these costs will go down per building. The size of these costs can't be estimated quantitatively at this stage.

Impact on SMEs

The availability of reliable and comparable data would have a positive effect on the performance of SMEs as they normally would not have the resources to invest in this type of market information. In addition, having an EU voluntary framework in place would also improve the situation for SMEs as they would not have to deal with several schemes, sometimes used in the same country. According to the Public Consultation, a sizable fraction (around 20 percent) of building owners uses more than one scheme to assess their building[170].

Moreover, it is expected that under this option, more guidance from the EU regarding the areas to include in assessments is provided, compared to the BAU[171]. This will increase the potential (and benefits) for the SMEs to be involved in this market for sustainable buildings, compared to the BAU.

Impacts on jobs

In terms of job creation, if more buildings are certified in more countries, it is expected that more jobs will be created compared to the BAU. This will be particularly visible in the following areas:

[169] Interview with HQE
[170] Public consultation
[171] Interview with HQE

- Direct jobs related to the certification and assessment process – we will need more assistance to developers, architects, engineers, maintenance professionals, assessors and accredited professionals compared to the BAU.
- Direct jobs related to the running of the scheme – particularly in countries which do not run own schemes. If the new EU framework would be adopted, this would entail establishment of national scheme operators/ green building councils.
- Indirect jobs related to innovation and green/ sustainable products and services as the assessment framework would push the demand for green buildings.

Impacts on other social aspects

With respect to the EU assessment framework consisting of core indicators, social impacts will depend on what type of indicators are included in the scheme. However, indirectly, "greening" the building improves the quality of such building from a long-term perspective. Given more buildings (residential and non-residential) are expected to be certified, these social benefits are expected to be higher, compared to the BAU scenario.

4.3.3 Environmental impacts

As discussed above, under the BAU scenario it is expected that energy efficiency in the use phase will continue to improve towards 2020 and 2030 according to the energy efficiency legislation. With respect to embodied impacts, those are today not tackled sufficiently. However, there is an important potential for their reduction in green buildings in future. Life cycle impacts are also tackled to a limited extent in the main existing schemes (see Box 5). A study for EURIMA states that in the four major building certification schemes on the EU market, the direct environmental life cycle performance of the selected building materials and products appears to be less important for the final rating than commonly thought, accounting at most for about 5% of the total score.[172] Given the low uptake of certifications expected under the BAU and the variety of methods to assess environmental building performance, considering Life Cycle impacts will continue to be a problem in the future.

The EU voluntary framework is foreseen to be designed such that the most important Life Cycle impacts are taken into account. This system/ tool would also facilitate data collection if it is cheaper and easier to be applied, which in turn will increase the number of assessed buildings, and eventually more comparable data will be generated. This information would allow for better measurement of Life Cycle impacts and determine the actual environmental improvement of assessed buildings compared to the BAU scenario. These impacts will also depend on the content of the core indicators incorporated into the framework.

Box 5: Life Cycle impacts across the existing schemes

A study by Force Technology for the European Insulation Manufacturers Association (EURIMA) published in May 2012 "***Analysis of five approaches to environmental assessment of building components in a whole building context***"[173] looks at BREEAM (UK), DGNB (Germany), HQE (France) and LEED (US). The primary conclusions from this report were:

- In all building certification schemes, the direct environmental life cycle performance of the selected building materials and products appears to be less important for the final rating than commonly thought, accounting at most for about 5% of the total score. The building materials and products may, however,

[172] Force Technology, (May 2012) "Analysis of five approaches to environmental assessment of building components in a whole building context" http://www.eurima.org/uploads/ModuleXtender/Publications/88/Force_Study_Building_certification_systems_May_2012.pdf

[173] http://www.eurima.org/uploads/ModuleXtender/Publications/88/Force_Study_Building_certification_systems_May_2012.pdf

also have a significant indirect influence on how the building performs in energy-related categories that are accounted for separately.

