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1. CONTEXT AND OBJECTIVES

In the context of the Framework Contract on the Sustainable Management of Resources[1], the European Commission (EC) is supporting studies for the definition of necessary knowledge regarding the current use of natural resources. This will be the basis for the development of future European policies in the area of sustainable resource management.

Construction and demolition (C&D) waste has been identified by the EC as a priority stream because of the large amounts that are generated and the high potential for re-use and recycling embodied in these materials. Indeed, a proper management would lead to an effective and efficient use of natural resources and the mitigation of the environmental impacts to the planet.

For this reason, the Waste Framework Directive[2] (WFD) requires Member States (MS) to take any necessary measures to achieve a minimum target of 70% (by weight) of C&D waste by 2020 for preparation for re-use, recycling and other material recovery, including backfilling operations using non hazardous C&D waste to substitute other materials.

The first step towards the implementation of this Directive is the assessment of the current situation within the EU-27. Indeed, C&D waste management practices are assumed to vary greatly from a MS to another. The European Commission entrusted BIO Intelligence Service and its partners, ARCADIS and IEEP (Institute for European Environmental Policy), with the present on C&D waste with two major goals. On the one hand, the study is aimed at providing precise orders of magnitude regarding the amounts that are generated, already re-used or recycled and the potential for improvement. On the other hand, study should identify major concerns that arise regarding the management of C&D waste within the EU-27 and potential drivers towards the improvement of re-use and recycling rates of this specific waste stream.

As a consequence, this study on C&D waste represents a useful tool for the definition of the future steps and trends regarding the management of this waste stream in Europe.

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[1] www.eu-smr.eu/intro/

[2] Directive 2006/12/EC revised by Directive 2008/98/EC

2. METHODOLOGY

BIO Intelligence Service developed efficient twofold methodology to collect the quantitative and qualitative data necessary for the assessment of the current situation regarding the management of C&D waste within the EU-27.

Focus on the materials

On the one hand, the focus was made on different fractions that are most likely found in the C&D stream. The aim here was to describe for each identified fraction the applications that are made in the construction sector (buildings and civil engineering), the amounts of waste that are generated, the composition of the waste stream, the treatment options in place, the current re-use and recycling rates already achieved, and the emerging techniques. Finally, the study for each fraction was completed with an assessment on whether the fraction can possibly contribute to the 70% target. Whenever it was possible, a breakdown per MS was realised based on available data.

The criteria for the choice of the fractions to be further studied in details depended either on the importance of the fraction in the total C&D waste stream and therefore on the potential contribution the material could bring to the 70% target or on the hazards that can be associated to it.

The identified fractions are the following:

- Asphalt
- Bricks, tiles and ceramic
- Concrete
- Gypsum
- Ozone depleting substances (ODS)
- Wood
- Dangerous substances: asbestos, lead based paints (LBP), phenols, Polychlorinated Biphenyls (PCB) and Polycyclic Aromatic Hydrocarbons (PAH)

For the analysis of each fraction, a list of contacts was developed. The experts (as they are referred to further in this report) for each fraction represent European associations and federations or the Industry (in the producers side as well as waste management side). It was assumed that they would be able to give the most precise data at the EU-27 level for a proper assessment of the situation.

The process for the collection of the data was the following:

- The preparation of an interview guide: relevant questions and issues to be tackled with the expert.

- A series of emails were sent to the contacts explaining the context of the study, asking for availability for the organisation of an interview, inviting to review the interview guide, asking for other relevant contacts.
- Interviews were then organised. During the interview, the expert was asked to give quantitative data as far as possible (production, waste generation, waste treatment rates), to express his/her point of view regarding the current management of the waste fraction and the drivers and barriers towards the 70% target. Finally, the expert was invited to share any document or source that could provide reliable and relevant data. In total 30 organisations have been contacted, 17 persons answered (more or less concerned by the study) and 12 interviews were realised. The list of the contacts is given page 117.
- Data obtained from the interviewed experts were crosschecked with data from other sources when available, and a large stakeholder consultation was realised on the draft final report, during which different points of view could be confronted, providing a more reliable, objective assessment.

Focus on 5 Member States

On the other hand, the accent was laid on five MS to describe the current situation regarding the management of C&D waste. The goal was to gather more precise information about the management of this waste stream in various national situations that can occur within the EU-27 and identify best practices.

The targeted MS were chosen after consultation with project partners and the Commission and were estimated to represent the wide variety of the practices in the construction sector and the management of waste. The targeted MS are the following: Finland, Belgium (Region of Flanders), Germany, Hungary and Spain. They are presented as case studies.

For this purpose, a similar methodology as the one used for the study on material fractions was adopted and aimed at getting reliable information for the experts of the sector in each MS.

As for the interview per MS, a case study template was defined to ease the collection of quantitative and qualitative data. This was sent to the relevant contacts before an interview was planned. The list of the contacts is given page 117.

Thanks to the interviews organised with the experts for the fractions or case studies, we had access to reliable sources of information that are summarised in the literature review chapter, page 111.

3. OVERVIEW OF C&D WASTE MANAGEMENT SYSTEMS IN THE EU

3.1. DEFINITIONS

3.1.1. C&D WASTE

The Waste Framework Directive 2008/98/EC explicitly defines the term 'waste' as any substance or object which the holder discards or intends or is required to discard.

Construction and demolition waste is further specified in the Waste Framework Directive in reference to the European List of Waste (Chapter 17). The 'definition' is based on the nature of the waste (type of material) as illustrated in the table below.

Task 1 report concludes that this nature-oriented definition is not sufficient to clearly identify a given waste stream as C&D waste.

The recommended theoretical approach to define C&D waste is to take into account both its nature (materials used in buildings) and the activities that originate it (construction and demolition activities), regardless of who performs these activities. However, current reporting does not allow quantifying C&D waste according to this definition, and the available data used as a proxy for the purpose of this report is "all waste generated under NACE code F (construction sector)", as reported by Member States to EUROSTAT. The two main problems associated to this definition are:

- It includes non-C&D waste generated by the construction sector (e.g. packaging waste, food waste, etc.), that is not included in the definition of the WFD.
- It excludes C&D waste generated by other economic sectors (e.g. other industries, households, etc.), that is included in the definition of the WFD.

However, the quantities related to the two aforementioned waste streams are likely to be relatively small compared to the total amount of C&D waste generated, and will therefore be neglected in the following estimations.

3.1.2. C&D WASTE RECYCLING

The quantitative target set by the Waste Framework Directive is the following: *"by 2020, the preparing for reuse, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste excluding naturally occurring material defined in category 17 05 04 in the list of waste shall be increased to a minimum of 70 % by weight."* In particular, energy recovery is excluded from this scope. It is important to stress that category 17 05 04 (excavated material) is not included in the calculation of the target. It was therefore excluded (when available data made this exclusion possible) from the following estimations.

3.2. Quantities and nature of C&D waste arising in the EU

3.2.1. Total C&D waste arising

Available estimates

Several recent sources provide with estimates of C&D waste arising in Europe.

Source	Total C&D waste arising (million tonnes)	C&D waste per capita[3]
[WBCSD 2009] (2002 data)	510	1.1
[ETC/RWM 2009](2004 data)	866	1.8
[EUROSTAT 2010] (2006 data)	970	2.0

Various estimates by experts in the sector are also available. Umweltbundesamt, in its 2008 Aggregates Case study, refers to amounts of "more than 200 million tonnes of these wastes produced every year, excavated materials not included, according to FIR[4]" [UBA 2008] (i.e. more than 0.5 tonnes per capita). The FEAD estimates this amount to "1.5 to 2 tons per capita per year, excluding excavation material" [FEAD 2010].

Available estimates are therefore highly variable. These differences are analysed in the following sections in order to identify the sources of discrepancies and correct them so as to estimate these quantities more accurately.

Analysis of geographic variations

ETC/SCP working paper – Present recycling levels of Municipal Waste and C&D Waste in the EU, published in April 2009 [ETC/RWM 2009], gives estimates of per capita generation levels in all MS, with the exception of Romania and Slovenia. These figures are based on EUROSTAT data, completed by national reporting. The reference year is 2004.

Table 1 - C&D waste arising per capita and added value of the construction sector [ETC/SRC 2009]

Country	C&D Waste arising (tonnes/capita)	Waste factor (1000 t / million € added value)
Austria	0.81	0.46
Belgium	1.06	0.955
Bulgaria	0.39	4.53
Cyprus	0.58	0.545
Czech Republic	1.44	4.037
Denmark	3.99	0.578
Estonia	1.12	4.144

[3] Population data from EUROSTAT (accessed April 2010) for the corresponding years
[4] FIR: Fédération Internationale du Recyclage (European Recycling Industry of C&D waste)

Country	C&D Waste arising (tonnes/capita)	Waste factor (1000 t / million € added value)
Finland	3.99	3.239
France	5.5	5.016
Germany	2.33	2.406
Greece	0.37	0.344
Hungary	0.43	1.629
Ireland	2.74	1.312
Italy	0.8	0.778
Latvia	0.04	0.118
Lithuania	0.1	0.343
Luxembourg	5.9	N/A
Malta	1.95	N/A
Netherlands	1.47	1.264
Norway	0.7	0.194
Poland	0.11	0.41
Portugal	1.09	1.574
Romania	N/A	0.02
Slovakia	0.26	1.047
Slovenia	N/A	1.261
Spain	0.74	0.525
Sweden	1.14	1.029
United Kingdom	1.66	1.14
EU 27	1.74	

NB: Reported quantities that highly differ from the average are highlighted in orange

These data show important differences between MS: generation per capita ranges from 0.04 tonnes per capita (Latvia) to 5.9 tonnes per capita (Luxembourg).

A cross-analysis with an economic indicator (waste generated per € added value in the construction sector) also results in important differences (0.02 to 5.02 thousand tonnes of C&D waste per million Euros added value in the construction sector).

Six countries (Denmark, Finland, France, Germany, Ireland and Luxembourg) report high quantities of C&D waste generation (over 2 tonnes per year per capita).

Seven countries (Bulgaria, Greece, Hungary, Latvia, Lithuania, Poland and Slovakia) report very low levels of C&D waste generation (below 500 kg per year per capita).

These high geographical variations cannot be assumed to reflect actual arising of C&D waste. According to the experts interviewed during the course of this study, the main reasons for these discrepancies are the unequal levels of control and reporting of C&D waste in MS, as well as differences in definitions and reporting mechanisms. **The quality of the available data is therefore the main issue in estimating the quantities of C&D waste generated.**

Other explanations for geographical variation include economic reasons (the quantities of C&D waste generated is highly dependent on the rate of new constructions, and the economic growth of the country), architectural habits (the types of materials used in construction shows great regional variation, e.g. in some regions brick is the main construction material, whereas in others concrete represents the majority; wood is a major construction material in northern countries like Finland or Sweden, etc.), cultural issues (e.g. demolition is seen as a failure in countries such as France, whereas it is regarded in a more positive way in other countries), or technical issues (the quality of the materials used in old construction influences the rate of demolition, e.g. more demolition is expected in new MS because of the low quality of the concrete used in old constructions). However, an accurate analysis of geographical variations would require reliable data, which is not the case with the current reporting system.

The estimations presented below were performed based on the available data by:

- Excluding excavation waste from the reported quantities in order to homogenise the perimeter
- Filling in data gaps/making assumptions for MS where no data is available

Exclusion of excavated material

Naturally occurring soil and stones, generated during construction activities (mostly in public works activities) are not to be included in the calculation of the recycling rates.

The six countries with high generation per capita generate close to 70% of the total C&D waste reported in the EU-27, while hosting only 32% of the population and representing 42% of the GDP[5].

An analysis of national reports for the above countries shows that the quantities reported in the ETC/SRC working document include high amounts of excavated material, which is not included in the definition of C&D waste for the purpose of the 70% target set by the WFD.

The inclusion of excavated material does not seem to be systematic in national reporting. As this flow represents up to 80% (e.g. in France) of the total amount of construction, demolition and excavation waste, uncertainty about their inclusion in national C&D waste statistics is a major source of uncertainty in data on C&D waste.

In order to get a better estimate of C&D waste in Europe, data for these six countries were corrected using national reporting excluding excavation material. Data were also corrected for the UK, where the reported quantities include around 45% of excavation material. For Finland, no complementary data could be found to correct the total amount, although the case study on Finland suggests that excavation materials represent an important part of the reported C&D waste. It was therefore assumed, based on the fraction of excavation materials reported in other countries, that 75% of the total C&D waste reported in Finland is excavation material.

[5] EUROSTAT GDP figures for 2009, last accessed May 2010

For these six countries, the following results are obtained:

Table 2 - Exclusion of excavation waste for countries with high generation per capita

Country	Reported quantities (tonnes per capita)[6]	Quantities (tonnes per capita), excluding excavation material
Denmark	3.99	0.83[7]
Finland	3.99	1.00[8]
France	5.50	0.99[9]
Germany	2.33	0.88[10]
Ireland	2.74	0.63[11]
Luxembourg	5.90	1.42[12]

The resulting ranges of quantities of C&D waste arising are the following:

- C&D waste (excluding excavation material): 0.63 to 1.42 tonnes per capita per year
- C&D waste + excavation waste: 2.3 to 5.9 tonnes per capita per year

Incomplete reporting

Very low levels of generation reported in some Members States probably reflects a lack of control by public authorities and therefore a very incomplete reporting of C&D waste arising. As a result, these quantities were assumed to be underestimated and the average generation rate per capita for other countries was applied[13] (0.94 tonne per capita per year).

Countries to which this correction was applied are the following:

Table 3 - Filling of data gaps for countries with low reporting ("low data" assumption)

Country	Reported quantities (tonnes per capita)[6]	"Low data" assumption (tonnes per capita)
Bulgaria	0.39	0.94
Cyprus	0.58	0.94

[6] ETC/RWM 2009
[7] Danish Environmental Protection Agency (DEPA), Waste Statistics 2004: 4.50 million tonnes of C&D waste
[8] Assumption of 75% excavation material
[9] ADEME&FNTP (Public works waste) and ADEME&FFB (Building C&D waste): 82% excavation material
[10] See Annex, Case Study Germany: 72.4 million tonnes of C&D waste excl. excavation material
[11] Irish Environmental Protection Agency (EPA), National Waste Report 2008: 77% excavation material
[12] ENECO S.a., Stand und Perspektiven bei der Entsorgung von unbelasteten mineralischen Inertabfällen im Grossherzogtum Luxemburg, 2003: 76% excavation material (2002 estimation)

Country	Reported quantities (tonnes per capita)[6]	"Low data" assumption (tonnes per capita)
Greece	0.37	0.94
Hungary	0.43	0.94
Latvia	0.04	0.94
Lithuania	0.10	0.94
Poland	0.11	0.94
Romania	0.00	0.94
Slovakia	0.26	0.94
Slovenia	0.00	0.94

New estimation of total C&D waste arising in EU-27

Building on the most recent consolidated data [ETC/RWM 2009], and applying the corrections mentioned above (exclusion of excavated materials when possible and data filling when data was assumed to be incomplete), an estimate of **0.94 tonnes per capita** of C&D waste (excluding excavation material) is made. This would amount to a total of approximately **461 million tonnes in 2005.**

Table 4 shows the new estimations per Member States (Table 1, corrected with the new estimations presented in Table 2 and Table 3Table 3).

Table 4 - Generation of C&D waste in EU-27 (ETC/RWM 2009 data, with new assumptions made by BIO)

Country	Generation of C&D waste (tonnes per capita) (a)	Pop. 2004 (million inhab.) (b)	Total generation in million tonnes (2004) (a*b)	Pop. 2005 (million inhab.) (c)	Total generation in million tonnes (2005) (a*c)
Austria	0,81	8,2	6,6	8,3	6,7
Belgium	1,06	10,4	11,1	10,5	11,1
Bulgaria	0,94	7,8	7,3	7,7	7,3
Cyprus	0,94	0,7	0,7	0,8	0,7
Czech Republic	1,44	10,2	14,7	10,3	14,8
Denmark	0,83	5,4	4,5	5,4	4,5
Estonia	1,12	1,3	1,5	1,3	1,5
Finland	1,00	5,2	5,2	5,3	5,2
France	0,99	62,8	62,1	63,2	62,6
Germany	0,88	82,5	72,4	82,4	72,3
Greece	0,94	11,1	10,4	11,1	10,5
Hungary	0,94	10,1	9,5	10,1	9,5
Ireland	0,63	4,0	2,5	4,1	2,6
Italy	0,80	58,5	46,8	58,8	47,0
Latvia	0,94	2,3	2,2	2,3	2,2

Country	Generation of C&D waste (tonnes per capita) (a)	Pop. 2004 (million inhab.) (b)	Total generation in million tonnes (2004) (a*b)	Pop. 2005 (million inhab.) (c)	Total generation in million tonnes (2005) (a*c)
Lithuania	0,94	3,4	3,2	3,4	3,2
Luxembourg	1,42	0,5	0,7	0,5	0,7
Malta	1,95	0,4	0,8	0,4	0,8
Netherlands	1,47	16,3	24,0	16,3	24,0
Poland	1,00	38,2	38,2	38,2	38,2
Portugal	1,09	10,5	11,5	10,6	11,5
Romania	0,94	21,7	20,4	21,6	20,3
Slovakia	0,94	5,4	5,1	5,4	5,1
Slovenia	0,94	2,0	1,9	2,0	1,9
Spain	0,74	42,3	31,3	43,0	31,8
Sweden	1,14	9,0	10,3	9,0	10,3
United Kingdom	0,91	60,1	54,8	60,4	55,2
EU 27	**1,09**	**490,38**	**459,60**	**492,41**	**461,37**

This estimate will be used for the purpose of this study, however it must be stressed that the uncertainty is extremely high.

This chapter tries to assess the possible ranges of quantities of C&D waste in Europe. To this end, quantities of C&D waste reported for the 6 countries which have reported the highest ratios per capita are presented. It is assumed that these countries are likely to have the most comprehensive data, and therefore represent the most reliable and representative sources.

The following ranges were extrapolated from the above assumptions.

Table 5 - Estimated ranges for the average generation of C&D waste in the EU, based on the above assumptions

	Low estimate	High estimate
Generation of C&D waste per capita (tonnes, Table 2)	0.63	1.42
Generation of CD&E waste per capita (tonnes, Table 2)	2.74	5.9
Total generation of C&D waste (million tonnes) – 2005	309	697
Total generation of CD&E waste (million tonnes) - 2005	1,346	2,898

C&D waste quantities are therefore likely to range between a total of 310 and 700 million tonnes per year in the EU-27 (0.63 to 1.42 tonnes per capita per year). The systematic inclusion of excavation waste would significantly increase these amounts, ranging from a total of 1 350 to 2 900 million tonnes of waste per year (2.74 to 5.9 tonnes per capita per year). The quality and reliability of the data currently available do not allow for a more precise range to be identified.

Construction waste and demolition waste

Construction waste on one hand, and demolition waste on the other are for the purpose of this study, considered as a whole. Current data does not allow a global distinction of these two categories. However, they have quite different characteristics, both in terms of quantities, composition and potential for recovery.

Construction waste (originating from new constructions) is usually less mixed, less contaminated, and its recovery potential is higher than demolition waste because of these characteristics. Its share in the total quantities of C&D waste is generally low (e.g. 16 % in Finland).

On the other hand, demolition (and rehabilitation) waste, which represents the highest amounts of C&D waste, tends to be more contaminated and mixed, and therefore is more difficult to recover.

Conclusions

Current data on C&D waste does not allow for a good estimate of the total quantities generated in Europe.

A harmonisation of reporting mechanisms and definitions clearly needs to be undertaken, and, in particular, excavation material needs to be systematically distinguished from the "core" C&D waste.

Reporting and calculation methods are currently being discussed, and a Technical Adaptation Committee (TAC) has met at several occasions in 2009 and 2010 to discuss the issues related to the targets set by the Waste Framework Directive (including the target on C&D waste). The process will lead to a Commission Decision clarifying the reporting obligations of each Member State, with the objective of harmonising data used to estimate the total amounts of C&D waste and the recycling rates.

This should result in more reliable and comparable data among MS.

3.2.2. Contribution of key material and substances to C&D waste

This section aims at estimating the average material composition of C&D waste, based on characterisation data available in some MS, and cross checking this data with EU experts estimates.

Characterisation of C&D waste: available data at the national level

Some Members States have reported results of material characterisation of the C&D waste stream. However, this reporting is not systematic, and is frequently based on surveys limited in time and in geographical scope.

The following table presents the available characterisation data in 9 MS. The composition of C&D waste varies significantly between those Members States.

Table 6 - Material composition of C&D waste for some European countries (UBA, 2008)[14]

Country	Netherlands	Flanders	Denmark	Estonia	Finland	Czech Republic	Ireland	Spain	Germany
Year	**2001**	**2000**	**2003**	**2006**	**2006**	**2006**	**1996**	**2005**	**2007**
Concrete	40%	41%	25%	8%	33%	33%	39%	12%	70%
Masonry	25%	43%	6%			35%		54%	
Other mineral waste	2%	-	22%	53%	-	-	51%	9%	-
Total mineral waste	**67%**	**84%**	**53%**	**61%**	**33%**	**68%**	**90%**	**75%**	**70%**
Asphalt	26%	12%	19%	4%	-	-	2%	5%	27%
Wood	2%	2%	-	-	41%	-	-	4%	-
Metal	1%	0%	-	19%	14%	-	2%	3%	-
Gypsum	-	0%	-	-	-	-	-	0%	0%
Plastics	-	0%	-	-	-	-	-	2%	-
Miscellaneous	7%	2%	28%	16%	12%	32%	6%	12%	3%

As is the case for the estimation of the total amount of C&D waste generated, the inclusion of excavated material represent an important bias. In order to obtain more comparable data, the above compositions were corrected in the following table by excluding this particular fraction for Denmark, Estonia and Ireland.

Table 7 - Material composition of C&D waste for some European countries (UBA 2008, after the exclusion of excavation material)[15]

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

[14] Highlighted cells show fractions that were identified as including large amounts of excavation waste

[15] Green cells highlight data that were corrected

The table below summarises the ranges in composition of C&D waste observed for those MS (except Estonia and Finland[16]), as well as the quantities resulting from this composition (based on the estimation performed in 3.2.1. for total C&D waste, i.e. 461 million tonnes).

Table 8 – Ranges of composition of C&D waste for the aforementioned MS (except Estonia and Finland)

Ranges	% - Min	% - Max	Million tonnes - Min	Million tonnes - max
Concrete and Masonry - total	**40,0%**	**84,0%**	**184**	**387**
Concrete	12,0%	40,0%	55	184
Masonry	8,0%	54,0%	37	249
Asphalt	**4,0%**	**26,0%**	**18**	**120**
Other mineral waste	**2,0%**	**9,0%**	**9**	**41**
Wood	**2,0%**	**4,0%**	**9**	**18**
Metal	**0,2%**	**4,0%**	**1**	**18**
Gypsum	**0,2%**	**0,4%**	**1**	**2**
Plastics	**0,1%**	**2,0%**	**0**	**9**
Miscellaneous	**2,0%**	**36,0%**	**9**	**166**

Material composing C&D waste: EU-27 estimates

Each material fraction within C&D waste was studied in detail in the course of this project, and the results of this analysis are presented in the following chapters. Estimates of the amounts of waste generated were requested from the main producers' federations and waste organisations at the European level. These estimates are summarised in the following table.

Table 9 - Experts estimates of waste quantities arising for some of the main materials composing C&D waste at the EU level

Material	Range (Million tonnes)	Source of estimates
Concrete	320-380	60-70% of C&D waste according to ECP[17]
Masonry	N/A	
Asphalt	47	EAPA[18]
Wood	10 - 20	[JRC 2009]; [WRAP 2009]
Gypsum	>4	

These are order of magnitudes, as no precise and available data is available at the EU level, and there is still a high uncertainty on these results. However, both sources show comparable orders of magnitude (confirming, in particular, the preponderance of concrete,

[16] Estonia and Finland are excluded because they show very specific composition (with a respectively high part of metal and wood)
[17] European Concrete Platform
[18] European Asphalt Producers Association

followed by masonry and asphalt), with the exception of gypsum waste, which seems to be underestimated by the characterisation method.

It must be noted that the material composition estimates are based on individual characterisations of the C&D waste stream, and cannot be considered as perfectly reliable. In practice, C&D waste (and particularly the mineral fraction) is not systematically separately collected in many MS, and therefore is managed as mixed C&D waste. For instance, the most usual way of processing C&D waste is by crushing the mixed inert fraction to produce recycled aggregates.

3.3. Recovery and recycling of C&D waste in the EU

There is currently no reliable data on recovery and recycling rates of C&D waste in the EU. Data on C&D waste treatment suffers from the same gaps and inconsistencies as generation data.

Please note that hereafter, "recycling rates" will be refer to the rates of "preparation for reuse, recycling and other form of material recovery[19]", as defined by the Waste Framework Directive.

Let's first have a look at available data.

Two recent sources (UBA 2009 & ETC/RWM 2009) provide recycling and recovery rates of C&D waste in some MS. Both sources are based on national reporting, through either EUROSTAT or individual questionnaires sent to MS. There are important differences between these two sources, both on quantities of C&D waste arising and reported recycling rates. These differences are again due to several inconsistencies in the perimeter and definition of C&D waste. Some figures include excavated material while some others do not (for example, Germany generates 73 million tonnes of C&D waste without excavation soil [UBA 2008] and 192 million tonnes with excavation soil [ETC/RWM 2009]). Likewise, some figures include waste from public works, while some others do not (for example, France generated 47.9 million tonnes of C&D waste from buildings, and this figure amounts to 343 million tonnes when waste from public work – which also includes a large part of excavation material – is included ([UBA 2008]).

[19] It must be stressed that the definition of recycling itself is not yet homogeneous between MS. However, given the lack of information on the actual final destination of the waste, it will be assumed that reported "re-use and recycling rates" in each MS matches the definitions of the Waste Framework Directive.

Table 10 - Comparison of reported recycling rates for C&D waste from two recent sources (UBA 2008 & ETC/RWM 2009)

Source	UBA 2009			ETC/RWM 2009		
Country	Year	Arising (million tonnes)	% re-used or recycled	Year	Arising (million tonnes)	% re-used or recycled
Austria	2004	6,6	76%	2006	6,7	60%
Belgium		12,3	86%	2004	11	68%
Belgium - Brussels	2000	1,2	59%	-	-	-
Belgium - Flanders	2006	9	92%	-	-	-
Belgium - Wallonia	1995	2,1	74%	-	-	-
Bulgaria	-	-	-	2004	3	-
Cyprus	-	-	-	2004	0,4	1%
Czech Republic	2006	8,4	30%	2006	11,8	23%
Denmark	2003	3,8	93%	2004	21,7	94%
Estonia	2006	2,4	73%	2006	0,7	92%
Finland	2004	1,6	54%	2004	20,8	26%
France	2004	47,9	25%	2004	342,6	62%
Germany	2002	73	91%	2006	192,3	86%
Greece	1999	2	5%	2004	4,1	-
Hungary	-	-	-	2006	5,4	16%
Ireland	2005	2,3	43%	2006	16,6	80%
Italy	2004	46,5	-	2004	46,3	-
Latvia	-	-	-	2006	0,1	46%
Lithuania	2006	0,6	-	2006	0,6	60%
Luxembourg	2005	7,8	46%	2004	2,7	-
Malta	-	-	-	2004	0,8	-
Netherlands	2005	25,8	95%	2005	25,8	98%
Poland	2000	2,2	75%	2006	16,8	28%
Portugal	1999	3	5%	2004	11,4	-
Romania	-	-	-	2005	0,4	-
Slovak Republic	-	-	-	2004	1,4	-
Slovenia	2005	1,1	53%	-	-	-
Spain	2005	35	-	2006	38,5	14%
Sweden	2006	11	-	2004	10,2	
UK		100,4	82%	2006	114,2	65%
UK - England	2005	89,6	80%	-	-	-
UK - Scotland	2003	10,8	96%	-	-	-
Average for x countries with available data			86%			66%
Total amount of C&D waste on which the estimation is based			252,7			820,2

In view of these fragmentary data, what could be said at the EU-27 level?

Overall, it seems very difficult to calculate recycling rates for C&D waste in Europe.

UBA 2009 reports recycling rates for 16 countries, representing 64% of the total amount of C&D waste generation they report. ETC/RWM 2009 reports recycling rates for 17 countries, representing 90% of the total amount of C&D waste generation they report. Based on these two samples, average recycling rates for countries where recycling data is available is respectively 86% and 66%.

But these two values are very likely to give overestimated indications of the recycling rate at the EU level.

In the 86% calculated for 16 MS from UBA 2008, countries with high recycling rates are overrepresented in the sample, and countries such as Italy or Spain, who reportedly generated high amounts of C&D waste with relatively low recycling rates, are not accounted for.

In the 66% calculated for 17 MS from ETC/RWM, relatively high recycling rates in Germany (86%) and Denmark (94%) are overweighed by the inclusion of high amounts of excavation soil. Countries with low recycling rates such as Poland (28%), or countries with no data available are also underrepresented, and would make the figure drop significantly.

The following table shows an attempt at correcting these different biases by:

- Considering the corrected quantities arising (see 1.1.1.): to avoid the overweighting of countries that include excavation waste in their reporting, and to correct the probable underestimations of quantities in countries with incomplete reporting
- Using the most recent recycling rates reported in ETC/RWM by default, and UBA 2009 when missing: although these rates may or may not be including excavated material, it is assumed that the overall recycling rates reflect in any case the situation in a given country
- Assuming a worst case scenario for countries where data is missing in both studies (i.e. 0% recycling rates): countries with low reporting are assumed to also have low control, and therefore low recycling rates, for C&D waste

Table 11 - Calculation of the average recycling rate of C&D waste (BIOIS, based on own assumption and data reported by ETC/RWM 2009 and UBA 2008, or individual estimations)

Country	Arising (million tonnes)	% Re-used or recycled
Austria	6,60	60%
Belgium	11,02	68%
Bulgaria	7,80	0%
Cyprus	0,73	1%
Czech Republic	14,70	23%

Country	Arising (million tonnes)	% Re-used or recycled
Denmark	5,27	94%
Estonia	1,51	92%
Finland	5,21	26%
France	85,65	45%[20]
Germany	72,40	86%
Greece	11,04	5%
Hungary	10,12	16%
Ireland	2,54	80%
Italy	46,31	0%
Latvia	2,32	46%
Lithuania	3,45	60%
Luxembourg	0,67	46%
Malta	0,8	0%
Netherlands	23,9	98%
Poland	38,19	28%
Portugal	11,42	5%
Romania	21,71	0%
Slovak Republic	5,38	0%
Slovenia	2,00	53%
Spain	31,34	14%
Sweden	10,23	0%
UK	99,10	75%[21]
EU 27	531,38	46%
(orange)	UBA 2009	
(red)	No data available: worst case scenario assumed	
(green)	Reminder: data from ETC/RWM 2009 corrected to exclude excavated material and fill data gaps	

This average of 46% **recycling rate for EU-27** is a broad estimation with a high uncertainty. However, it looks rather plausible, and within the range of estimates proposed by experts and literature: **30[22] to 60%**[23].

At a national level, the current situation is as follows:

[20] Corrected with the exclusion of excavated material (source : Laurent Chateau, ADEME)
[21] Corrected with the exclusion of excavated material (source : Survey of Arisings and Use of Alternatives to Primary Aggregates in England, 2005)
[22] [UBA, 2008]
[23] European Concrete Platform, 2010

- 6 countries report recycling rates that already fulfil the Directive's target (Denmark, Estonia, Germany, Ireland, the UK and the Netherlands)[24]
- 3 countries report recycling rates between 60% and 70% (Austria, Belgium, and Lithuania)
- 4 countries (France, Latvia, Luxembourg and Slovenia) report recycling rates between 40% and 60%
- 8 countries report recycling rates lower than 40% (Cyprus, Czech Republic, Finland, Greece, Hungary, Poland, Portugal and Spain)
- For 6 countries, no data was available to estimate the recycling rates (Bulgaria, Italy, Malta, Romania, Slovakia and Sweden)

3.4. CURRENT POLICIES AND STANDARDS

Five case studies were performed on European MS: Germany, Finland, Spain, Hungary and Belgium (Flanders).

These case studies particularly focused on policy drivers and regulations influencing the management of C&D waste.

3.4.1. EUROPEAN POLICY DRIVERS

The revised Waste Framework Directive, with its objective to reach 70% of preparation for re-use, recycling and other forms of material recovery of C&D waste, is likely to represent the main European policy driver towards better recycling of C&D waste in the coming years. However, MS are still in the process of integrating the 70% target into their national legislation, and it is currently difficult to assess how this will be implemented.

The actual impact of this target also depends on the current recycling rates achieved by different MS. For example, in Flanders, the European policy instruments have only played a secondary role, as Flanders was early in adopting more stringent waste legislation (e.g. landfill prohibition for unsorted waste, waste collected for recovery, homogeneous waste fractions fit for recovery, like C&D waste). As a result, the 70% target was already reached in the year 2000. Germany is revising its *Act for Promoting Closed Substance Cycle Waste Management*, with a target even higher that the WFD (80% in the draft). On the other hand, for countries with currently low recycling rates for C&D waste, reaching the target might represent a significant challenge, and therefore will need to adapt their current policy framework to achieve it. For example, Spain (with current recycling rates below 15%) is currently revising its national plan on C&D waste, developing measures and setting intermediary targets. In Finland, European legislation has been taken into account but cannot be seen as a major driver behind national strategy towards C&D waste. The current target set in Finland (70% by 2016) includes energy recovery; high amounts of waste wood

[24] At the regional level, Flanders also largely reached this target with a recycling rate over 90%.

in C&D waste (up to 40% when excavated soils are excluded) indeed represent a serious obstacle towards reaching the target.

Directive 99/31/EC on landfill has also represented an important driver towards better management of C&D waste. In Spain for example, where most C&D waste is landfilled (and approximately half of this amount entering unauthorised landfills), it has contributed to a better control of C&D waste, the emergence of a new recycling infrastructure, and a better control of unauthorised landfills.

3.4.2. Identified national policies and standards

Current policies and standards influencing the management of C&D waste can be classified into 5 main categories:

- Waste framework policies: National policies or regulation on waste, usually at least transposing concepts, targets, and obligations set in the European WFD
- Landfill regulations: as stated above, stricter control of landfilling of certain types of waste represents a major driver towards better management of C&D waste.
- C&D waste policies: when specific obligations regarding the management of C&D waste are not directly included in the waste framework policies, specific policy or legal documents may have been developed, specifically addressing the issue of C&D waste.
- Secondary raw material regulation and standards, e.g. standards on the quality of secondary materials from C&D waste
- C&D sites regulations and standards, e.g. requirements for buildings specifically addressing C&D waste

Waste framework policies

Waste framework policies and regulations developed in MS set the general framework for the management of waste material. They are the main tools for the transposition of the Waste Framework Directive.

Most of the MS studied do not integrate specific provisions (other than general objectives) for C&D waste in these waste framework policies, and this waste is most of the time subject to specific strategies or legal documents, as presented below.

C&D Waste policies and legislation

Most of the studied countries also have policies and regulation specifically targeting C&D Waste.

Among the five selected countries and regions, **Flanders** (Belgium) was the first to implement its *Executing plan C&D waste* in 1995. This first plan already set quantitative targets for the recycling and material recovery of C&D waste (75% by 2000, which has been exceeded as over 85% of C&D waste were recovered or recycled in 2000). The oldest data available (1992) report that 66% of C&D waste was already recycled or reused.

This plan also set prevention targets for C&D, but these provisions have not been efficient as the C&D waste amounts have kept increasing. The new *environmentally responsible material use and waste management in the construction sector, sectorial executing plan,* aims at achieving this objective, particularly through:

- Material bound environmental profile of constructions, in order to allow the Flemish Government to develop and impose material use prescriptions after 2009.
- Promoting selective demolition with standardised specifications
- A global management system for rubble granulates
- Promoting further reuse of the stony fractions of C&D waste
- Promoting recycling of specific waste fractions cellular concrete, gypsum, plastics, flat glass, mineral insulation materials and roofing bitumen.

In **Germany**, the construction industry itself took the initiative in 1996 through a voluntary commitment to cut in half the amounts of C&D waste landfilled (as the reference year was 1995, this was equivalent to reaching 70% of recycling and recovery of C&D waste). The construction industry monitors itself C&S waste and has issued 5 bi-annual reports to the authorities, showing over accomplishment of the targets. However; some experts interviewed warn that the high amounts of C&D waste landfilled in 1995 (60%) might not reflect reality as these quantities might not have been properly documented at the time, and recycled quantities might already have been higher. Today, no formal continuation of this initiative is planned at the moment, but higher targets for C&D waste should be included into national waste regulation as mentioned above.

Finland has adopted a *Government Decision on Construction Waste* in 1997, setting an indicative target of 50% of recycling and recovery (including energy recovery) of C&D waste by 2000.

Spain has developed its first national plan on C&D waste in 2001 (PNRCD 2001-2006). There is already a second PNRCD 2007-2015, which is Annex 6 to the national integrated waste management plan (Plan Nacional Integrado de Residuos, PNIR). It is currently being revised to integrate the new targets set by the WFD. Due to a lack of enforcement and supporting regulation, the first plan has not been successful in diverting C&D waste from landfills. The *Royal Decree 105/2008*, regulating the production and management of C&D waste, establishes the responsibilities of the waste producers, holders, and managers, without setting any quantitative targets. However, this decree requires that construction and demolition waste plans have to be established for every construction project; in addition information on hazardous wastes has to be included in demolition projects. A deposit will have to be paid to the authorities, which will be returned when proof of lawful disposal/recycling of C&D wastes is provided (details hereof are regulated at regional level).

- **Landfill legislation**

All MS have transposed the provisions of the Landfill Directive. However, there is still a lack of enforcement in some MS, where some non-compliant landfills have not been closed.

The most drastic measures to prevent landfilling of C&D waste were adopted in **Flanders**, with straightforward landfill bans for recyclable fractions of C&D waste. The efficiency of this measure was stresses by most experts interviewed. However, its applicability might depend on the local context: in Flanders, low historical landfill rates of C&D waste, high density of population and scarcity of landfill space available may have contributed to the efficiency of this measure.

In addition to landfill bans, high landfill taxes (e. g. in the Netherlands) have also proven to be a useful instrument to divert C&D waste from landfills.

In **Germany**, high recycling rates were achieved although there is no national ban on landfilling of C&D waste material.

In **Spain**, however, the lack of control of unauthorised landfills and the high differences in landfill taxes between regions were identified as one of the main barrier to the recovery of C&D waste.

The very large quantities of C&D waste generated can explain that landfill bans and taxes prove remarkably efficient in improving recycling rates. The Flemish experience shows that landfill bans and high levies on landfilling are a key towards higher recycling rates of C&D waste. These instruments are easy to implement. However, their effectiveness depends on appropriate enforcement and control, as well as on the existence of a network of alternative treatment plants.

- **Secondary raw material legislation and standards**

The promotion of recycled material from C&D waste was also identified as a key driver towards higher recycling rates for C&D waste. Some of the countries studied have used this approach, along with the aforementioned policies and regulation, to drive the recovery of C&D waste.

The examples of such regulations and standards listed below do not represent an exhaustive list, and only the most relevant were selected.

In **Flanders**, the implementation order of the waste framework policy (VLAREA) specifically assesses the conditions of use of secondary raw material in construction, particularly on the nature of the waste used and the concentrations of heavy metals and aromatic hydrocarbons. These requirements are mandatory. Other standards on construction products, and particularly secondary raw materials, such as COPRO or QUAREA, are generally voluntary but are requested when using secondary raw materials.

Likewise, in **Germany**, a draft *Ordinance on substitute construction material* (implementation date not known), will determine the conditions for harmless used of recovered excavation material and mineral waste. It is complemented by mandatory standards on construction material such as the Technical delivery conditions for mineral materials in road construction, and multiple DIN[25] standards in the construction sector. The Federal Union of Recycling Building Material (Bundesvereinigung Recycling-Baustoffe e.V. – BRB) has also published guidelines aiming at ensuring the quality of recycled material used in construction.

In **Finland**, the Government Decree on the Recovery of certain wastes in earth construction (591/2006) promotes the recycling of waste in some constructions activities such as public roads, parking areas, sports grounds, etc., by removing the obligation of obtaining an environmental permit for the recovery of concrete waste and fly ashes in these applications.

Technical requirements for the use of C&D mineral waste in the production of aggregates are also addressed by the individual CEN Aggregate Product Standards, which set clear quality requirements for the different types of applications (e.g. aggregates for concrete, aggregates for mortar, aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction, etc.), and ensure that the end-products are durable and meet their technical specifications. These standards were developed in 2004 and clearly address “aggregates from natural, recycled and manufactured materials”.

- **C&D sites legislation and standards**

Finally, regulation and standards on environmental performances of buildings and construction sites have been identified. In principle, these standards could include criteria influencing the management of C&D waste, for example the use of recycled materials in the building, specific requirements for waste management on new buildings construction sites, or during the dismantling and demolition of the building. However, few building standards presenting these types of criteria have been identified.