- The DGNB and the HQE schemes seem to follow the provisions in the upcoming European standards EN 15804 and EN 15978 (under CEN TC350) as close as possible and they are therefore well suited to describe the material and building impacts during building lifetime.
- The HQE and DGNB schemes require that life cycle assessments (LCA) of building products are available. In DGNB, the LCAs are an integral part of calculating and rating the building performance, while HQE rewards the calculation of the contribution from building products, but not necessarily the results. However, if the life cycle results are used actively, e.g. in the choice of products, the overall rating of the building may improve.
- The UK-based BREEAM scheme appears to use an LCA approach which is not in full accordance with international standards and practice.
- The US-based LEED scheme does not use any kind of quantitative information about the life cycle environmental performance of materials and products. It does, however, give a small credit if EPDs are available.

4.4 A mandatory framework consisting of core indicators to be used for the assessment of the environmental performance of buildings (Option 3.2)

This option would imply introducing core sustainability indicators into a mandatory certification system, such as for example the EPBD certification system. This system has been briefly described in the section on the baseline scenario. The assessment of this option is based on the same assumptions as those used for voluntary framework (see section 3.3). In addition, it is assumed that legislation would first target a mandatory framework for public buildings.

According to the public consultation, 43% of the respondents are of the opinion that a mandatory European framework consisting of core indicators is an effective option and another 26% consider this a somewhat effective option. There is some variation of this outcome when the different groups are taken into account. Most support for this option is coming from public authorities (70%), research organisations (56%), companies (54%), and private citizens (53%). Those least in favour are Industry associations (22%), and NGOs (31%). When including those who think this a somewhat effective option, these shares increase to 80%, 78%, 71%, 88%, 48% and 69%. If a set of benchmarks would eventually be added to this option, almost half (49%) of the respondents consider this an effective option and another 19% consider this a somewhat effective option.

Following the same approach as used by the recast EPBD, a mandatory framework consisting of core indicators would first be applied to new and renovated buildings. Information on core sustainability indicators would inform potential buyers and tenants not only about the energy but also about the environmental performance of a building.

This should increase the demand for sustainable buildings but also provide a system to collect comparable data across the EU and provide an incentive for better environmental performance. Based on a number of sources[174], we estimate the total floor space of public buildings at 3 019 million m^2, or some 29 million public buildings. To **estimate the uptake of the mandatory schemes** by 2020 and 2030 we assumed a one per cent increase in new building every year. Using this growth rate gives us 0.32 million new buildings by 2020 and 0.36 million new buildings by 2030. To substantiate these estimates, further market analysis would be needed.

[174] www.entranze.eu, BPIE, REH-H, IWU, ODYSSEE, ENEA and others

4.4.1 *Economic and social impacts*

Impact on private sector actors

The benefits of a mandatory framework for producers (such as architects, designers, manufacturers of construction products, construction companies, developers and investors) could be important as these actors would benefit from an expanded market and from improved market information.

The certificates based on a set of core indicators to assess the environmental performance of buildings can be a powerful tool to create a demand-driven market for sustainable buildings, as they allow economic agents to estimate costs in relation to environmental performance. The aim of the certificate would be to make the complex issue of the environmental performance of a building transparent to non-environmental experts (such as average building owners and tenants) and therefore tackle the lack of information market failure.

With regard to the procedure for and cost of **issuing certificates** (for example within the EPBD system), we see two basic models:

1. Require an on-site check of the building by an expert to gather information on its technical shape, followed by a calculation of the environmental rating of the building based on this information. This model follows some of the national certification regimes for energy assessment.
2. Allow for the building owner to give technical information (which could be of doubtful quality due to non-expertise) on the building to the expert, who prepares a certificate only based on this information and using many simplified and standardised assumptions depending on the building type, without visiting the site.

Regarding the green voluntary schemes, the certification process differs per scheme. However, it follows the first basic model, i.e. there is an external assessor or auditor preparing and verifying the material and data needed for certification.

Although model two would imply a low cost for certification, it does not always reflect the actual shape of a building and therefore can lead to incorrect rating results and inappropriate recommendations in the certificate. Therefore, model one would be more in line with the objectives of the policies to be pursued under this option.

The costs for the private sector to develop an administrative system for the certification system, is estimated to be around EUR 7 million. If separate administrative systems are developed in every MS, total costs could run up to around EUR 50 million.[175]

In terms of certification costs, the EPC costs under the recast EPBD system vary per country and region. The Concerted Action EPBD reports on the average price of a certificate in several countries. Not all countries report these prices and/or a system to collect such information is not in place yet.