- **Building standards**

Historically, these types of standards have focused on the energy efficiency of buildings, which can explain why C&D waste prevention and recycling has not been a key target for the criteria they impose.

However, some standards or certification schemes have been developed taking into account these issues. For example, the *German Sustainable Building Certificate,* a voluntary scheme run by the German Sustainable Building Council (DGNB[26]) sets different criteria to ensure the sustainability of buildings, and in particular two criteria regarding C&D waste:

- Within the technical quality criteria, “Ease of dismantling and recycling”

[25] Deutsches Institut für Normung
[26] http://www.dgnb.de

- Within the process quality criteria, "Construction site/construction process", establishing that the waste produced on-site should be prevented or recycled, and, if not recyclable, disposed of in a way that prevents harm to the environment.

  Other existing building standards (e.g. HQE – Haute qualité environnementale in France, BREAM in the UK) could also encourage these practices.

Other policies

Public authorities, as the owner of public infrastructure, have an important role to play in the definition of requirements on C&D waste prevention and management for the buildings and infrastructure they purchase or control. European GPP (Green Public Procurement) sets a range of recommendations for the procurement of construction works. It addresses the design, construction, use and disposal phase of buildings such as public services buildings and office buildings. In particular, the core GPP criteria require the contractor to put appropriate measures in place to reduce and recover (reuse or recycle) waste that is produced during the demolition and construction process. It is required to have a recovery rate of **at least 60%** related to weight percentage segregation[27]. Criteria were also set for specific building materials such as windows, thermal insulation, hard floor-coverings and wall panels[28].

3.5. Towards the 70% target

3.5.1. Trends in the evolution of C&D waste arising

As presented above, it is very difficult to assess the present situation in Europe, due to lack of homogeneous data and reporting between MS. In this context, without a precise quantitative assessment of the current situation, it is not easy to predict trends in the future.

However, it is likely that the quantities of C&D waste arising will keep increasing, at least as fast as the economy. The case of Flanders, although achieving high recycling rates, shows that there might even be a negative decoupling, meaning that the amounts of C&D waste grow faster than the economy. However, the uncertainty of the decoupling studies does not permit the definition of a clear trend for the next few years. The priority given to waste prevention in European and national policy, as well as more and more voluntary initiatives of the industry towards material efficiency, could set the conditions for a decrease in the amounts of C&D waste generated according to some experts, but concrete measures are only starting to be implemented (e.g. WRAP cases studies on C&D waste prevention[29]) and it seems unlikely that a decrease (independently of the economic situation) will be observed before 2015.

[27] http://ec.europa.eu/environment/gpp/pdf/toolkit/construction_GPP_product_sheet.pdf
[28] http://ec.europa.eu/environment/gpp/second_set_en.htm
[29] http://www.wrap.org.uk/construction/tools_and_guidance/designing_out_waste/case_studies.html

Considering these difficulties in addressing the question of the evolution of the amounts of C&D waste generation, **great care must be taken with the following estimates**.

Two approaches were taken to forecast the quantities of C&D waste, each with its own limits:

Forecast #1: based on the production index of the construction sector (EUROSTAT data series from 2005 to 2009, industry estimates from 2009 to 2013, and gross BAU estimates for the period 2014-2020)

Forecast #2: based on assumptions on the new constructions, renovation and demolition rates from 2005 to 2020. For this forecast, the following assumptions were made:

- 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 results obtained with these two forecasts are presented in the table below.

Table 12: Future trends in the generation of C&D waste

Year	Forecast #1 (million tonnes)	Forecast #2 (million tonnes)
2005	461	461
2006	477	466
2007	487	470
2008	469	454
2009	427	514
2010	413	531
2011	413	535
2012	423	539
2013	434	491
2014	445	496
2015	456	501
2016	467	506
2017	479	511
2018	491	516
2019	503	521
2020	516	526

Both estimates reflect the effect of the economic crisis, with decreases in the amounts generated between 2007 and 2008. Whereas forecast #1 shows a continuous decrease until 2011(due to the economic crisis) and then a progressive increase, forecast #2 suggests that amounts of C&D waste generated start increasing again in 2009 (mainly due to more important renovation activities linked to stricter environmental criteria for buildings.

On the long term, these effects cancel out and both forecasts show similar patterns, with a total generation of C&D waste in 2020 around **520 million tonnes.**

Reminder: these figures exclude excavated material. If this fraction taken into account, the amounts of C&D waste generated are likely to be 4 times higher; the total production would therefore amount to approximately 2 100 million tonnes in 2020.

As far as the composition of C&D waste is concerned, it is likely to be similar in the coming years: the mineral fraction (concrete and masonry in particular) represents the large majority of C&D waste (up to 85%), and, with the exception of countries where wood is a major building material, will represent the main contribution to the 70% target.

3.5.2. BARRIERS AND DRIVERS TOWARDS THE 70% TARGET

Without any dramatic economic event, it seems that the amounts and composition of C&D waste will follow the trends that have been observed to this day. Existing barriers, and drivers to overcome them, will therefore still be relevant in the near future.

- **Economic barriers: High availability and low cost of raw materials**

The largest share of C&D waste is usually composed of concrete, masonry, asphalt and other mineral waste such as stones, sand, or gravel. The main barrier to recycling of this mineral fraction is that virgin material that would be substituted by the recycled fraction (such as natural aggregates) are often easily and locally available, and can be produced at low costs. As a result, the economic attractiveness of secondary raw materials from mineral C&D waste can be low compared to virgin raw materials; recycling of the mineral fraction of C&D waste has been mostly successful in high-density area, where virgin raw materials extracted from quarries are less available[30].

The main corresponding policy option to overcome this is making landfilling of waste unattractive, by introducing a ban or high levies on landfilling of C&D waste has proven to be a driver towards higher recycling rates; it leads to an increase in the supply of secondary material from mineral C&D waste, which in turn tends to make them more economically attractive (higher availability and lower prices).

Alternatively, taxes on resource extraction could contribute to increase the price of primary raw materials and make recycling more competitive.

[30] For instance, the choice of resources used to produce aggregates is directly related to comparative processing costs, market price and distance to market. WRAP carried out two detailed assessments of this relationship, one for England [WRAP 2006] and the other for Scotland [WRAP 2007].

Cross-border effects can also hinder the recycling of C&D waste; in particular, local or regional differences in legislation and landfill prices can contribute to the export of C&D waste to countries where landfilling is authorised and/or cheaper (e.g. exports of gypsum waste from Denmark and the Netherlands to Germany). A harmonisation of landfill regulations and prices among Member States would contribute to overcome this problem.

The example of the deposit system in Spain (companies must pay a deposit to the local authority, which is paid back when proof of appropriate treatment of the waste is given) is another example of an economic incentive.

Regarding C&D waste generated in smaller amounts by other economic sector, and in particular by households, experiences of take-back centres in countries such as Denmark or France (where C&D waste can be brought free of charge by residents) has been reported to be efficient.

- **Cultural barriers: Misconception of the quality of recycled products**

Recycled aggregated from the mineral fraction of C&D waste still suffer from misconception about their quality by consumers, especially for their use in structural application (e.g. use of secondary aggregates in the production of structural concrete).

The main corresponding drivers to overcome this are:

- Turning waste into a valuable raw material: this can be achieved through quality certification of secondary raw material from C&D waste.
- Communicating on the benefits of secondary raw material: it has been proven that up to 20% of recycled aggregates can be used in structural concrete, without changing the quality of the product. In certain applications, such as road works, recycled aggregates present better properties than virgin aggregates. Knowledge transfer from MS with a long experience in recycling C&D waste can be crucial and facilitate a fast adoption of new technologies and procedures in MS which are setting up now schemes for recycling of C&D wastes. Partnership projects between MS or regions and activities of European industrial federations could help bridge this knowledge and experience gap.
- Development of end-of-waste criteria for materials as foreseen in the Waste Framework Directive could also contribute to improve the image of the recyclates and reduce uncertainty of the markets.
- Further research on applications of recycled C&D waste and particularly on long-term behaviour could contribute to reduce uncertainty linked to the use of recycled products.
- Green Public Procurement (GPP): given the significant share of public funded construction, GPP can play a major role to promote recyclates and the use of recyclable materials. This voluntary instrument can help stimulate a critical mass of demand for more sustainable construction materials which otherwise would

be difficult to get onto the market. A number of regions and municipalities are applying GPP criteria but further use should be encouraged.

- **Technical barriers: ineffective sorting and contamination of the waste flow**

The key to the successful recycling of the mineral fraction of C&D is that the waste collected is “clean”, i.e. free of contaminants and other materials.

The main drivers to overcome this are the following:

- Encourage the sorting of C&D waste “at source”: efforts should be made to sort out the different materials composing C&D waste; clear identification of materials and potential contaminants should be performed in order to avoid contamination of the inert fraction and ensure high quality of recycled material. This will also drive the separation and collection of “smaller”, but valuable fractions such as glass, metals, plastics, gypsum, etc., and the appropriate management of hazardous materials such as ODS containing foams.
- Selective demolition / controlled deconstruction: practices of “controlled deconstruction”, consisting in the systematic removal of contaminants prior to demolition, as well as the sorting of different building materials, should be encouraged and generalised.

3.5.3. Is the 70% target achievable?

As 5 MS already achieve recycling rates of 70% or more, some of them very comfortably (with recycling rates over 80%), it would seem that this objective is feasible. However, countries with very low recycling rates (less than 40%) will certainly face a challenge in reaching this target, as it will be necessary to develop the appropriate infrastructure, as well as markets for the recycled products. For example, Spain, with a current reported recycling rate below 15% will need to put significant efforts into controlling the enforcement of existing regulation at the national level; however, some experts are optimistic as local case studies in Spain have shown that recycling rates over 90% are feasible.

The mineral fraction of C&D waste should easily find applications as aggregates in road construction and in structural concrete for example, as long as the quality of the secondary materials is ensured, through early decontamination of the waste and quality certification.

Focussing on this stony fraction should be, in most cases, sufficient to guarantee a recycling rate close to, if not higher than 70%. Moreover, as the recovery of mineral waste requires selective demolition and the appropriate sorting of C&D waste, this is likely to drive the recycling of the smaller fractions and contribute also to a separation and better management of fractions of hazardous C&D waste.

However, it must be stressed that some countries such as Finland report relatively low shares of mineral waste compared to wood waste[31]. These countries might face more difficulties in reaching the target, as energy recovery of wood waste, which is encouraged by European and national policies as a renewable source of energy, is not included in the 70% target set by the Directive, and re-use and recycling options are limited. It might be relevant to consider an amendment to the 70 % target in the case of wood waste, with a prior assessment of whether energy recovery from wood waste presents equal, or higher, environmental benefits than recycling or material recovery.

Last but not least, achievability of the 70% target will also depend on the capacity of the market to absorb recyclates. This can be especially relevant during economic downturns: construction activities can decline because of economic or sectorial crisis, rendering absorption of recyclates temporarily difficult.

3.5.4. Beyond the current Directive's targets

The WFD sets a target of 70% of preparation for re-use, recycling, and other forms of material recovery of C&D waste, including backfilling. The findings of this study suggest that this objective should be achievable for most MS. This therefore raises the question of how to go beyond this objective. Four main directions can be considered.

1- Increasing the target

First, from a quantitative point of view, the best practices in Europe show that – depending on the context – recycling rates over 80% or 90% are feasible. For those countries which are already achieving higher re-use, recycling and recovery rates, the WFD does not provide an incentive to achieve higher targets. In principle, differentiated targets for these MS could be set in the WFD or alternatively, in their national legislation (some MS have already set or are setting more ambitious targets in their national legislation).

2- Setting a hierarchy within the different options permitted to reach the target

Secondly, the treatment options that can be used to reach the target do not provide equal environmental benefits. For instance, the brief environmental assessments performed in this study suggest that, at least for the mineral fraction (particularly concrete and masonry), environmental benefits of preparation for re-use are significantly higher than those of recycling. This is mainly due to the fact that the processing of aggregates from C&D waste is similar to the processing of virgin aggregates (similar energy consumption and dust emissions during the crushing steps, similar fuel consumption for transportation, etc.). On the other hand, the production of building materials like concrete and bricks is energy intensive, and the avoidance of this production through preparation for re-use would represent high environmental benefits.

Moreover, some of the experts interviewed warn that the definition of "backfilling" should be strictly clarified in order to avoid "hiding" landfilling operations in this definition.

[31] See Table 6

Moreover, backfilling operations should be registered and notified to authorities, as this is the case for recycling operations. Specific environmental concerns related to backfilling have been raised: for example, there is a need to control hazardous substances in backfilling to avoid the leaching of hazardous substances in the environment. The suspicion of asbestos contamination of road pavements, built 20 to 25 years ago in the Netherlands, illustrates this problem.

It is difficult to assess how backfilling can contribute to reaching the target, as there is no specific reporting on this type of material recovery. Available data and interviews with experts suggest that this practice is quite limited in countries like Flanders or Germany, which achieve high recycling rates.

Clearer definitions are therefore required, and it would likely be interesting to address the relevance of setting individual targets for preparation for re-use and recycling on one hand and other forms of material recovery (including backfilling and other forms of "downcycling") within the overall target of the Directive. This would ensure higher overall environmental benefits of reaching the target.

3- Addressing "small" fractions of C&D waste more specifically

The 70% target itself does not directly represent an incentive for the appropriate treatment of the smaller fractions of C&D waste[32], which can be nonetheless valuable as secondary material (glass, plastics, metals, etc.) To some extent, fractions that can be easily separated and have a high market value (e.g. metals) are already re-used, recycled or recovered. For other fractions, single targets or other incentives could be envisaged.

In addition, some C&D waste fractions represent a significant environmental challenge (ODS containing insulating foams, asbestos, and other hazardous substances). In principle, separation of the fractions falling which are classified as hazardous wastes and implementation of legal provisions regarding management of hazardous waste would allow avoiding negative impacts on health and the environment. However, these fractions could also be addressed more specifically (e.g. ODS containing foams through ODS regulations) in order to ensure that the best environmental options are adopted. In that case, better implementation of European legislation on hazardous waste (and particularly the obligation to sort out this waste) is required, and would in turn increase the recyclability of the non-hazardous C&D waste, as it would lower the contamination of the recyclable materials. Moreover, demolition companies should also take EU legislation regarding health and safety aspects at work into account when dealing these hazardous wastes and ensure the workers take preventive measures.

4- Setting quantitative targets for the prevention of C&D waste

Waste prevention being at the top of the hierarchy, the reduction and re-use of building materials should be also addressed more specifically, through the promotion of increased

[32] In most cases, it seems that the target can be achieved by recycling the most important fractions that are concrete, masonry and asphalt

material efficiency, eco-design of buildings (particularly design to reduce the need for deconstruction), and re-use of building parts. Given the huge amounts of materials concerned, and the potentially high environmental savings, C&D waste prevention should be specifically addressed when setting waste prevention targets (to be developed by 2014 by the Commission). Methodological and practical guidance on designing out waste in construction has been developed by WRAP, both for buildings[33] and in civil engineering[34]. This guidance is supported by a Net Waste Tool[35] for assessing the cost benefits of a range of waste reduction and re-use options. Such options include design optimisation (reducing the amounts of material needed for the construction), design that allows re-use of components or life-time extension for refurbishment, etc.

5- Avoiding distortions

Different conditions in neighbouring regions and/or MS can lead to distortions in the management of C&D waste and hinder recycling. Some co-ordination of policies (especially between regions) would be helpful since low landfill fees in a given region can divert C&D waste from recycling schemes in a neighbouring region, even within the same country. In addition, the example of gypsum wastes (which are been e. g. applied in Germany for rehabilitation of decommissioned potash mines) shows that backfilling operations can undermine existing recycling schemes.

6- Developing End-of-Waste criteria

The End-of-Waste (EoW) concept in EU legislation was introduced in 2005 by the Thematic Strategy on the prevention and recycling of waste, and was later adopted by the European Parliament and the Council in the revised Waste Framework Directive in 2008. Setting EoW criteria for certain types of C&D waste could contribute to increasing the market for secondary raw materials obtained from C&D waste. In this respect, the recent ECHA decision stipulating recycled aggregates as “Articles” under REACH[36] was welcomed by the industry.

[33] http://www.wrap.org.uk/construction/tools_and_guidance/designing_out_waste/dow_buildings.html
[34] http://www.wrap.org.uk/construction/tools_and_guidance/designing_out_waste/dow_civil_eng.html
[35] http://www.wrap.org.uk/construction/tools_and_guidance/net_waste_tool/index.html
[36] ECHA, Guidance on waste and recovered substances, may 2010

3.6. ANNEX: DATA TABLES

Table 13 - C&D waste generation per capita (raw data from ETC/RWM 2009)

Waste generation (tonnes per capita)	1999	2000	2001	2002	2003	2004	2005	2006	Waste factor (1000t / million € added value)
Austria						0,81		0,81	0,46
Belgium	0,84	0,95	0,81	0,8	1,11	1,06	1,22	1,18	0,955
Bulgaria						0,39			4,53
Cyprus						0,58			0,545
Czech Republic	0,78	0,91	0,85	0,85	1	1,44	1,2	1,15	4,037
Denmark						3,99			0,578
Estonia	0,57	0,74	0,64	0,94	0,93	1,12	1,61	0,54	4,144
Finland						3,99			3,239
France						5,5			5,016
Germany	3,15	3,17	3,05	2,92	2,71	2,33	2,24		2,406
Greece	0,17	0,19	0,41	0,38	0,37	0,37			0,344
Hungary		0,29	0,49	0,59	0,51	0,43	0,49	0,54	1,629
Ireland			1,7			2,74	3,6	3,95	1,312
Italy		0,48	0,54	0,65	0,74	0,8	0,78		0,778
Latvia				0,06	0,03	0,04	0,07	0,05	0,118
Lithuania						0,1		0,18	0,343
Luxembourg						5,9			
Malta						1,95			
Netherlands	1,14	1,49	1,48	1,47	1,467	1,47	1,58		1,264
Norway	0,24	0,25	0,27	0,28	0,27	0,7	0,32		0,194
Poland						0,11	0,14	0,44	0,41
Portugal						1,09			1,574
Romania	0,02	0,01	0,02	0,03	0,01		0,02		0,02
Slovakia					0,07	0,26			1,047
Slovenia									1,261
Spain			0,59	0,58	0,66	0,74	0,8	0,88	0,525
Sweden						1,14			1,029
United Kingdom			1,74	0,74	0,75	1,66	1,9	1,89	1,14

4. Material focus: CONCRETE

Applications in the construction sector	Buildings, roads, infrastructure			
Production in the EU-27	Total: about **1,350 Mt**[37] (2008) - Ready-mixed concrete: 900 Mt - Precast concrete: between 200 and 250 Mt			
Waste generation in the EU-27	No specific data available; estimated average: 60-70% of total C&D waste (i.e. about **320-380 Mt**[38]), with high geographical variations (20-80% according to MS)			
Treatment options	**Landfill**	**Recycling into aggregates for road construction or backfilling**	**Recycling into aggregates for concrete production**	**Re-use of precast elements (concrete blocks)**
Current rates	N/A	N/A	N/A	N/A
Potential rates	Experts foresee that **0%** landfill can be achieved	Could absorb up to **75%** of waste concrete	Could absorb up to 135 Mt of recycled aggregates[39] (i.e. **40-50%** of waste concrete)	N/A
Environmental impacts	Land-use, transportation	**Low to medium net benefits** (as only the preparation of virgin aggregates is avoided) Potential energy and local pollution savings in dense areas (shorter transportation) Land use and biodiversity issues related to extraction Resource consumption	**Low to medium net benefits** (as only the preparation of virgin aggregates is avoided) Potential energy and local pollution savings in dense areas (shorter transportation)	**High potential net benefits** (due to the avoidance of cement production)
Barriers to re-use and recycling of the waste	- High availability and low cost of raw material - Uncertainty on the supply of secondary material - Misconception of the quality of recycled products compared to new materials			
Existing and potential drivers to re-use and recycling of the waste	- High demand for aggregates in road construction, coupled with a higher quality of recycled concrete aggregates compared to virgin aggregates - Design for deconstruction to drive to re-use of concrete blocks - Sorting at source to increase the quality - Landfill taxes or landfill bans to promote alternatives - Inclusion of requirements for the use of re-use or recycled materials into building standards - Quality certification for recycled materials			

[38] Based on about 540 million tons of C&D generated in EU-27 in 2008 (see chapter 4.1 above)

[39] Up to 20% of coarse aggregates used for the production of structural concrete can be made of recycled aggregates. This would represent approximately 10% of the concrete mix. 10% x 1,350 Mt = 135 Mt

4.1. PRODUCT DESCRIPTION AND APPLICATIONS

Concrete is a man-made construction material that is widely used around the world for any type of building or infrastructure due to its physical and aesthetic properties.

Concrete is made from coarse aggregates (gravel or crushed stone), fine aggregates (sand), water, cement and admixtures. Cement is a hydraulic binder that hardens when water is added and represents between 6 and 15% of the concrete mix depending on the application while aggregates represent 80% in mass and water 8%.

Structural concrete takes almost completely the form of reinforced concrete which is a composite material consisting of concrete and steel. While concrete provides the material's compressive strength, steel provides its tensile strength in the form of embodied reinforcing bars and mesh.

Steel reinforcement plays a key role in reinforced concrete structures as it ensures ductile behaviour in earthquakes for example. Reinforcing bars are usually formed from ridged carbon steel, the ridges giving frictional adhesion to the concrete. The amount of steel used in reinforced products is relatively small. It varies from 1% in small beams and slabs to 6% for some columns, according to purpose and design conditions[40].

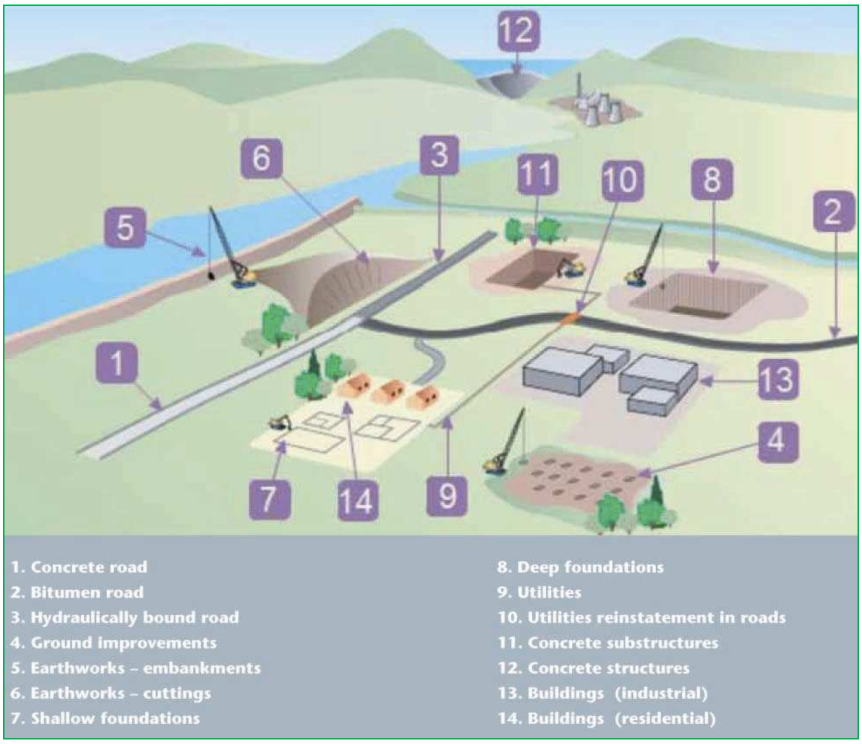
The steel used in reinforced concrete utilises 100% recycled scrap steel as feedstock[41] and at the end of its life, all reinforcing steel can be recovered, recycled and used again in a closed-loop system.

Steel reinforced concrete can be used for any type of structure (bridges, highways, and runways) and buildings but it is generally used for applications carrying heavy loads such as footings, foundation walls and columns.

The different applications of concrete are illustrated in the following figure.

[40] [Mehta]
[41] http://www.sustainableconcrete.org.uk/main.asp?page=53

Figure 1 – Concrete various applications [WBCSD, 2009]



As shown previously, buildings and civil engineering infrastructures are the two main applications of concrete and are developed in the following sub-sections. A special focus is also laid on reinforced concrete as it is a very specific application with precise composition, properties and uses.

4.1.1. BUILDINGS

Concrete is a well established construction material that is widely used across Europe for all types of buildings: residential (individual, apartment) and non residential (public, commercial, industrial and agricultural). Each of these applications represents approximately 30% of the total use of concrete although differences appear between MS[42]. For example, residential applications are likely to represent a more important share in southern European countries (Spain for instance) due to wide residential construction campaigns.

The most common uses of concrete in the building construction sector are:

- Foundations
- Floors for ground or upper floor levels
- Structural frames (e.g. beams, columns, slabs)
- External and internal walls, including panels, blocks or decorative elements with a whole selection of colours and finishes

[42] Interview with Alessio Rimoldi, Secretary General, European Concrete Platform

- Roof tiles
- Garden paving (concrete slabs or blocks, which are virtually everlasting in that type of use).

Two types of concrete are distinguished:

"Dense concrete" which is invariably used in the construction of industrial and commercial buildings and all infrastructural projects, is strong and durable, resists fire, and has good sound insulation, vibration absorption and thermal properties.

"Lightweight concrete", in the form of concrete masonry blocks, is used mainly in the construction of individual dwelling. Because of their inherent properties, concrete blocks used as partition walls typically do not require additional sound or fire protection.

4.1.2. CIVIL ENGINEERING

Concrete is well suited for civil engineering construction since it is able to resist moisture and weather variations, mechanical constraints, and high temperatures. Concrete also absorbs sound, reduces temperature swings and provides protection against different types of radiation and rising sea levels.

Its inherent durability and strength make it especially suitable for the construction of dams; other concrete applications for infrastructures also include:

- Roads (especially under tunnels for fire prevention, bridges, increasingly road central safety barriers).
- Power plants, many of which use and store potentially dangerous nuclear fuels, are constructed almost entirely of concrete for safety and security reasons.
- Other common industrial applications such as silos, storage tanks, water treatment and run-off catchment systems.

4.2. QUANTITATIVE ANALYSIS

4.2.1. PRODUCTION DATA

With a 2006 worldwide consumption estimated between 21 and 31 billion tonnes[43], concrete is the second most consumed substance in the world after water.

Concrete is manufactured and delivered to the end-user in two main forms: ready-mixed concrete and precast concrete.

In terms of volume, at EU-27 level, the total ready-mixed concrete production reached 900 million tonnes[44] in 2008 with a generated turnover of 18.7 billion Euros[45]. An interesting

[43] [WBCSD, 2009]

[44] Calculated based on the data presented in the following table, assuming an average density for concrete between 2.4 and 2.6

fact is that the ready-mixed concrete production and the workforce diminished of 8.5% and 14.7% respectively between 2006 and 2008 while the turnover increased of 10.2% during the same period.

The production of precast concrete, on the other hand, although smaller in terms of volume (it is estimated that the production of precast concrete represents between one fourth and one third of the production of ready-mixed concrete), generates a higher turnover[46].

As concrete is generally locally produced, it can be assumed that the produced quantities of ready-mixed and precast concrete match the quantities used in buildings and infrastructure.

The following table gives a precise overview of the quantities of ready mixed concrete produced between 2006 and 2008 in some MS, as well as the cement consumption for the same time period.

[45] Italy, Spain, France, Austria and Germany account for more than 70% of the total 2008 turnover.
[46] Interview with Alessio Rimoldi,

Table 14 - Quantitative data of the ready mixed concrete industry between 2006 and 2008 [ERMCO, 2008]

	Concrete production (million m³)		Growth rate 2006/2008	Population (million inhabitants)		Production per capita		Cement consumption (million tonnes)		Growth rate 2006/2008
Country	**2006**	**2008**		**2006**	**2008**	**2006**	**2008**	**2006**	**2008**	
Austria	11,0	11,5	4,55%	8,27	8,33	1,33	1,38	5,6	5,7	1,79%
Belgium	12,2	11,8	-3,28%	10,51	10,60	1,16	1,11	6,3	7,1	12,70%
Bulgaria	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cyprus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Czech Republic	8,0	9,6	20,00%	10,20	10,38	0,78	0,92	4,8	5,1	6,25%
Denmark	2,8	2,7	-3,57%	5,43	5,48	0,52	0,49	1,8	1,9	5,56%
Estonia	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Finland	2,7	2,8	3,70%	5,20	5,48	0,52	0,51	1,9	1,9	0,00%
France	43,3	44,1	1,85%	63,00	63,75	0,69	0,69	23,9	24,1	0,84%
Germany	43,4	41,0	-5,53%	82,44	82,22	0,53	0,50	28,6	27,3	-4,55%
Greece	24,0	22,0	-8,33%	11,13	11,21	2,16	1,96	11,5	10,3	-10,43%
Hungary	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ireland	9,2	10,0	8,70%	4,21	4,40	2,19	2,27	4,7	3,4	-27,66%
Italy	77,5	73,2	-5,55%	58,75	59,62	1,32	1,23	45,9	41,8	-8,93%
Latvia	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lithuania	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Luxembourg	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Malta	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Netherlands	8,5	10,5	23,53%	16,33	16,41	0,52	0,64	5,6	6,3	12,50%
Poland	14,2	15,8	11,27%	38,16	38,12	0,37	0,41	14,5	16,8	15,86%
Portugal	11,0	11,0	0,00%	10,57	10,62	1,04	1,04	7,8	7,2	-7,69%
Romania	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Slovakia	2,9	3,7	27,59%	5,39	5,40	0,54	0,69	2,3	2,6	13,04%
Slovenia	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spain	97,8	69,0	-29,45%	43,76	45,28	2,23	1,52	55,9	42	-24,87%
Sweden	3,0	3,5	16,67%	9,05	9,18	0,33	0,38	2,1	2,5	19,05%
United Kingdom	25,1	20,5	-18,33%	60,39	61,19	0,42	0,34	13,8	10,2	-26,09%
Total/average EU-27	**396,6**	**362,7**	**-8,55%**	**442,79**	**447,67**	**0,90**	**0,81**	**237,0**	**216,2**	**-8,78%**

The concrete production growth rate shows that some countries have known a dramatic decrease reaching almost 30% for Spain and 28% for Slovakia between 2006 and 2008, whereas the Netherlands have on the contrary known a growth of more than 23% and the Czech Republic, 20%. The average evolution scheme was an increase of the concrete production until 2008 followed by a decline due to the global economic situation[3]. The production of the concrete industry is closely related to the economic situation and the building and infrastructure needs.

The per capita production figures show that some countries have a concrete production largely above the European average of 0.80m³ per capita: Ireland, Greece and Spain in the first places produce between 1.52 and 2.27m^3 per capita. This again reflects the specific economic and demographic situation in each individual country.

Concrete production is a driver for cement consumption. The ready-mixed concrete industry alone consumed 216.2 million tonnes of cement in 2008, i.e. about 75% of the EU-27 cement production[47].

4.2.2. Waste generation and treatment data

Concrete waste can arise from different sources: returned concrete which is fresh (wet) from ready-mix trucks, production waste at a pre-cast production facility (which are not within the scope of this study) and C&D waste, which is the most significant source.

Several issues are raised when trying to estimate the quantities of concrete waste produced and treated.

First, available data on concrete waste management and recovery is not always available at the national level as the reporting beyond general C&D waste generation in not systematic. The comparison is also often meaningless due to the discrepancies between MS regarding the definitions and measurement methods, as noted by the World Business Council for Sustainable Development (WBCSD)[48]. For instance, some countries include excavated soil in their calculation others account for it separately from other C&D waste.

Moreover, the concrete C&D fraction is estimated fluctuating between 20 and 80% of the total C&D waste arising depending on the European country considered. Differences in building traditions, as well as the aforementioned discrepancies in statistical data, can explain the width of this range. A European average of 60% to 70% of the concrete fraction in C&D waste can however be roughly estimated[42].

Moreover, re-use, recycling and recovery rates are also a source of discrepancies between MS. Indeed, the national specific legislation does sometimes encourage such practices (the Netherlands and Germany for example) but does not provide incentives in others.

For the reasons above, it is currently not possible to estimate a specific recycling rate for concrete. Data produced in the CSI reports presents recycling rates between from 10% to 100%, but these data are not specific to concrete and suffer from the non-homogeneous definitions and data reporting presented above.

[47] Estimated at 283 million tonnes in 2007 <www.researchandmarkets.com/reportinfo.asp?report_id=651928>
[48] [WBCSD, 2009]

4.3. Recovery techniques

4.3.1. Existing options

Although an important fraction of concrete waste is still landfilled within the EU, this practice is being increasingly discouraged. The main options for re-use, recycling and other material recovery of concrete waste are described below.

- **Re-use**

Concrete can be re-used in various ways in its original form. An example is to leave the concrete structure in place while modernising the inside space or façade/curtain wall of the building.

Another option is the re-use of specific concrete elements with little processing: pre fabricated elements and concrete blocks are cut in smaller elements and cleaned of mortar. This requires the careful and therefore time-consuming dismantling of the building to avoid damaging the elements and the transportation to the other construction site.

- **Recycling and other material recovery**

Concrete can be reprocessed into coarse or fine aggregates.

The first step is to remove all impurities such as insulation and steel reinforcement before crushing and grading. As a consequence, an effective sorting out at the construction site or at the treatment facility is essential to maximise the recycling potential. Mobile sorters and crushers are often installed on construction sites to allow on-site processing. In other situations, specific processing sites are established. Sometimes machines incorporate air knives to remove lighter materials such as wood, joint sealants and plastics. Magnet and mechanical processes are used to extract steel, which is then recycled.

Once sorted and processed, these aggregates can be used as such in road works, or reintroduced into the manufacturing of concrete. These different possible applications are described below.

Coarse aggregates can be used for road base, sub-base and civil engineering applications. Finnish research[49] has found that recycled concrete specified to an agreed quality and composition in the sub-base and base layers can allow the thickness of these layers to be reduced due to the good bearing properties of the material. Indeed, for such an application the unbound cementitious material present in recycled aggregates has proved superior behaviour than virgin aggregates such that the strength is improved providing a very good construction base for new pavements.

Therefore, the use road construction sector represents one of the main applications for recycled concrete aggregates and can significantly contribute to reaching the 70% target

[49] [Rudus, 2000]

(the demand of recycled aggregates for road construction could already buffer up to 75% of the concrete waste generated).

Coarse aggregates can also be used as a filling material in quarries (referred to as backfilling) which is in practice especially in Eastern Europe whereas in Western Europe quarries are rehabilitated into leisure spaces. Crushed concrete can also be used in earthwork constructions, to build streets, yards and parking areas, as backfilling for pipe excavations, environmental construction, foundations for buildings, etc.

Fine aggregates can also be obtained from concrete waste and used in place of natural sand in mortars. However, the use of recycled concrete fine aggregates could affect directly the mortar content and therefore its workability, strength and can cause shrinkage due to high water absorption. This could increase the risk of settlement and dry shrinkage cracking. For these reasons, recycled fine aggregates are not used in the production of structural concrete. Moreover, the contamination of concrete with gypsum may hinder the recyclability of the material, as cleaning represents important additional costs, both economical and environmental.

The above applications are often referred to as "down-cycling"[50] as opposed to reintroducing recycled concrete directly into concrete production, where it can be used as a substitute to natural aggregates. Both coarse and fine recycled aggregates can be used in concrete production. However, as cement is not recyclable, this option still requires the consumption of virgin cement. Technically, the use of recycled aggregated in the production of concrete is limited for structural reasons. A study by the National Ready Mixed Concrete Association (NRMCA) in the US has concluded that up to 10% recycled concrete aggregate is suitable as a substitute for virgin aggregates for most concrete applications. UK research indicates that up to 20% of total aggregates[51] may be replaced by good quality crushed concrete. Under these conditions, recycled concrete can be used for most common concrete applications. Actual practices vary greatly; for example, countries like the UK and the Netherlands already achieve a recycled concrete content of 20%[52], whereas this application is almost non-existing in other countries such as Spain[46].

4.3.2. Emerging techniques

Although not commercially feasible at present, some emerging technologies include[53]:

- To replace the fossil fuel reliance of the recycling into aggregates process: closed-cycle construction using mechanical and thermal energy. The University of Delft, together with TNO, is working on a novel closed-cycle construction concept whereby concrete waste and masonry debris are separated back into

[52] Figures for the UK are subject to uncertainty, and some experts estimate they are in fact lower.
[53] [WBCSD, 2009]

coarse and fine aggregates and cement stone using mechanical and thermal energy supplied by the combustible fraction of C&D waste. This technique is assumed to encourage the recycling into aggregates while moving away from fossil fuels reliance and the associated environmental impacts.

- To improve the efficiency of the crushing process for the recycling into aggregates option: electrical decomposition of concrete. To break down concrete (or rocks), high shear stress is needed by way of a shock wave. Conventional technology uses mechanical force. Alternatively heat (see above) or electrical energy can be used. Electrical energy can be used to create pulsed power. At the present time, high initial outlay costs are a barrier to use; however, niche applications can benefit from this technology where high repetition actions are needed. The environmental impacts of using electricity also need to be considered. This technique is expected to encourage recycling into aggregates through possible costs reductions.

4.4. Environmental and economic impacts of concrete waste management

This section describes the environmental and economic impacts of concrete by focusing on the impacts of the various treatment options, including the benefits of re-use and recycling of concrete C&D waste.

4.4.1. Environmental and health impacts

The following table summarised the impacts and benefits of the different end of life options for concrete, which are further detailed below.

Table 15 – Impacts and benefits for each option for the management of concrete

LANDFILL

Direct impacts	Avoided Impacts	Net benefits
Transportation of waste to the landfill No significant release of pollutants to water. Use of land space		-

RECYCLING AS AGGREGATES FOR DIRECT RE-USE (E.G. ROAD WORKS) WITH NO FURTHER PROCESSING

Substituted material (in the same proportion): aggregates from rocks and gravel extracted from quarries

Direct impacts	Avoided Impacts	Net benefits
Transportation of waste concrete Processing of waste concrete into aggregates: dust production and noise during crushing and sieving steps Transportation of recycled aggregates	Extraction of raw materials (rocks and gravel for aggregates): land-use for quarries, production of dust, use of natural resources Transportation of raw materials Quarrying (land use , biodiversity) Use of Resources Processing of raw materials into aggregates: dust production and noise Transportation of aggregates	**o/+**

RECYCLING AS AGGREGATES FOR STRUCTURAL CONCRETE

Substituted material (the proportion to which virgin aggregates are substituted by recycled aggregates is unknown): aggregates from rocks and gravel extracted from quarries

Direct impacts	Avoided Impacts	Net benefits
	Extraction of raw materials (rocks and gravel for aggregates): land-use for quarries, production of dust, use of natural resources	
Transportation of waste concrete	Transportation of raw materials	
	Quarrying (land use , biodiversity)	
	Use of Resources	
Processing of waste concrete into aggregates: dust production and noise during crushing and sieving steps		o/+
Transportation of recycled aggregates	Processing of raw materials into aggregates: dust production and noise	
Production of cement: energy consumption, greenhouse gases and pollutants emissions	Transportation of aggregates	
Transportation of cement	Production of cement	
Concrete production	Transportation of cement	
	Concrete production	

RE-USE OF CONCRETE BLOCKS

Substituted material (in the same proportion): manufactured concrete

Direct impacts	Avoided Impacts	Net benefits
Transportation of waste concrete Processing of concrete blocks: energy for cleaning and decontamination Transportation of concrete to the new construction site	Extraction of raw materials (rocks and gravel for aggregates): land-use for quarries, production of dust, use of natural resources, biodiversity Transportation of raw materials Processing of raw materials into aggregates: dust production and noise Production of cement Transportation of cement Concrete production Transportation of concrete	++

- **Direct impacts of landfilling**

When landfilling concrete, the release of constituents into groundwater is low. The chemical analysis of water samples show dissolved substances at levels much lower than the very stringent limits set by the World Health Organisation for drinking water[54]. Only the sulphate ion ($S04^{2-}$) is regularly found at high concentrations, but always much lower than the levels found in many popular brands of mineral waters[55].

The major environmental impact of landfilling comes from the use of space for the storage of inert C&D waste. This is particularly relevant in countries where land is scarce and disposal costs are expensive.

- **Direct impacts of reprocessing into aggregates**

As presented in the previous section, recycling of concrete involves processing into coarse or fine aggregates, through processes that are similar to those used with natural aggregates (screening, crushing and transportation).

The emissions of dust and particles produced during the crushing step of concrete but also during the storage phase before re-using, are probably the most important environmental impact during the treatment of concrete C&D waste[56] and can cause serious health problem for workers. The activities that can generate dust are the following:

[54] [WHO, 2006] <http://www.who.int/water_sanitation_health/dwq/gdwq0506.pdf>
[55] [ECP, 2009]
[56] [VITO, 2006]

- Loading of aggregate onto storage piles (batch or continuous drop operations).
- Wind erosion of pile surfaces and ground areas around piles.
- Load-out of aggregate for shipment or for return to the process stream (batch or continuous drop operations).