The table 4.10 below provides an overview of the average price of a certificate for a number of countries. It is important to observe that there is no information available on price of certification for public buildings.

Table 4.10 Average price of a certificate for selected countries and regions

Country	Average price of a certificate
BE – Walloon region	• Single family house EUR 300 (VAT included), before it was EUR 480 • Apartment EUR 190, before EUR 300

[175] Estimated based on the certification system under the recast EPBD (Ecorys 2008)

<table>
<tr><td></td><td>The total turnover generated since the beginning of the certification of existing residential buildings in June 2010 is about 50 M€ (VAT included).</td></tr>
<tr><td>BG</td><td>Between 1 and 2 EUR/m2</td></tr>
<tr><td>DE</td><td>Between EUR 50 and EUR 800 for residential buildings</td></tr>
<tr><td>FR</td><td><table><tr><td>Type of housing</td><td>Studio/F1
F1bis</td><td>2 room
appartment</td><td>3 room
appartment</td><td>4 room
appartment</td><td>5 room
appartment</td></tr><tr><td>Mean price (EUR)</td><td>80/110</td><td>90/120</td><td>100/130</td><td>110/150</td><td>120/160</td></tr></table></td></tr>
<tr><td>PL</td><td>EUR 10 -1000 (and above for public buildings)</td></tr>
<tr><td>RO</td><td>EUR 50 – 150 for an individual dwelling
EUR 500 – 100 for a collective residential building</td></tr>
<tr><td>ES</td><td>No fixed costs nor tax at national level, e.g. Castile and Leon (regions) taxes:
0.40 €/m2 for residential blocks,
0.97 €/m2 for single-family houses,
0.79 €/m2 for small non-residential buildings, and
0.89 €/m2 for big tertiary buildings
This administrative tax varies between a minimum of 150 € for single-family houses and a maximum of 1,200 € for large tertiary buildings. Extremadura also charges an administrative cost of 21.79 € per registered certificate.
Costs for certificates: market - costs from 40 €/apartment for blocks of flats, to 250 € for detached houses, and 0.5 €/m2 for tertiary buildings.</td></tr>
<tr><td>SE</td><td>At least EUR 1000 – stable price</td></tr>
<tr><td>England and Wales/ Scotland</td><td>The cost of certificates varies greatly. Indicative start costs (i.e., lowest market costs) in December 2012 based on Google search are:
for residential buildings: from 40 to 70 GBP (circa 50 to 90 €);
for non-residential buildings: from 150 to 200 GBP (circa 190 to 250 €).</td></tr>
</table>

We do not expect that certification costs would significantly increase if additional “sustainable” core indicators would be introduced into the system.

Impact on innovation and research

As we explained in the section on BAU, the introduction of certification tends to drive innovation and under a mandatory scheme there would be an stronger incentive for market players to innovate and thereby obtain a share of the market.

Impact on jobs

When the use of certification schemes to assess the environmental performance of public buildings becomes mandatory, there is likely to be a modest increase in the number of jobs. There are three sources for this growth: i) schemes are likely to be developed as an ‘upgrade’ of EPC which requires existing assessors to upgrade their skills and this will generate employment for training institutes and independent consultants; ii) the number of buildings to be assessed is expected to increase by one percent per year; and iii) an increased use of recycled materials has the potential to increase employment, although there is limited evidence to back up this argument.

Impact on other social aspects

The social impacts (other than jobs) reflecting the use of certification schemes have been described in the section on BAU option. Here, we repeat the most important elements.