The emissions from the sorting processes can be controlled by spraying water on the piles of crushed concrete to avoid dust dispersion into the air.

The noise from the machines at the crushing step of aggregates, both virgin and recycled, for the production of concrete is one of the major health concerns. Indeed, at some work stations it can reach 85dB[57] during the production process.

Efforts have been made to mitigate the effects on workers thanks to quieter machines and the use of hearing protection inside concrete plants which is compulsory.

When concrete is being placed, it is usually compacted by vibration which can damage workers' hands and can be avoided through the re-use of concrete.

Net benefits of re-use and recycling

The benefits of re-use and recycling of concrete depend on the material that recycled concrete substitutes.

Substitution to coarse or fine aggregates

After recycling into coarse or fine aggregates, waste concrete simply replaces virgin aggregates (crushed rocks, gravel, sand) that would otherwise have been extracted from quarries and processed.

Recycling therefore avoids the use of natural resources and land space in quarries. Quarrying activities might also generate biodiversity issues, which are avoided through recycling.

On the other hand, avoided impacts related to transportation and processing of virgin aggregates are not significantly different from those generated to prepare recycled aggregates. In some cases, however, recycled aggregates can be locally available, reducing the transportation distances. This would result in positive net benefits, particularly in fuel consumption and greenhouse gases emissions[58].

Overall, the environmental benefits of recycling of concrete into coarse or fine aggregates are probably moderate.

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[57] [ECP, 2009] 85dB is equivalent to the noise created by a dense freeway traffic; as a comparison, a pneumatic drill generates between 100 and 110DB and a plane taking off 120dB.

[58] A case study presented in the report of the WBCSD, estimating the outcome of recycling 85% C&D waste (mostly concrete) into aggregates for road works, showed a potential reduction of 77% of the energy consumption, mainly due to reduced transportation (of waste to landfills and of raw materials from quarries to construction sites).

Re-use – Substitution to manufactured concrete

The direct re-use of concrete blocks avoids the production of concrete, and therefore the associated impacts of cement production.

Indeed, most environmental impacts of concrete production originate from the production of the cement composing it (at least 80% of the impacts during the production process[59]). The following table illustrates these results for the energy consumption indicator (cement production accounts for 82% of the total energy consumption necessary for the production of all the concrete components).

Table 16 – Energy consumption associated with each concrete constituent [60]

Constituent	Energy (MJ/kg concrete)
Coarse aggregate	0.028
Fine aggregate	0.028
Portland cement	0.735
Water	0.000
Manufacturing	0.102
Total	0.893

Other significant impacts of cement production are the release of carbon dioxide during the decarbonation of limestone (about 60%[61] of the total CO_2 emissions generated during the cement production[62]) in the cement kiln at a very high temperature, but also nitrous oxide (NO_x), sulphur dioxide (SO_2), small quantities of chlorides, fluorides, carbon monoxide, heavy metals, organic compounds and dust.

The typical greenhouse gases emissions for the manufacturing of cement are estimated at 0.6 tonne of CO_2 per tonne of cement thanks to the efforts to increase the efficiency of the firing process in the cement kiln[8]. Moreover, the use of CO_2-neutral fuels (30% of the total fuel used during the production process) and the use of alternative materials have lead to substantial CO_2 savings. Experiments carried out in Northern Europe have shown that the level can even be lowered to 0.35 tonne of CO_2 per tonne of cement by implementing even further these measures.

Taking into consideration the avoided production of cement when reusing concrete, the following table illustrates the potential savings at the EU-27 level.

[59] [Habert, 2008] *The following indicators were studied: energy consumption, global warming potential, acidification, eutrophication, ozone depletion, human toxicity among others*

[60] [Struble, 2004]

[61] [ECP, 2009]

[62] The remaining 40% CO2 emissions are generated through fuel combustion and the use of electrical power.

Table 17 – Re-use of concrete: CO_2 savings through avoidance of cement production

	Greenhouse gases emissions: t eq. CO_2/t cement	Greenhouse gases emissions[63]: t eq. CO_2/t concrete	Greenhouse emissions at the EU-27 level[64]: in million tonnes eq. CO_2	Potential savings (hyp: 10% re-used concrete): in million tonnes eq. CO_2
Current situation	0.6	0.07	64.8	6.48
Scenario 1: optimal efficiency of cement production (based on best available techniques observed in Europe)	0.35	0.04	37.8	3.78

The re-use of concrete blocks can therefore have significant environmental benefits, mostly through the avoidance of cement production.

4.4.2. Economic impacts

Despite the environmental benefits of recycling concrete, its limited production costs do not encourage re-use and recycling. Nevertheless, using recycled concrete can also show economical advantages, depending on the local situation. The identified factors include:

- Proximity and quantity of available natural aggregates
- Reliability of supply, quality and quantity of C&D waste (availability of materials and capacity of recycling facility)
- Government procurement incentives
- Standards and regulations requiring different treatment for recycled aggregate compared to primary material
- Taxes and levies on natural aggregates and on landfill

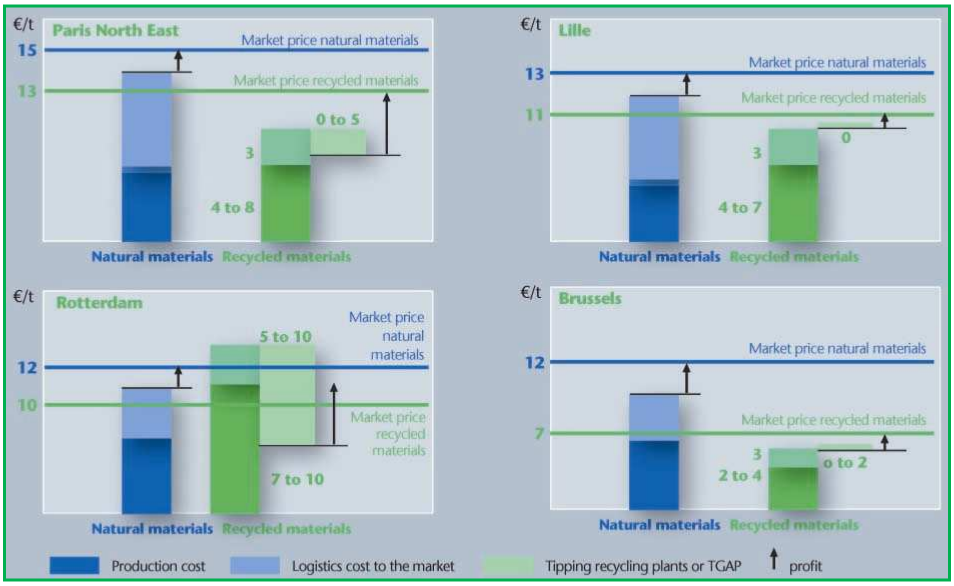
Recycled concrete aggregates in Europe can sell for 3 to 12 € per tonne with a production cost of 2.5 to 10 € per tonne. The higher selling prices are obtained on sites where all C&D waste is reclaimed and maximum sorting is achieved, there is strong consumer demand, lack of natural alternatives and supportive regulatory regimes.

The following figure illustrates the geographic variation in the comparable profit margin. In Paris there is a lack of natural aggregates making recycled aggregates an attractive alternative and the recycling market is driven mainly by civil works companies. In Rotterdam, higher production costs for recycled materials compared to virgin materials are compensated by high tipping fees. In Brussels the lack of landfill space pushes C&D companies to drop market prices to find solutions for their waste, while in Lille the

[63] Calculation based on an average 12% cement content in concrete
[64] 900 million tonnes as shown in 4.2.1.

abundance of quarries makes the higher production costs a limiting factor (as raw materials have lower costs).

Figure 2 – Comparison of the market prices for natural and recycled materials in some European cities [WBCSD, 2009]



4.5. TOWARDS THE 70% TARGET: DRIVERS AND BARRIERS

As developed in the above sections, concrete C&D waste shows high potential improvement for re-use, recycling and other forms of material recovery. The barriers and drivers identified by the experts interviewed are summarised below.

- **Use of recycled concrete aggregates in road works: a high potential in the short and mid-term**

Nowadays, concrete is mainly recycled into aggregates for road construction and the potential for improvement is still wide but considering that the need for such infrastructures will reach its maximum at some point[65] and that the demand for aggregates will be sustained mainly through the maintenance and the replacement of roads, research has to be encouraged to find alternatives that will allow to achieve the 70% target and more in the long term.

- **Sorting at source: separation for an improved material quality**

An effective sorting out of mixed C&D waste is necessary to produce a higher non-contaminated concrete C&D waste fraction, to make easier the further recycling of this specific waste stream and improve the overall recycling rates[66].

[65] Interview with Alessio Rimoldi, Secretary General, European Concrete Platform
[66] Interview with Alessio Rimoldi, Secretary General, European Concrete Platform

Landfilling ban: a driver towards the development of alternatives

The landfilling ban at the European level following the example set by the Netherlands would incentivise concrete waste producers into more re-use and recycling[67].

This goes hand in hand with the funding of research for the development of new options and for the improvement of the existing options (in terms of energy consumption, efficiency and costs). Moreover, the ban of disposing of concrete waste in landfills is likely to ensure a more regular waste supply for recycling industries.

According to the European Ready Mixed Concrete Organization, the goal of "zero landfill" of concrete can be achieved if the structure of a building is carefully planned and designed, and if the building undergoes successful renovation and deconstruction.

Quality certification for recycled materials: a secure framework for the re-use and recycling of concrete waste

Quality certification of secondary materials (obtained after concrete waste has been processed) is expected to act as a proof that these materials can meet high security standards and achieve the same properties as virgin materials. Therefore, it is one of the solutions to promote the use of recycled aggregates and concrete blocks by contractors and manufacturers. CEN standards for aggregates already establish such requirements for aggregates used in concrete, mortar, and other applications.

Building conception: designing for the end of life

Acting at the design phase of a building is another way of tackling the issue of C&D waste. Indeed, a careful design of the buildings and infrastructures would allow the dismantling and maximise the potential for re-use and recycling. Such an approach is also likely to lengthen the service life of buildings, decreasing the amount of concrete waste produced and therefore improving the current re-use and recycling rates.

Green building systems: promoting the use of former concrete waste

Green building systems (e.g. German Sustainable Building Certificate, HQE – Haute Qualité Environnementale in France, BREEAM - BRE Environmental Assessment Method in the UK) can encourage the re-use of concrete elements and the use of structural concrete made of increasing recycled aggregates by integrating such criteria in their rating charts. This would influence public perception regarding the quality of recycled concrete and promote large possibilities for its use, by specifically addressing the recycled concrete issue in the system.

[67] Ibid.

5. Material focus: BRICKS, TILES AND CERAMIC

Applications in the construction sector	Brick: masonry construction especially for building and Tile: covering of roofs, floors and walls These ceramic products are made of fired clay		
Production in the EU-27	6.8 billion Euros sales in 2003 (for 23 European countries) No data available on quantities		
Waste generation in the EU-27	N/A		
Treatment options	**Landfill**	**Recycling** (replaces sand, gravel, stones, rocks e.g. to fill roads, to produce tennis sand, to serve as aggregate in concrete)	**Re-use**
Current rates	N/A	N/A	N/A
Potential rates	N/A	N/A	N/A
Environmental impacts	Land-use, transportation	**Few significant net benefits when crushing is needed** (as only the preparation of virgin aggregates is avoided) or **some net benefits when crushing is not necessary** Potential energy and local pollution savings in dense areas (shorter transportation)	**Higher potential net benefits** (due to the avoidance of bricks, tiles and ceramics energy intensive production)
Barriers to re-use and recycling of the waste	- Reduced costs of bricks, tiles and ceramics produced from raw materials		
Existing and potential drivers to re-use and recycling of the waste	- Design for the end-of-life (design for deconstruction to drive to re-use of bricks and tiles) - Increase the life span of buildings (>100 years) to reduce the amounts of waste generated. - Landfill taxes or landfill bans to promote alternatives		

5.1. PRODUCT DESCRIPTION AND APPLICATIONS

A ceramic is an inorganic, non-metallic solid prepared by the action of heat and subsequent cooling. Ceramic materials may have a crystalline or partly crystalline structure, or may be amorphous. Because most common ceramics are crystalline, its definition is often restricted to inorganic crystalline materials. Ceramics are used in buildings as structural products including blocks but also used for external and internal walls, for external wall cladding, as pavers, water/sewage pipes, floors and roof tiles.

Facing bricks and blocks are ceramic materials that are usually laid using mortar or glues. In many European MS including France, Germany, the UK, bricks have been used in construction for centuries as a part of the architectural heritage.

A tile is a manufactured piece of hard-wearing material such as ceramic with a hard glaze finish used for covering roofs, floors and walls. Most ceramic construction products are traditionally made from locally available materials such as clay.

The advantage of clay construction products is to be found in the energy saving during the use phase. Indeed, their density leads to lower variation in temperature and moisture, i.e. cooler in summer and warmer in winter.

5.2. QUANTITATIVE ANALYSIS

5.2.1. PRODUCTION DATA

The European Ceramic Industry is characterised by mostly small and local producers as well as some global leaders, such as Wienerberger[68] for bricks, roof tiles, blocks and pavers (based in Austria) and Monier[69] for roofing materials for pitched roofs, roof and chimney systems (headquarters in Germany[70]).

The main bricks producing countries are Spain and Italy while France has a very strong roofing tile industry[71].

Data regarding the production of tiles, bricks and ceramic in general at the national level for EU-27 MS is lacking, the reporting not being systematic.

The only available data at the European level is an indication of the sales volume for bricks and roof tiles in Europe (limited to 23 countries[72]), which was estimated at 6.8 billion Euros sales in 2003 (with a 50,000 workforce). As international trade is assumed to be of limited

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68 www.wienerberger.com
69 www.monier.fr
70 Interview with expert Christophe Sykes, CERAME-UNIE
71 www.cerameunie.eu/industry.html
72 Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, UK, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Sweden, Spain, and 4 other European countries not members of the European Union

importance for the ceramic Industry because it relies on the availability of local materials, this sales volume gives a good idea of the consumption volume of these products in Europe.

5.2.2. Waste generation and treatment data

Despite the potential long life of ceramic-based products that can easily exceed 100 years, clay brick buildings are most of the time demolished well before the end of their useful life, exception made of Scandinavian countries where clay brick buildings are usually used throughout their life-time. Bricks and tiles being highly durable materials, they can be re-used after a building has been demolished. Nevertheless, deconstruction allowing for the re-use of this type of materials is not common outside Denmark.

In 2006 approximately 318,000 tonnes of clay products from the building sector were recycled in Denmark. Clay products (bricks & roofing tiles with some mortar) have shown a higher increase in recycling rates compared to other building waste such as concrete & asphalt. Indeed, in 1996 approximately 93,000 tonnes of clay products was recycled. Therefore, an increase of recycling of 240% has taken place for clay products in ten years. Recycled clay products are mainly used as a filler material in concrete production[73].

Nonetheless, the amounts of bricks and tiles waste, the associated recycling and re-use rates are not available at the EU-27 level due to the absence of a systematic European reporting system.

Recycling and re-use rates are estimated to vary greatly across the EU depending on the construction standards, the life span of buildings and national legislation despite the huge recycling potential of bricks, tiles and ceramics. Indeed, the reclaim of bricks and roof tiles has been in place traditionally in many countries among which Belgium, France and Germany to give an old style to new buildings (The Netherlands and the UK to a smaller degree[74]).. Recycling and re-use practices among other MS are less developed though the bricks and tiles waste amounts are assumed to be more important, especially in Southern European MS such as Spain, Italy and Greece. This is due to the demolition practices not allowing for the recovery of these building elements.

5.3. Recovery techniques

5.3.1. Existing options

Recycling and re-use are detailed in this section.

- **Recycling**

A high proportion of ceramic C&D waste is well suited to being crushed and recycled as a substitute for newly quarried (primary) aggregates in certain lower grade applications such

[73] Interview with Christophe Sykes, CERAME-UNIE
[74] Ibid.

as engineering fill and road sub-base. This practice has been common (though not necessarily widespread) in several MS for many years[75].

For instance, in the Netherlands where strong measures are taken for the protection of the environment, the recycling of this fraction is well established while it is under development in other MS such as Greece[76].

Using bricks, tiles and ceramics waste from demolition sites raises however some issues. Indeed, if the technical criteria for the use of granulated ceramic material are few, it needs to be absolutely free of contaminating elements such as mineral wool, concrete, heavy metals and PAHs[77] (Polycyclic Aromatic Hydrocarbons) that may leach and cause ground water pollution. This often mixed and contaminated fraction needs therefore to go through cleaning, crushing and sieving processes before further recycling.

The different recycling options promoted by the European Tiles and Bricks Association[78] are described below:

- To fill and stabilise minor roads, especially in wet areas such as woods and fields. The practice is common in countries that lack adequate stone supplies such as Denmark. The material is generally used uncrushed.
- Crushed clay bricks, roof tiles and other masonry can be used on larger road building projects, especially as unbound base material. It is used to build roads in countries such as Germany, Denmark, the Netherlands, Switzerland and UK. In Germany, the maximum brick content for such use is 30%, due to quality requirements for frost attacks and impact resistance. The material replaces natural materials, such as sand and gravel, which are normally used in large amounts for this purpose.
- Aggregates for in-situ. Crushed clay bricks and other masonry can also be used to level and fill pipe trenches. The fine crushed material will replace natural materials such as sand.
- Crushed clay bricks, tiles and other masonry can also be used as aggregate in concrete. The crushed material replaces other raw materials such as sand. This is commonly practiced in Austria, Denmark, Switzerland and especially the Netherlands[79].
- Tennis sand produced by crushing red bricks and roof tiles. The fine surface layer is laid over courser-grained layers that can comprise crushed clay brick matter. The process is most efficient when it occurs at brick or tile factories where there is an abundance of scrap material.

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[75] [Symonds, 1999]
[76] Interview with Christophe Sykes, CERAME-UNIE
[77] www.staywithclay.com/downloads/en-StayWithClay-Part5-DemolitionAndRecycling.pdf
[78] TBE AISBL, www.tiles-bricks.eu
[79] www.tiles-bricks.eu

- Crushed bricks and tiles can also be used as plant substrates. The material may be mixed with composted organic materials and is especially suited for green roofs: the porosity of the material allowing retaining water plants can rely on during dry periods.

Re-use

Extracting roof tiles and storing them for re-use is not difficult and bricks that are left over from building projects can also be diverted to other uses among which the incorporation into new buildings : for example, a new architectural trend in Berlin is to reuse facing bricks in new buildings. To do that, building deconstruction is imperatively required. However, these materials are often contaminated which raises several issues:

- Cleaning bricks is time consuming, difficult and dusty work that, if mechanised, is apparently rarely successful.
- Cement rich mortars are difficult to remove. In countries like Greece, where mortar from ancient constructions is a full ceramic material, it does not need to be removed.
- Excess mortar dust can inhibit the adhesion between mortar and bricks and lead to weaker masonry, depending on the mortar composition.
- Bricks may vary in quality. It is therefore difficult to assess the strength and load-bearing capacity of masonry made from recycled bricks. European and national standards are very strict and it is extremely difficult to be sure that re-used bricks used in new structures will be durable.
- Due to the difficult nature and high labour costs associated with the process, the use of re-used bricks may be more expensive than the use of new bricks.

5.3.2. Emerging techniques

An increasing amount of scientific research is carried out to improve the techniques to separate and clean bricks from other mixed C&D waste and especially from contaminants but at the present time, no emerging techniques have been identified[80].

5.4. Environmental, economic and social impacts of bricks, tiles and ceramics waste management

5.4.1. Environmental and health impacts

The following table summarises the impacts and benefits of the recycling and recovery options of bricks, tiles and ceramics, which are further described below.

[80] Interview with Christophe Sykes, CERAME-UNIE

Table 18 – Impacts and benefits for each option for the management of bricks, tiles and ceramics waste

LANDFILL

Direct impacts	Avoided Impacts	Net benefits
Transportation of waste to the landfill No release of pollutants to water if the fraction is not contaminated (bricks, tiles and ceramics are made of clay, a natural material). Use of land space		-

RECYCLING IN MINOR ROAD WORKS WITH NO FURTHER PROCESSING (E.G. UNCRUSHED)

Substituted material (in the same proportion): aggregates from rocks and gravel extracted from quarries

Direct impacts	Avoided Impacts	Net benefits
Transportation of bricks, tiles and ceramics waste Transportation of recycled material Use of recycled aggregates: dust production when loading, unloading the trucks and spreading the material on the roads	Extraction of raw materials (rocks and gravel for aggregates): land-use for quarries, production of dust, use of natural resources Transportation of raw materials Biodiversity impacts Use of resources Production of aggregates from virgin materials: dust production and noise during crushing, sieving steps Transportation of aggregates Use of virgin aggregates: dust production	+

RECYCLING IN HEAVY ROADS WORKS WITH FURTHER PROCESSING

Substituted material (in the same proportion): aggregates from rocks and gravel extracted from quarries

Direct impacts	Avoided Impacts	Net benefits
Transportation of bricks, tiles and ceramics waste	Extraction of raw materials (rocks and gravel for aggregates): land-use for quarries, production of dust, use of natural resources Transportation of raw materials	o
Production of aggregates from bricks, tiles and ceramics C&D waste: dust production and noise during crushing and sieving steps Transportation of recycled material	Biodiversity Use of resources Production of aggregates from virgin materials: dust production and noise	
Use of recycled aggregates: dust production when loading, unloading the trucks and spreading the material on the roads	Transportation of aggregates Use of virgin aggregates: dust production	

RE-USE OF BRICKS, TILES AND CERAMICS C&D WASTE

Substituted material (in the same proportion): manufactured bricks and tiles

Direct impacts	Avoided Impacts	Net benefits
Transportation of bricks, tiles and ceramics waste Processing of bricks, tiles and ceramics waste: energy for cleaning and decontamination	Extraction of raw materials (clay material): land-use for quarries, use of natural resources Biodiversity Transportation of raw materials	++
Transportation of bricks, tiles and ceramics to the new construction site	Bricks, tiles and ceramic production: important initial energy consumption (energy intensive industry), associated greenhouse gases emissions Transportation of bricks, tiles and ceramics to the construction site	

Direct impacts of landfilling

Landfilling bricks, tiles and ceramics does not raise serious environmental issues especially for the release of pollutants into water except when these materials are coming from C&D activities and therefore often contaminated with potentially dangerous fractions: insulation wool, mortar, concrete[81].

The major environmental impact of landfilling comes from the use of space for the storage of inert C&D waste, particularly in countries where land is scarce.

Direct impacts of recycling as a road works material

As presented in the above sections, the recycling of bricks, tiles and ceramics involves processing steps (crushing, sieving, transportation) in almost all cases, except for the use for minor roads where crushing is not necessary. These processes are therefore similar to the processing of natural materials which balances the environmental effects.

The production of dust and particles during the crushing, sieving, transportation and storage steps is avoided , for example by spraying water on the crushed materials, by covering the conveyor belts and machineries, by enclosing dust producing processes and maintaining cleanliness of the industrial vehicles used for loading and transporting recycled bricks, tiles and ceramics[82].

The noise from the aforementioned processes is a serious concern for the workers health and can be mitigated through appropriate personal training and equipment and through the use of quieter machines.

Net benefits of re-use and recycling

Substitution to coarse and fine aggregates

The use of recycled bricks, tiles and ceramics in the form of coarse and fine aggregates in the different recycling options developed in the above sections replaces virgin materials that would have been extracted and processed, which thus saves the use of raw aggregates and land space used for quarries. However, the use of raw materials is not really the issue since it is largely available locally in Europe and the extraction of clay for construction products represents only 5%[83] of the total mineral extraction. Such a material is therefore not threatened by intensive exploitation. Finally, the impact of transportation of raw materials that is avoided through the use of recycled coarse and fine aggregates is limited since clay brick and tile plants are often situated alongside clay deposits or sand quarries, minimising the energy spent on transportation.

[81] These materials contain chemicals used as additives and that may have serious environmental impacts.
[82] www.tiles-bricks.eu
[83] Ibid.

Re-use – Substitution to bricks, tiles and ceramics produced from virgin materials

The direct re-use of reclaimed bricks and tiles avoids the manufacturing processes, the associated energy consumption and gaseous emissions. Indeed, the Ceramic Industry is very energy intensive with an energy share of up to 30% of production costs[84].

As an example, the specific energy consumption for the brick and roof-tile industry varied in 2001 between 1.4 and 2.42 GJ per tonne[85] which represents between 80 and 138 CO_2 equivalents per tonne considering that the most commonly fuel used in this industry is natural gas[86]. This amount of CO_2 equivalent is avoided thanks to the re-use of bricks and roof-tiles.

However, it must be noted that the specific energy consumption for the production of 1 m^2 brick wall was reduced by 40% from the 1990s to 2007, as the initially required 190 kWh were reduced to 115 kWh.

The re-use of bricks and roof tiles also allows avoiding gaseous emissions to the atmosphere that normally occur during the manufacturing process. They are mainly of three kinds:

- Emissions coming from ceramic conversion of the raw material in the kiln. The emissions are HCl (hydrochloric acid), HF (hydrofluoric acid), SOx (sulphuric acid) and C02.
- Exhaust gas emissions from combustion processes (from drying and firing plants). The emissions are CO (carbon monoxide), CO2, NOx (nitrogen oxides) and particles.
- Emissions of VOC's (Volatile Organic Compounds) due to the use of organic substances (additives).

5.4.2. Economic impacts

The harnessed extraction of clay and the development of new manufacturing techniques maintain clay bricks and tiles as competitive building materials that have good quality, long life, minimal maintenance requirements and provide energy efficient solution during the use phase. The reduced costs of bricks, tiles and ceramics produced from raw materials are therefore not encouraging the development of recycling[87]. The above mentioned number of SMEs would also decrease the chances for developments in recycling (heavy financial burden to SMEs while relatively small financial gains - if any -) except with the development of specific recycling facilities covering larger areas in a MS.

[84] www.cerameunie.eu/bricks.html
[85] www.staywithclay.com
[86] The emission factor used for the calculation is equal to 57 kg eq CO_2/GJ
[87] www.tiles-bricks.eu

5.5. TOWARDS THE 70% TARGET: DRIVERS AND BARRIERS

If the recycling and re-use is well established in countries such as the Netherlands and Germany, the effort required in order to increase recycling and re-use rates and help reach the 70% target is assumed to be important in other countries. Recycling techniques already exist but measures have to be taken to promote their development. Some potential drivers and barriers are summarised below.

- **Landfilling ban: a promotion for existing and developing recycling options**

The landfilling ban at the European level following the example set by the Netherlands would greatly encourage bricks and tiles waste producers to process their waste stream through the existing recycling chains and even fund research for the development of more efficient and highly demanding recycling techniques.

Moreover, the ban of disposing of bricks, tiles and ceramics waste in landfills (or the increase of landfill taxes) is likely to ensure a more regular waste supply for recycling industries.

- **Building conception: designing for the end of life**

Designing for the deconstruction of buildings would make easier the reclamation of bricks and tiles, improve the quality of the waste stream and therefore increase the re-use of these elements for new construction projects.

From another point of view, projects could be designed for longer life span, leading to the reduction of the waste stream.

6. Material focus: ASPHALT

Applications in the construction sector	Pavement for road construction and maintenance			
Production in the EU-27	Total: almost **300 Mt** (2008) - 291 Mt of hot mix asphalt - 2.8 Mt of cold mix asphalt - 2.1 Mt of warm mix asphalt			
Waste generation in the EU-27	**47 Mt** of reclaimed asphalt (2008)			
Treatment options	**Landfill**	**Recycling in a stationary plant**	**In-situ Recycling**	**Material recovery**
Current rates	N/A	N/A(up to 83% already achieved by some MS, e.g. Germany)		N/A(up to 41% achieved by some MS, e.g. Hungary)
Potential rates		Could absorb between **30 and 80%** of reclaimed asphalt	Estimated at almost **100%**	N/A
Environmental impacts	Potential emissions of PAH when asphalt is contaminated with tar, land-use, transportation	**Positive potential net benefits** as the preparation of virgin aggregates is avoided, reducing the carbon footprint	**Positive potential net benefits** (the preparation of virgin aggregates and the transportation of both reclaimed and newly produced asphalt are avoided)	**Positive potential net benefits** as the preparation of virgin aggregates is avoided
Barriers to material recovery and recycling of the waste	- Availability and cost of raw material - The actual scientific knowledge for the improvement of the manufacturing process			
Existing and potential drivers to material recovery and recycling of the waste	- Increase virgin materials costs to create a new demand for reclaimed asphalt - Landfilling ban to encourage recycling practices - Improve the communication to show the economic benefit that would be associated with recycling practices			

6.1. PRODUCT DESCRIPTION AND APPLICATIONS

Asphalt is a black viscous and elastic material made of bitumen acting as a binder composted of a mixture of aggregates, sand, filler and occasionally a number of additives.

Three major types of asphalt are distinguished depending on the production temperature: hot[88], warm[89] and cold[90] mix asphalt. The other asphalt materials are cutback, mastic and natural asphalt but they represent a minority which explains why they are not tackled in this chapter.

To produce asphalt, a large panel of mix types exist depending on the asphalt position in the road structure (base[91], binder[92] or surface course[93]), on its particular function, on climatic conditions and on the nature of raw materials locally available[94].

The primary use of asphalt is in road infrastructure construction and in airports for runways and therefore referred as asphalt pavement[95]. Over 90% of the total road network in Europe is made of asphalt.

The following table summarises the uses that are made of asphalt in road structure.

Table 19 - Application in surface, binder and base courses in % of total annual production [EAPA, 2008]

Country	Surface course	Binder course	Base course
Austria	15	10	75
Belgium	47	N/A	53
Bulgaria	N/A	N/A	N/A
Cyprus	N/A	N/A	N/A
Czech Republic	59	19	22

[88] Hot mix asphalt (HMA) is a mixture of aggregate and bitumen, sometimes including modifiers, that is produced by mixing hot dried aggregate (150°C) with heated binder. Paving and compaction must be performed while the asphalt is sufficiently hot. HMA is commonly used for all kind of roads: high-traffic areas, low traffic areas, parking lots, airports, etc.

[89] Warm mix asphalt concrete (WMA) reduces the temperature required for manufacture by adding asphalt emulsions, waxes, or zeolites. This process results in less fossil fuel consumption and reduced emission of fumes.

[90] Cold mix asphalt is produced by emulsifying the bitumen in water with (essentially) soap prior to mixing with the aggregate. While in its emulsified state the asphalt is less viscous and the mixture is easy to work and compact. It is commonly used as a patching material and on lesser trafficked service roads.

[91] The sub-layer material of an asphalt roadway placed directly on top of the undisturbed soil so as to provide a foundation to support the top layer(s) of the pavement.

[92] Coarse aggregate with a bituminous binder between the foundation course and the wearing course of the asphalt pavement

[93] The top layer of the asphalt pavement

[94] [EAPA, 2005]

[95] A pavement consisting of a surface course of mineral aggregate coated and cemented together with asphalt cement on supporting course. It can be the result of hot, warm or cold mixtures depending on the characteristics of the road under construction or renovation (heavy or light traffic). Asphalt pavement is commonly composed of 5% asphalt cement and 95% aggregates (stone, sand, and gravel).

Country	Surface course	Binder course	Base course
Denmark	44	5	51
Estonia	68	29	3
Finland	87	N/A	13
France	N/A	N/A	N/A
Germany	30	19	51
Greece	40	35	25
Hungary	56	38	6
Ireland	40	20	40
Italy	50	30	20
Latvia	N/A	N/A	N/A
Lithuania	32	34	34
Luxembourg	N/A	N/A	N/A
Malta	N/A	N/A	N/A
Netherlands	32	4	60
Poland	80	10	10
Portugal	50	28	22
Romania	30	24	46
Slovakia	N/A	N/A	N/A
Slovenia	48	9	43
Spain	51	24	25
Sweden	40	20	40
United Kingdom	N/A	N/A	N/A
Average EU-27	**47.3**	**21.1**	**33.6**

The production of asphalt in a given country is highly dependent on the number of new roads built? For example, Poland presents a high production of asphalt for surface course, likely because major road construction works are undergone because of the preparation of the Football European Championship of 2010.

In average, the most common use of asphalt in road works is for surface course (47% in EU-27). Large discrepancies between countries can however be noted: as an example, Finland shows the higher use of asphalt for the surface of the pavement with 87% of the total use of asphalt, while in Austria only 15% is used for this same application.

6.2. QUANTITATIVE ANALYSIS

6.2.1. PRODUCTION DATA

Approximately 291 million tonnes of hot mix asphalt, 2.8 million tonnes of cold mix asphalt and 2.1 million tonnes of warm mix asphalt were produced in 2008[96] in Europe. Since 1973,

[96] [EAPA, 2008]

the asphalt production has been decreasing but seems to have reached a more or less stable level, because of the volume of the maintenance works related to road construction.

Production takes place in a fixed or mobile mixing plant with two main processes namely in batch plants and in continuous mixing or drum mixers. In Europe there are at the moment approximately 4,500 mixing plants. The production rate of these installations may vary between 25 and 800 tonnes per hour.

Raw materials may be transported over long distances. The finished product however is normally applied within 30-50 km of the mixing plant. Distances up to 100 km may however be observed.

The following table gives production data for hot mixed asphalt for 2005 and 2008 for most MS at the EU-27 level.

Table 20 – Total production of hot mixed asphalt in 2005 – 2008 in million tonnes [EAPA, 2008]

Country	2005	2008	Population in 2008	Production per capita (tonnes/capita)	Share to the total EU-27 production in 2008 (%)	Growth rate 2005/2008
Austria	10.0	9.5	8,318,592	1.1	3.3%	-5.0%
Belgium	5.2	4.9	10,666,866	0.5	1.7%	-5.8%
Bulgaria	N/A	N/A	7,640,238	N/A	N/A	N/A
Cyprus	N/A	N/A	789,269	N/A	N/A	N/A
Czech Republic	5.6	7.3	10,381,130	0.7	2.5%	30.4%
Denmark	3.2	3.1	5,475,791	0.6	1.1%	-3.1%
Estonia	1.2	1.5	1,340,935	1.1	0.5%	25.0%
Finland	6.2	6.0	5,300,484	1.1	2.1%	-3.2%
France	40.1	41.8	63,982,881	0.7	14.4%	4.2%
Germany	57.0	51.0	82,217,837	0.6	17.5%	-10.5%
Greece	7.0	8.1	11,213,785	0.7	2.8%	15.7%
Hungary	3.8	2.5	10,045,401	0.2	0.9%	-34.2%
Ireland	3.4	2.8	4,401,335	0.6	1.0%	-17.6%
Italy	40.1	31.6	59,619,290	0.5	10.9%	-21.2%
Latvia	0.6	0.6	2,270,894	0.3	0.2%	0.0%
Lithuania	N/A	2.2	3,366,357	0.7	0.8%	N/A
Luxembourg	N/A	0.6	483,799	1.2	0.2%	N/A
Malta	N/A	N/A	410,290	N/A	N/A	N/A
Netherlands	8.6	9.3	16,405,399	0.6	3.2%	8.1%
Poland	15.0	15.0	38,115,641	0.4	5.2%	0.0%
Portugal	11.1	9.0	10,617,575	0.8	3.1%	-18.9%
Romania	2.8	3.3	21,528,627	0.2	1.1%	17.9%
Slovakia	1.8	2.2	5,400,998	0.4	0.8%	22.2%
Slovenia	1.5	2.6	2,010,269	1.3	0.9%	73.3%
Spain	41.5	42.3	45,283,259	0.9	14.5%	1.9%
Sweden	7.2	8.7	9,182,927	0.9	3.0%	20.8%
United Kingdom	27.9	25.0	61,179,256	0.4	8.6%	-10.4%
Total/average EU-27	300.8	290.9	497,649,125	0.6	100.0%	-3.3%

France, Germany, Italy and Spain produce 166.7 million tonnes of hot mix asphalt accounting for around 60% of the total production at the EU level. When considering the production in tonnes per capita, it ranges from 0.2 (Hungary and Romania) to 1.3 (Slovenia), the average at the EU-27 level being at 0.6 tonne per capita.

For some countries, data are not available for the moment (Bulgaria, Cyprus, and Malta).

6.2.2. WASTE GENERATION AND TREATMENT DATA

Asphalt waste is generated during the demolition of existing infrastructures, when the existing asphalt layer is removed[97]. Asphalt waste generated through these steps is referred as reclaimed asphalt[98] and can be 100% recycled depending on the recycling technique as shown in 6.3.1.

The following table summarises the available data on quantities of reclaimed asphalt for most countries at the EU-27 level, and the total recycling rates achieved. The percentage of reclaimed asphalt available for each recycling technique, i.e. hot, cold and unbound layers, refer to the recycling rates currently achieved by the Asphalt Industry[99].

[97] According to EAPA experts, no asphalt waste is generated during the construction of new roads as surplus material is usually taken back by the producer.

[98] Reclaimed asphalt pavement (RAP) is the term given to removed and/or reprocessed pavement materials containing asphalt. These materials are generated when asphalt pavements are removed for reconstruction, resurfacing, or to obtain access to buried utilities. When properly crushed and screened, RAP consists of high-quality, well-graded aggregates coated by bitumen.

[99] Interview with Mr Egbert Beuving, Director of the EAPA

Table 21 - Recycling and incorporation rates of reclaimed asphalt. Adapted from [EAPA, 2008]

Country	Available reclaimed asphalt (tonnes) [100]	Population in 2008[101]	Available reclaimed asphalt per capita (kg/capita)	% of available reclaimed asphalt used in hot and warm recycling	% of available reclaimed asphalt used in cold recycling	% of available reclaimed asphalt used in unbound layers[102]	Total recycling and recovery rates (%)	Incorporation rate[103] (%)
	[a]	[b]	[a]/[b]	[c]	[d]	[e]	[c]+[d]+[e]	[f]
Austria	350,000	8,318,592	42,1	N/A	N/A	N/A	N/A	N/A
Belgium	1,500,000	10,666,866	140,6	55	0?[104]	0?	55?	44.0
Bulgaria	N/A	7,640,238	N/A	N/A	N/A	N/A	N/A	N/A
Cyprus	N/A	789,269	N/A	N/A	N/A	N/A	N/A	N/A
Czech Republic	1,500,000	10,381,130	144,5	25	30	30	85	10.0
Denmark	414,000	5,475,791	75,6	59	0	41	100	52.0
Estonia	N/A	1,340,935	N/A	N/A	N/A	N/A	N/A	N/A
Finland	500,000	5,300,484	94,3	N/A	N/A	N/A	N/A	N/A
France	6,500,000	63,982,881	101,6	23	<2	>40	65?	10.0
Germany	14,000,000	82,217,837	170,3	82	0	18	100	60.0
Greece	0	11,213,785	0,0	0	0	0	0	0.0
Hungary	27,560	10,045,401	2,7	26	18	41	85	5.0
Ireland	80,000	4,401,335	18,2	15	N/A	N/A	15	1.5
Italy	13,000,000	59,619,290	218,1	N/A	N/A	N/A	N/A	30.0
Latvia	N/A	2,270,894	N/A	N/A	N/A	N/A	N/A	N/A

100 [a], [c], [d], [e], [f] were taken from [EAPA, 2008]
101 Source: Eurostat
102 Unbound layers refer to reclaimed asphalt in the base course which are not bound with bitumen contrary to the top layers
103 Refers to the percentage of the new hot and warm mix production that contains reclaimed material
104 Everywhere in this table, "0?" is an assumption made by BIO in the absence of data suggesting that the expected quantity might be 0 considering the already relatively high percentage of at least one other recovery option.

Country	Available reclaimed asphalt (tonnes) [100]	Population in 2008[101]	Available reclaimed asphalt per capita (kg/capita)	% of available reclaimed asphalt used in hot and warm recycling	% of available reclaimed asphalt used in cold recycling	% of available reclaimed asphalt used in unbound layers[102]	Total recycling and recovery rates (%)	Incorporation rate[103] (%)
Lithuania	N/A	3,366,357	N/A	N/A	N/A	N/A	N/A	N/A
Luxembourg	N/A	483,799	N/A	N/A	N/A	N/A	N/A	N/A
Malta	N/A	410,290	N/A	N/A	N/A	N/A	N/A	N/A
Netherlands	3,500,000	16,405,399	213,3	83	0.50	0?	83.5?	66.0
Poland	1,100,000	38,115,641	28,9	4	N/A	N/A	>4	0[105]
Portugal	N/A	10,617,575	N/A	N/A	N/A	N/A	N/A	N/A
Romania	18,000	21,528,627	0,8	60	10	5	75	15.0
Slovakia	N/A	5,400,998	N/A	N/A	N/A	N/A	N/A	N/A
Slovenia	25,600	2,010,269	12,7	51	49	0	100	N/A
Spain	1,150,000	45,283,259	25,4	48	18	30	96	8.0
Sweden	1,000,000	9,182,927	108,9	65	0?	0?	65?	50.0
United Kingdom	4,000,000	61,179,256	65,4	N/A	N/A	N/A	N/A	N/A
Total for the 14 MS for which recycling rate is available	**30,815,160**	**330,911,148**	**93.1**	**60.4**			**82.9**	
Total for the 18 MS for which reclaimed asphalt data is available	**48,665,160**	**465,328,770**	**104.6**					

[105] Rate indicated by EAPA but seems contradictory with the 4% of available reclaimed asphalt used in hot and warm recycling

As for the production of asphalt waste, the quantities of reclaimed asphalt vary greatly from a MS to another. Romania generates the least amount with only 18,000 tonnes while Germany produces 14 million tonnes of reclaimed asphalt. Germany, France, Great Britain and Italy generated 37.5 million tonnes of reclaimed asphalt in 2008 which represents almost 80% of the total amount generated throughout the EU (around 47 million tonnes). Those figures are more easily comparable when related to the total population. The available reclaimed asphalt per capita ranges from 0.8 (Romania) to 218.1 kg per capita (Italy), with an average of 104.6 kg per capita for EU-27.