- Guidelines for environmental schemes such as BREEAM reflect the social and economic benefits of meeting the environmental objectives and can thereby raise the awareness amongst owners, occupants, designers and operators of the benefits of green buildings with lower environmental impacts and a reduced material use.
- In a consultation by BREAM, 94% of client respondents indicated social benefits were a major reason for undertaking BREEAM assessment. These social benefits include promotion of

greater health and well-being and encouragement of sustainable business practices. Of the three elements of sustainability – environmental, economic and social – it was found that the most commonly stated benefits fell in the social category.
- In addition, almost 30% of BREEAM client respondents whose project has been certified agree it improved employee retention and around 35% that it improved employee productivity.
- More than 70% of BREEAM client respondents whose project has been certified agree it improves CSR. As a result the company becomes more attractive to employees and also improves public image and thus generates more orders and most of the time higher quality.
- The social impacts of environmental assessment systems for buildings also contribute, apart from image and CSR improvements, to a higher level regarding the quality of life. Around 60% of BREEAM client respondents whose project has been certified agree it improved occupant satisfaction and comfort. This is also interesting under the health aspects as environmental friendly buildings emit a lower level of VOC (volatile organic compounds), SVOC (semi-volatile organic compounds), and POM (particulate organic matter).

Administrative burden on public authorities

As the option is aimed at public buildings, the development and monitoring of the schemes by governments causes some administrative costs. However, for reasons similar to the low impacts on jobs, it can be expected that the administrative burden of including additional indicators in the existing schemes for energy assessment will be low.

According to the public consultation, half of the respondents who represent public authorities expect that with this option, the benefits would significantly outweigh the costs, and an additional 10% of respondents expect that benefits slightly outweigh the costs.

4.4.2 Environmental impacts

The magnitude of the environmental impacts / resource use savings from public buildings being certified as “sustainable”, compared to industry standard buildings is very difficult to determine. With the mandatory option, all new buildings would use a certification scheme, which over time would mean that there would be a significant improvement in the net sustainability of buildings.

According to the McGraw-Hill Construction, environmental benefits of green buildings for builders and owners are (in declining order of importance): reduced energy consumption; reduced greenhouse gas emissions, protected natural resources, improved indoor air quality, and reduced water use. These benefits also differ per scheme as schemes differ with respect to incorporating environmental indicators.

4.5 Comparison of options

In the table below we list the three options and indicate our assessment of the total impact on the various issues discussed in this report for each of the options. Cost items for buildings, i.e. operational costs, assessment/ consultation, certification and over costs show expected impacts per building (not total costs). A decrease in these costs per assessed buildings is portrayed as positive impact (+ sign), while an increase in these costs is showed as negative impact (-). The total costs for these categories depend on the number of assessed buildings. The more assessed buildings there are, the higher the total costs. However, since the goal is to have more assessed buildings, this is not portrayed as a negative impact.

Moreover, it is expected that the development of the two options, 3.1 and 3.2 would only be finished towards the year 2020. Hence, the two options are likely to make a significant difference only after their implementation, i.e. after 2020.

Impacts		Policy option 1 (BaU) 2020	2030	Policy option 3.1 (Voluntary) 2020	2030	Policy option 3.2 (Mandatory) 2020	2030
				Expected implementation		Option put in place	Expected full implementation
Economic							
1	Harmonisation of the market	-	-	+	++	+++	+++
2	Operational costs of buildings	+	+	+	++	+	++
3	Return on investment	+	+	++	++	++	++
4	Assessment/ consultation costs	0	0	+	+	++	++
5	Certification costs	0	0	+	++	+++	+++
6	Over costs to get certified	+	+	++	++	+++	+++
7	Administrative costs - development of a new framework	0	0	--	--	---	---
8	Implementation cost	0	0	++	++	+++	+++
9	Impact on SME	0	0	+	+	+	+
Social							
1	Employment	+	++	++	++	++	++
2	Health	+	+	+	++	++	++
Environmental							
1	Comparable & accurate data	-	--	+	+	++	++
2	Environmental performance of buildings	+	++	++	+++	++	+++
3	Assessed # commercial buildings	+	+	++	+++	++	+++
4	Assessed # residential buildings	+	+	++	++	0	+++
5	Embodied energy	0	0	+	+	+	+

Impacts		Policy option 1 (BaU) 2020	2030	Policy option 3.1 (Voluntary) 2020	2030	Policy option 3.2 (Mandatory) 2020	2030
Distributional impact							
1	Uptake by different MS	+	+	++	++	+++	+++

Legend: expected changes compared to the status quo (2014)

0 - no change; + small positive change; ++ positive change; +++ significant positive change, - slight negative change; -- negative change; --- significant negative change

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