The reclaimed asphalt incorporation rates (content of reclaimed asphalt in the new asphalt produced) at the EU-27 level range from 0 to 66%. The highest reclaimed asphalt contents are found in the Netherlands with 66%, then in Germany with 60% and finally Denmark with 52%. In average, Western European countries have higher reclaimed asphalt content rates in hot and warm asphalt mix (41%[106] in average) than Eastern European ones (6%[107] in average). There is thus clearly some potential to recycle more asphalt.

When looking at the total recycling rates, taking into account hot and cold recycling and the material recovery of reclaimed asphalt as unbound layers, a large variability exist between MS when the information is available. Indeed, the recycling rates vary between 0 and 100%, with an average of 82.9% for the 14 countries for which recycling rates are available[108]. Countries such as the Czech Republic, Denmark, Germany, Hungary, the Netherlands, Romania, Slovenia and Spain are already achieving recycling rates superior to 70%. On the other hand, Greece and Poland show the smallest recycling rates with respectively 0 and 4%. The lack of information for other MS does not allow for a complete analysis of the current situation.

6.3. RECOVERY OPTIONS

6.3.1. EXISTING OPTIONS

Landfilling and energy recovery not being recognised as interesting options by the Asphalt Industry because of the associated costs and the loss of a "secondary raw material", the recovery and recycling of reclaimed asphalt have become more widespread in the last decades. If reclaimed asphalt is free of contamination, it can be guaranteed that the total amount of this reclaimed asphalt can be recovered or recycled as a construction material.

Strict guidelines on the nature of the reclaimed material (size distribution, bitumen content, filler content, bitumen viscosity or hardness, etc.) are enforced in the asphalt industry to guarantee good quality end materials.

[106] Belgium, Denmark, France, Germany, Greece, Ireland, Italy, the Netherlands, Spain and Sweden were taken into account. The average was weighted by the amount of reclaimed asphalt available in each country.

[107] Czech Republic, Hungary, Poland and Romania were considered for this calculation. The average was weighted by the amount of reclaimed asphalt available in each country.

[108] The average was weighted by the amount of reclaimed asphalt available in each country.

A distinction is made in the following subsection between recycling, where the reclaimed asphalt is reprocessed into new mixes, and other forms of material recovery.

- **Recycling**

Recycling means adding the reclaimed asphalt to new asphalt mixes, with the aggregates and the old bitumen performing the same function as in their original application. Therefore, reclaimed asphalt replaces virgin aggregates and part of the binder. If asphalt is known as 100% recyclable material, the recycling rate depends on the applied technique.

The recycling processes can be divided into two major methods: hot or cold mix recycling techniques. These can be further sub-divided into stationary plant or in-situ recycling. Stationary plant recycling (or “Offsite recycling”) consists in removing the material from the site to a plant located elsewhere which recycles the reclaimed asphalt in order to re-introduce it either on the original project or on other projects. In-situ recycling allows the reclaimed material to be incorporated directly back into the new asphalt pavement under construction or maintenance.

The recycling options that are further described in this chapter are available since 1975 and are considered at the point of being able to deal with the current amount of recycled asphalt.

Within both the cold and hot recycling process, screening and crushing of the reclaimed asphalt could be needed and special storage facilities at the mixing plant may be necessary. Modern plants are engineered to facilitate the addition of reclaimed material.

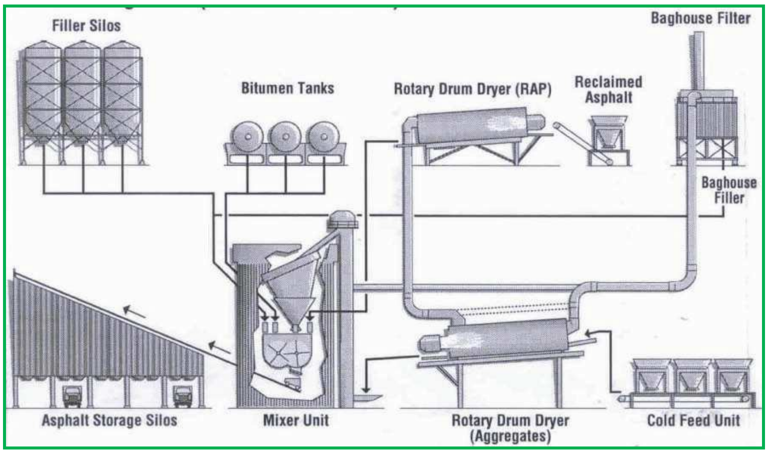
The maximum amount of recycled material that can be incorporated in the new mix is determined by the mixing equipment but also by some parameters related to the old asphalt like consistency of material, moisture content, etc. To achieve the highest levels of recycling it is necessary to either confirm the lack of variability in the feedstock or to have precise data on its range of properties. The requirements for reclaimed asphalt are formulated in the European Standard EN 13108-8 “Reclaimed asphalt”.

The difference between the cold and hot recycling methods only relies on the process to heat reclaimed asphalt pavement (RAP).

- **Hot mix recycling in a stationary plant**

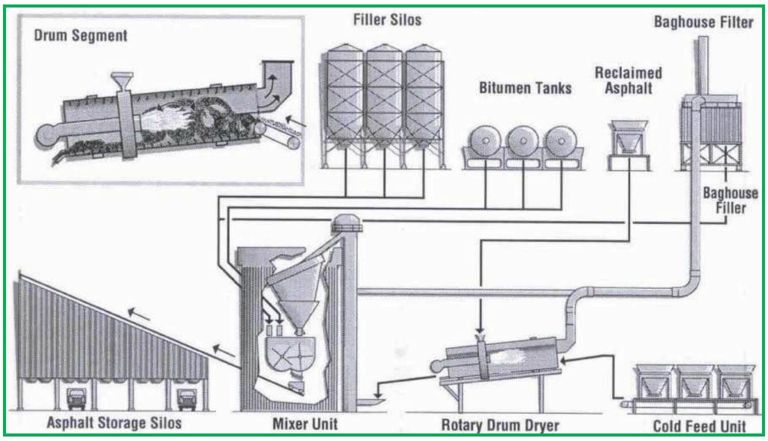
In the case of the “hot method” in a hot mix recycling stationary plant, the reclaimed asphalt pavement (RAP) taken from demolished or renovated roads in general is transported to the asphalt plant. After being crushed and sieved (if needed), the RAP is directly preheated which requires an extra dryer (a dryer being already used to heat the virgin aggregates that are then incorporated into the asphalt mix). Incorporation rates for the hot method are typically **30-80%**, the upper limit being determined by the quality requirements of the mix specification in relation to the properties of the old asphalt.

Figure 3 - Batch mixing plant for the hot RAP method [EAPA, 2005]



A variation of the hot recycling is feeding the RAP into the same dryer as for virgin aggregates (method called recycling ring). The heating of the RAP takes place behind the flame, ensuring that it is not overheated. This method allows up to **35%** incorporation rate. It is possible to use a recycling ring in combination with a rotary drum dryer achieving incorporation rates up to **50%.**

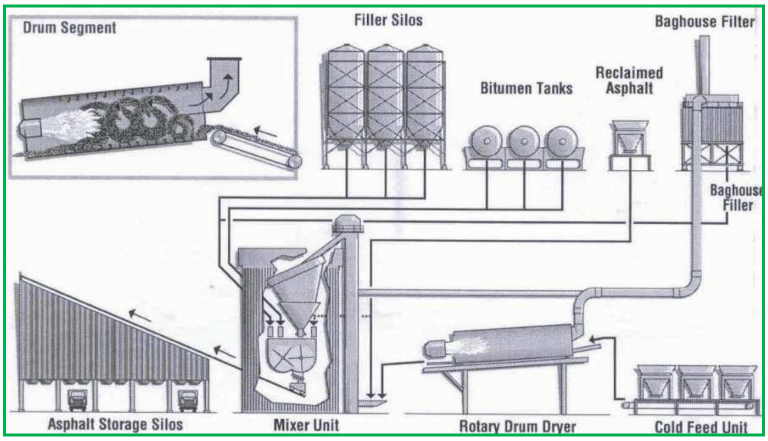
Figure 4 - Batch mixing plant: recycling via a recycling ring [EAPA, 2005]



- **Cold method in hot mix recycling in a stationary plant**

As for hot method, reclaimed asphalt is crushed and screened (if needed) so as to produce a consistent feedstock. The difference between hot and cold methods in hot mix recycling relies on the process to heat RAP: in the first case a specific dryer is needed while in the other case reclaimed asphalt is heated through the contact with heated virgin aggregates. In both cases, the reclaimed asphalt is used to produce new hot mix asphalt. The appropriate amount of new bitumen is then added in the mixing unit according to desired end properties.

Figure 5 - Batch mixing plant for the cold RAP method [EAPA, 2005]



Cold methods in hot mix recycling achieve incorporation rates between **10 and 40%**, depending on the RAP moisture content and quality, the type of the plant's vapour extraction system and the technical process limitations regarding maximum permitted temperatures. Modifications to the plant are needed if quantities of more than approximately 10% of old asphalt are to be added to the mixing process.

Though tar is not used anymore in road construction, amounts of asphalt containing tar[109] can still be reclaimed when renovating old roads. In this case, the waste is considered hazardous and the hot recycling is not allowed. In some countries however, it is allowed to rely on cold techniques with or without binders.

Cold mix recycling technologies in a stationary plant

The cold mix technology is a recent development that had been used for several years already.

Reclaimed asphalt is returned to off-site plants with the same controlled crushing and screening process as for hot mix recycling. The similar requirements of the feedstock for hot and cold mix plants make it feasible to operate both processes on the same location.

Two types of binder, foamed bitumen and bitumen emulsion, have been used combined with the recycled asphalt. Both methods are able to produce materials with 90% recycled asphalt content.

It is important to notice that the final engineering properties may in some cases be inferior to that of hot mix, but in others cases when using end-product specifications it can be at least equal.

[109] The definition of "asphalt containing tar" can differ from a country to another because there are different limits among MS depending on the national legislation. The definition in the EURAL waste list classifies reclaimed asphalt containing more than 0.1 % coal tar as hazardous waste.

The smaller number of components and less complex nature of cold mix plants has led to their successful adoption when needed in remote locations for short-term reconstruction programs.

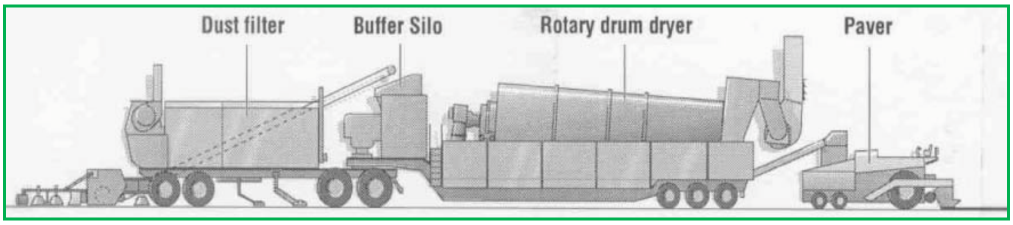
- **Hot mix in-situ recycling**

In some cases, the location of a given project does not make it feasible to return reclaimed material to a plant for recycling. Therefore, in-situ recycling techniques have been developed to address this issue. Nevertheless, the use of this technique throughout the EU is mostly limited as a maintenance tool of road works.

This technique involves the same process as for the hot mix recycling in a stationary plant while avoiding the transportation step. The existing pavement is partly removed to a controlled depth (not to disturb the sub-course), then the RAP is heated and mixed before bitumen and/or virgin aggregates could be added. Finally, the reclaimed mixture is laid back at its original place, creating a new asphalt surface course.

Among other advantages there is the reduction in RAP transportation to an off-site recycling facility and the rapid re-opening of a new road surface.

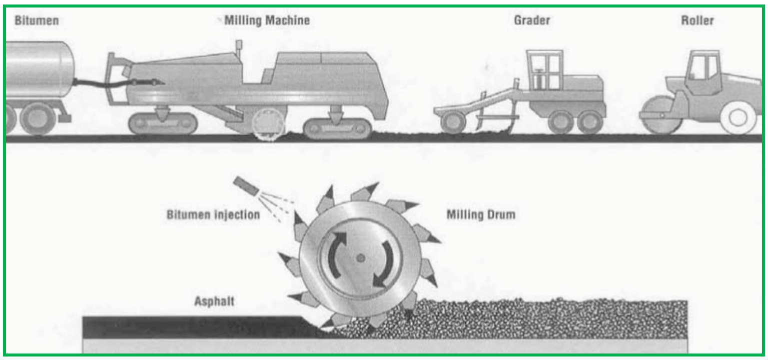
Figure 6 - Asphalt recycling travel plant [EAPA, 2005]



- **Cold mix in-situ recycling**

The cold mix in-situ system is comparable to the hot one except to the way bitumen is added. Indeed, bitumen is foamed thanks to an improved milling machine. The existing pavement is sprayed in a chamber in which the bitumen is foamed and mixing takes place. The recycled pavement is then spread ready for compaction and the application of a new running surface.

Figure 7 - Cold-mix recycling [EAPA, 2005]



It should be noted that the cold in-situ recycling is a method of recycling where no newly produced asphalt is used.

The following table summarises data regarding the number of stationary and mobile plants available throughout the EU and the number that are able to deal with reclaimed asphalt for the hot recycling method. Stationary plants represent the majority with more than 3,720 (almost 90% of the total 4,142 recycling plants) while only 422 mobile plants exist. Considering the facts that not all production sites are able to re-introduce reclaimed asphalt in the manufacturing process and that both hot and cold recycling methods can be operated in the same plants, these figures show a great potential adaptation of existing plants through investments.

Table 22 - Number of production sites and number fit for hot recycling [EAPA, 2008]

Country	Stationary plants	Mobile plants	Number fit for hot recycling
Austria	116	1	40
Belgium	40	0	23
Bulgaria	N/A	N/A	N/A
Cyprus	N/A	N/A	N/A
Czech Republic	110	3	70
Denmark	42	2	46
Estonia	10	15	6
Finland	64	25	44
France	434	79	150
Germany	665	N/A	620
Greece	240	10	0
Hungary	68	11	42
Ireland	58	15	15
Italy	650	10	280
Latvia	18	1	N/A
Lithuania	39	1	21
Luxembourg	4	0	2
Malta	N/A	N/A	N/A
Netherlands	45	0	45
Poland	280	20	2
Portugal	15	110	20
Romania	N/A	N/A	N/A
Slovakia	41	0	9
Slovenia	19	2	N/A
Spain	379	104	29
Sweden	83	13	65
United Kingdom	300	N/A	N/A
Total/average EU-27	**3,720**	**422**	**1,529**

■ **Other forms of material recovery**

Material recovery refers to the utilisation of reclaimed asphalt as road base course material, with the recovered aggregate and bitumen performing a lesser function than in the original application.

To this end, reclaimed asphalt has to be crushed and sieved into different fractions for more accurate mix designs.

6.3.2. Emerging techniques

Further research to develop new techniques or to improve the efficiency of the existing processes by using for example less energy and reducing the operating costs could contribute to increasing recycling rates.

For instance, some current internationally coordinated research projects are aiming for further improvement of the technology cold mixing in-situ recycling[110].

6.4. Environmental and economic impacts of asphalt waste management

6.4.1. Environmental and health impacts

The following table summarises the impacts and benefits of the different end of life options for asphalt, which are further detailed below.

Table 23 – Impacts and benefits for each option for the management of asphalt

LANDFILL

Direct impacts	Avoided Impacts	Net benefits
Transportation of waste to the landfill Potential PAH releases to water (when contaminated with tar) Use of land space		-

[110] [EAPA, 2005]

RECYCLING IN A STATIONARY PLANT TO MAKE NEW ASPHALT

Substituted material (in the same proportion): aggregates from sand, stone and gravel extracted from quarries

Direct impacts	Avoided Impacts	Net benefits
Transportation of waste asphalt	Extraction of raw materials (sand, stone and gravel): land-use for quarries, production of dust, use of natural resources, biodiversity Transportation of raw materials	
Processing of waste asphalt into aggregates: particles generation and noise during crushing and screening steps Production of new asphalt from reclaimed asphalt: fuel consumption for heating and associated greenhouse gases emissions (the energy consumption may be lower for the cold mix recycling method as the fuel consumption associated with the extra dryer of the hot mix recycling method is avoided) Transportation of recycled asphalt	Processing of raw materials into aggregates: dust production and noise Production of asphalt from raw materials: fuel consumption for heating and bitumen production, and associated greenhouse gases emissions (the energy consumption may be lower for the cold mix method as the required temperature is lower that for the hot one, avoiding an extra fuel consumption) Transportation of asphalt made from virgin materials	+

IN-SITU RECYCLING TO MAKE NEW ASPHALT

Substituted material (in the same proportion): aggregates from sand, stone and gravel extracted from quarries

Direct impacts	Avoided Impacts	Net benefits
Processing of waste asphalt into aggregates: particles generation and noise during crushing and screening steps Production of new asphalt from reclaimed asphalt: fuel consumption for heating and associated greenhouse gases emissions Use of binders for fluxed asphalt in cold recycling processes	Extraction of raw materials (sand, stone and gravel): land-use for quarries, production of dust, use of natural resources, biodiversity Transportation of raw materials Processing of raw materials into aggregates: dust production and noise Production of asphalt from raw materials: fuel consumption for heating and associated greenhouse gases emissions Transportation of asphalt made from virgin materials	+

RECOVERY OF RECLAIMED ASPHALT AS A ROAD BASE COURSE IN THE FORM OF AGGREGATES

Substituted material (in the same proportion): aggregates from sand, stone and gravel extracted from quarries

Direct impacts	Avoided Impacts	Net benefits
Transportation of reclaimed asphalt Processing of waste asphalt into aggregates: dust production and noise during crushing and sieving steps (not relevant when the material is resulting from milling operations, therefore meeting the size requirements) Transportation of recycled aggregates	Extraction of raw materials (sand, stone and gravel): land-use for quarries, production of dust, use of natural resources, biodiversity Transportation of raw materials Processing of raw materials (rocks, stone, gravel, sand) into aggregates: dust production and noise Transportation of virgin aggregates	+

Direct impacts of landfilling

According to the EAPA[111], asphalt pavement (new or containing reclaimed asphalt) does not leach significantly. Therefore the major environmental impact is the use of land space, as for the other studied fractions.

However, a potential complicating factor may be the presence of contaminants such as tar[112], whose higher concentrations of PAH's (polycyclic aromatic hydrocarbons) and/or phenol content and associated effects on human health (carcinogenic) led to the end of its use. Although it has been replaced entirely by bitumen for asphalt mixes in Europe, it may still be encountered in various proportions in some areas when old pavements are removed. In this case, RAP is classified as hazardous waste and must be managed according to the European legislation.

Direct impacts of recycling

For both recycling in a stationary or mobile plant, reclaimed asphalt might have to go across the crushing and screening steps before being reintroduced into the manufacturing process. This is expected to produce particles and may raise health concerns if the machinery is not covered. However, these impacts are also related to the processing of raw materials. Moreover, when the reclaimed asphalt is obtained from milling operations (by a milling machine) the particle size might be the right one and then no additional crushing is needed.

The direct impacts of transportation are highlighted only when RAP is being sent back to asphalt manufacturer (i.e. for recycling in stationary plants). Fuel consumption and greenhouse gases emissions are comparable to the ones associated with the transportation of raw materials.

Direct impacts of material recovery

They are similar to the ones developed in the above subsection: related to transportation of both reclaimed asphalt and recycled aggregates and the production of particles and noise. These impacts are estimated to be the same as for virgin aggregates.

Net benefits of recycling and material recovery

Recycling of reclaimed asphalt allows saving natural resources that would have been extracted in quarries and limiting the transportation when they are located in remote places. Bitumen being also re-used, unnecessary bitumen production is also avoided. This reduces the fuel and energy consumption related to the extraction step and the production of bitumen, which therefore limits the emissions of greenhouse gases.

Indeed, the carbon footprint for recycled asphalt is lower than for asphalt made of virgin materials. The equivalent carbon dioxide indicator is 1.25 kg CO_2 equivalents per tonne of

[111] Interview with Mr Egbert Beuving, Director of the EAPA
[112] Tar is the result of the distillation of coal, while bitumen is the result of the distillation of crude oil.

asphalt per annum for a 40-year old asphalt pavement made of virgin materials while it is 0.7 kg CO_2 equivalents per tonne of asphalt containing reclaimed asphalt (divided by almost 1.8).

The net benefits for in-situ recycling could be assumed higher than for a stationary plant or recovery as transportation to the recycling plant and to the construction site are avoided. However, this is of limited importance since transportation only represents 6% in the carbon footprint balance because both extracted materials and reclaimed asphalt are available locally. The benefits would therefore come almost entirely from the extraction step that is assumed to be energy intensive and generate greenhouse gases.

6.4.2. Economic impacts

The processes for the preparation of reclaimed aggregates (crushing, sieving) being the same as virgin materials, the production costs are estimated to be identical. On the other hand, the availability of virgin aggregates explains why the supply costs for these materials are limited which therefore does not encourage asphalt producers to turn to reclaimed asphalt as a substitution. However, landfilling and incineration for energy recovery are not considered as viable asphalt management options according to the industry as asphalt is an added-value material that is easily recycled thanks to the existing techniques[113].

6.5. Towards the 70% target: Drivers and barriers

As shown in the above sections, 8 MS are already achieving recycling rates over 70%, while 2 others (Belgium and France with respectively 55% and 65% recycling rates) are getting closer. Therefore, asphalt waste shows great potential for recycling for MS with low recycling rates (Poland and Greece) and those for which data is not available. In addition to the environmental benefits developed in the above section, asphalt producers can also find in developing recycling options economic benefits due to the avoidance of unnecessary landfill and energy recovery costs, as well as saving costs related to virgin aggregates purchase. The barriers and drivers identified by the experts interviewed are further described below.

- **Investments**

Asphalt recycling plants need to be modified to be able to introduce more reclaimed material in the manufacturing process. Moreover, the improvement of the recycling rates and the efficiency of the process (reducing the energy consumption would reduce the costs of recycled material) goes hand in hand with scientific research. All these actions represent substantial investments that may require financial support.

[113] Interview with Mr Egbert Beuving, Director of the EAPA

- **Increasing cost of virgin materials: a driver towards the systematic use of reclaimed asphalt**

Even if the availability of virgin materials is not yet the issue, the increasing cost of virgin materials would push asphalt producers to turn to reclaimed asphalt as a secondary raw material. This would create a demand and economic opportunities that would drive the improvement of recycling rates.

- **Landfilling ban: a driver towards the systematic recycling of reclaimed asphalt**

Though landfilling is not commonly practiced for asphalt waste, a landfilling ban (as already enforced in the Netherlands) or high landfill taxes would therefore lead to higher amounts to be managed by waste producers and asphalt manufacturers. The expected direct effect is the shift towards the obligation of applying the existing recycling techniques that are readily available to deal with important amounts of reclaimed asphalt.

- **Increasing the communication to asphalt producers to promote recycling**

Even though asphalt producers are well aware of the economic benefits that can come from recycling RAP in certain parts of Europe, a better communication from national environmental agencies towards the Asphalt Industry would highlight such benefits in other countries. A way of delivering this message would be the organisation of workshops and conferences where asphalt producers would measure the benefits in practical and economic terms.

Finally, it should be noted that the name “asphalt waste” does not stimulate the use of reclaimed asphalt. The word waste is mostly associated in a negative way. Indeed, using waste in the production of new products is often seen as a potential problem. Considering reclaimed asphalt as a product, as aggregates, would stimulate its re-use and recycling.

- **Presence of contaminants preventing recycling**

Before the use of asbestos was prohibited, asbestos fibres were used in the production of asphalt. This was for example the case in France before 1997, and this raises the issue of recycling asphalt that was produced before this date: difficulties linked to the identification of asphalt containing asbestos were raised by some experts[114].

[114] Laurent Chateau, ADEME, comments on the draft final report

7. Material focus: WOOD

Applications in the construction sector	Roof structure, building framework, floors, doors, etc.
Production in the EU-27	Total production value: **268.4 billion Euros** (2007) - Furniture industry accounts for **48%** - Construction Sector accounts for **20%** Estimated consumption of construction wood in EU-27: **41.5 million tonnes**[115]
Waste generation in the EU-27	Total amount of waste generated within the EU-27: **70.5 million tonnes** (2004) Estimation for C&D wood waste: **10-20 million tonnes generated/year** [116]in the EU-27

Treatment options	**Landfill**	**Recycling into derived timber products**	**Energy recovery**
Current rates	**35%**	**31%**	**34%**
Potential rates	N/A	N/A	N/A
Environmental impacts	**Production of methane (CH_4)** land use, transportation	**Positive net benefits** due to the avoidance of logging and the release of CO_2 to the atmosphere (associated to fossil fuel consumption and the carbon sink) and the exploitation of natural resources.	**Positive net benefits** due to the avoidance of CO_2, particulates, VOCs (volatile organic compounds), PAHs (polycyclic aromatic hydrocarbons) release to the atmosphere. The produced heat can be used in cogeneration (produce electricity and provide public buildings, plants or homes with heat)

Barriers to re-use and recycling of the waste	- Competition between energy recovery and material recovery - Contamination with hazardous substances
Existing and potential drivers to re-use and recycling of the waste	- Collection schemes for C&D wood waste - Efficient sorting of the waste stream

[115] Extrapolated from UK data (WRAP, 2009)
[116] Based on various estimates provided by [JRC, 2009]and [WRAP, 2009]

7.1. Product description and applications

More that 50% of the worldwide supply of wood is used as firewood or for the production of charcoal (energy use). Only less that 50% is available for industrial use which includes[117]:

- Paper (printing, packaging, cardboard and newspaper)
- Sawn wood
- Panels and fibreboards
- Sawdust

In the construction sector, wood is used in a wide variety of products:

- Roof structure
- Building framework
- Wooden floor and terrace
- Wood beams to sustain construction frameworks
- Kitchens, doors

7.2. Quantitative analysis

7.2.1. Production data

In 2007, overall production value in the EU woodworking industries reached 268.4 billion Euros. Extra-EU imports and exports are relatively small (respectively 25.6 billion Euros and 22.6 billion Euros in 2007) [CEI, 2007]. This production value has grown steadily over the past few years; as a result the apparent consumption within EU-27 is close to the production value of the sector.

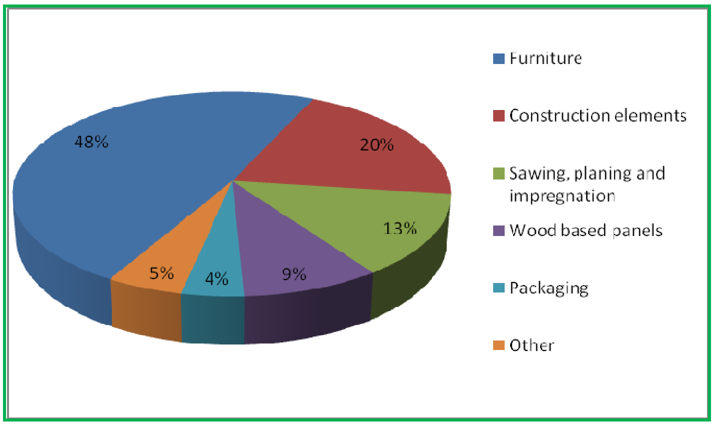
[117] [JRC, 2009]

Table 24 – Production of the woodworking industry in the EU in million Euros between 2003 and 2007 (Source: The Woodworking Industry in the European Union in 2007, CEI Bois & European Panel Federation)

	2003	2006	2007	Growth rate 2003/2007	Growth rate 2006/2007
Sawmilling of wood	27.550	34.200	37.522	36,2%	9,7%
Manufacture of wood-based panels	19.085	23.732	25.168	31,9%	6,1%
Manufacture of other builders' carpentry and joinery (construction elements)	41.813	47.500	53.050	26,9%	11,7%
Manufacture of wooden packaging	8.114	9.967	10.995	35,5%	10,3%
Manufacture of other products of wood	12.219	11.386	12.142	-0,6%	6,6%
Subtotal	108.781	126.785	138.877	27,7%	9,5%
Manufacture of furniture	106.852	121.091	130.024	21,7%	7,4%
Total	215.633	247.876	268.901	24,7%	8,5%

The following diagram illustrates the share of each subsector to the production of the woodworking industries in 2007:

Figure 8 – Relative importance of the subsectors in the production of 2007 [CEI, 2007]



The share of the furniture industry accounted for 48% of the total woodworking industries production value in 2007. Within the other branches of the woodworking industry, the construction elements sector is a leading subsector, accounting for 20% of the total.

No European statistics on the consumption of wood products by the construction sector was identified. In the UK alone, WRAP estimated that the construction industry consumes approximately 5.1 million tonnes of wood per year. A population based extrapolation allows an estimation of construction wood consumption of about **41.5 million tonnes per year in EU-27**[118].

7.2.2. WASTE GENERATION AND TREATMENT DATA

The total amount of waste wood generated at the EU-27 level is estimated at 70.5 million tonnes in 2004, among which 45.7 million tonnes were recycled directly or in energy recovery processes (65% recycling)[119]

Among this stream, the JRC recognises that current statistical data do not allow for a precise allocation of this waste flow to C&D waste. Indeed, wood separately collected from C&D waste (category 17 02 01 of EWC) is reported to EUROSTAT along with other wood waste, making the allocation impossible due to the aggregated data basis. The JRC therefore proposes an estimation of **9,757,000 tonnes of C&D waste wood** (14% of the total waste wood generated).

However, these figures are probably underestimated. A market survey performed in 2008 by WRAP in the UK indicates that the wood waste arising from the C&D sector accounted for 2,321,900 tonnes per year, representing over 50% of the total wood waste generated[120]. A (population-based) extrapolation of these figures to the EU-27 would give an estimated **18,887,000 tonnes** of C&D wood waste.

Best available data therefore leads to an estimation of C&D wood waste generation ranging from **10 to 20 million tonnes per year in the EU-27**.

Even though we are considering C&D waste as one and only stream, the C&D activities produce quite different types of waste. Construction generates off cuts from structural timbers, timber packaging, scaffolding, and wooden hoardings while demolition produces used structural timbers, e.g. floorboards, joists, beams staircases and doors[121].

The destination of the waste is presented in the following table.

Table 25 – Treatment of wood waste (incl. C&D wood waste) in the EU-27 in 2004 (Source: JRC 2009)

Treatment option	% of wood waste generated
Recycling	31%
Energy recovery	34%
Disposal (landfill or incineration w/out energy recovery)	35%

65% of the wood waste generated in Europe was therefore estimated to be recovered (as material or energy).

[118] EUROSTAT population data was used to perform this extrapolation.
[119] [JRC, 2009]
[120] [WRAP, 2009]
[121] [WRAP, 2005]

As waste from the wood sorting process is relatively low (5% of the amount entering sorting facilities), there is a certain potential of improvement through a more systematic source separation and collection of wood waste. Extrapolating from the above figures, if all wood waste was correctly sorted, respectively up to **45% and 50%** of wood waste would be recycled and incinerated with energy recovery.

The suitability of wood waste for recycling depends on its level of contamination. The following categories are usually distinguished:

- Untreated lumbers
- Coated lumbers with surface coating not containing organohalogen compounds
- Coated lumbers with surface coating containing organohalogen compounds
- Lumbers treated with timber preservative

Recycling is suitable only for the first two categories; the only option for the other types of wood is energy recovery in specialised plants meeting high standards for emission control.

In 2004, around 15% of the waste wood generated in the EU-27 was classified as hazardous waste.

7.3. RECOVERY OPTIONS

7.3.1. EXISTING OPTIONS

The main existing options for recovery are the following:

- Energy recovery
- Recycling in the production of derived timber products
- Other forms of material recovery: landscaping, animal bedding, equestrian surfaces, composting, etc.

Before the recovery of wood waste, pre-treatment steps are usually required.

Pre-treatment

The pre-treatment applied to bulk C&D wood waste are the following[1]:

- Manual sorting to remove contaminants
- Single-stage, two-stage or three-stage crushing
- Segregation of ferrous and non-ferrous materials (by magnets or cyclones)
- Segregation of minerals like concrete through sieving
- Segregation of light-weight elements like plastics through single-stage or multi-stage air sieving

Energy recovery

Ways to obtain energy from wood waste can be:

- In small heating systems
- In heating systems requiring authorisation
- In facilities for gasification
- In facilities for the production of cement and cement clinker
- In municipal waste incinerators

Energy recovery is, most of the time, the only option available for wood waste contaminated with hazardous substances. Moreover, it is encouraged by European (Directive on the production of electricity from renewable energy sources) and national policies on renewable energies.

Recycling into derived timber products

In the past few years, the wood recycling has known improvements along with the development of companies dedicated to this activity. C&D wood waste can be remanufactured into high added-value products such as medium density particle boards or fibreboards or even wooden plastic that can contain a high proportion of recycled materials.

This application is by far the main application for recycled wood. Latest UK data (2007) show that wood panel manufacturers use 58% of the wood waste in the UK.

The particle board production in the EU-27 is estimated[122] to be around 30 million m^3. 1m^3 of particle boards necessitating 0.65 tonnes of wood on average, 19.5 million tonnes of wood are needed each year to sustain the European production of particle boards. The share of post-consumer recycled wood input into this production shows high geographical differences (from 20% in France to 80% in Italy), and is estimated to reach 24% on average[122] (5 million tonnes). This represents **25% to 50%** of the C&D waste wood generated in Europe. This estimation is in line with the average EU-27 recycling rate of 31% proposed by the JRC (see 7.2.2.

Other forms of material recovery

Other forms of recovery of non-contaminated wood waste include:

- Landscaping, where recycled wood can be used as decorative mulches, surface material for pathways, or impact absorbing playground surfaces
- Equestrian surfaces, for both indoor and outdoor arenas
- Animal bedding products

[122] [EPF, 2010]

The extent of such applications in the EU is currently unknown. However, WRAP's study shows that the production of animal bedding and equines surfaces is the third most important end user industry of recycled wood.

7.3.2. Emerging techniques

- **Colour indicator techniques to detect contamination of wood waste**

The potential contamination of wood waste with hazardous substances is a key factor to determine whether this waste is suitable for recycling or other forms or material recovery, or has to be incinerated in specialised plants. Research has been done in order to facilitate the detection of contaminated wood waste and the effective sorting of the waste stream. An example of this is the set of methods published by WRAP on colour indicator techniques to detect contamination of wood waste with wood preservatives or copper.

- **Re-use**

Wood from buildings reaching their end of life can be directly re-used when proper deconstruction methods have been implemented. This could be encouraged by the increasing market demand for large dimensions building pieces. Nevertheless, these practices seem very marginal at the moment.

7.4. Environmental, economic and social impacts of wood waste management

7.4.1. Environmental impacts

The following table summarises the impacts and benefits of the recycling and recovery options of waste wood, which are further described below.

Table 26 – Impacts and benefits for each option for the management of wood waste

LANDFILL

Direct impacts	Avoided Impacts	Net benefits
Transportation of wood waste to the landfilling site Release of methane to the atmosphere (except when burnt in flare for its complete combustion, therefore replaced by CO_2) Use of land space		--

ENERGY RECOVERY

Substituted material: fossil fuels or any other source of energy (depending on the country)

Direct impacts	Avoided Impacts	Net benefits
Transportation of wood waste to the incineration plant	Energy consumption based on fossil fuels resources (energy recovery from wood waste is encouraged and considered as a renewable energy) as the heat produced can be used to heat surrounding buildings or to produce electricity.	+
No release of pollutants the air thanks to appropriate air control equipment and dust filters	Release of CO_2, particulates, VOCs (volatile organic compounds), PAHs (polycyclic aromatic hydrocarbons) compared to other material incineration.	

RECYCLING INTO DERIVED TIMBER PRODUCTS

Substituted material (in the same proportion): aggregates from rocks and gravel extracted from quarries

Direct impacts	Avoided Impacts	Net benefits
Transportation of waste wood to wood manufacturers	Exploitation of forests: energy consumption for logging and associated greenhouse gases emissions (or release considering that trees act as carbon sinks) Transportation of virgin wood to the manufacturing plant (may be substantial when considering tropical wood from South America or South East Asia)	+
Production of timber products from waste wood: energy consumption for the cleaning, cutting, crushing steps, noise production	Production of timber products from wood: energy consumption for the cleaning, cutting, crushing steps, noise production	

- **Impacts of landfilling**

As for other organic materials, landfilling of C&D wood waste leads to emissions of methane which is a greenhouse gas showing a global warming potential of 72 over 20 years, while carbon dioxide's is 1. Moreover, landfill of wood is associated with the unnecessary use of land and may lead to the contamination of the water table in the case the contaminated fractions has not been properly removed or isolated from the environment. The sources of contamination come from the surface chemicals that are used as glue, varnish, coating or wood preservatives to increase the material durability.

- **Impacts of energy recovery**

Both Directive 2001/77/EC on the production of electricity from renewable energy sources and the Renewable Energy Directive favour the recycling market of waste wood and in particular C&D waste wood.

- **Impacts of recycling into derived timber products**

Compared to incineration, recycling of C&D wood waste allows avoiding the production of particulates, carbon monoxide and various volatile organic compounds, i.e. PAHs, from the inefficient burning of wood. These hazards should however be limited when incineration takes place in a plant compliant with the Waste Incineration Directive.

To ensure good quality products made from secondary wood, the standard limits for toxic elements in recycled wood are the same as for raw materials. The limit values of chemical contamination in supplied material have to comply with existing regulations and are summarised in the following table.

Table 27 - Chemical contamination limits for recycled wood use [EPF, 2002]

Elements/Compounds	Limit values (mg/kg recycled)
Arsenic (As)	25
Cadmium (Cd)	50
Chromium (Cr)	25
Copper (Cu)	40
Lead (Pb)	90
Mercury (Hg)	25
Fluorine (F)	100
Chlorine (Cl)	1000
Pentachlorophenol (PCP)	5
Creosote (Benzo(a)pyrene)	0.5

For C&D wood waste that show contamination rates below the standards, surface treatments have to be realised to scrap the contaminated surface and to be able to use it as a secondary material.

The recovery of C&D wood waste allows saving natural resources even if nowadays wood is considered as renewable resource and that forestry is supervised within European countries where cut trees are replaced for a sustainable exploitation. Unfortunately, that is not always the case for tropical woods that are imported on the European market.

7.4.2. Economic impacts

Due to the competition of utilisation and the limited supplies, the market price for recycled wood is going up. The margin of the market price is influenced by the following elements:

- The regionally available amount of waste wood
- The intensity of the competition between material and energy recovery
- Seasonal variations (winter stock etc.)

In Germany for example, prices for waste wood differ not only depending on the type of wood but also between regions. Therefore, average prices only give some orientations. For highly contaminated waste wood, the distributor even has to face additional costs for proper disposal and/or special treatment (negative values in the following table).

Table 28 – Average prices range for selected waste wood fractions in Germany [JRC, 2009]

Waste wood categories	Average prices in €/tonne between July 2002 and July 2007
Non treated waste wood – wood chips	22 to 28
Pre-treated waste wood – prefolding (0-300 mm)	- 4 to +4
Non-treated waste wood – prefolding (0-300 mm)	14 to 18
Contaminated waste wood – wood chips (0-150 mm)	-20 to +9
Pre-treated waste wood – wood chips (0-150 mm)	5 to 13
Contaminated waste wood – prefolding (0-300 mm)	-34 to -2

In general, the prices for sorting, storage and treatment of specific waste wood fractions are not an incentive to the development of waste wood recovery.

7.5. Scenario towards the 70% target: Drivers and barriers

Recycling could be improved by measures by the MS to promote efficient sorting of C&D wood waste to avoid contamination, to make greater amounts of wood waste available for the industry and as a consequence achieve better recovery rates from C&D wood waste.

As a result of the European strategy of security and sustainable energy and the Landfill Directive, the use of waste wood for either material or energy recycling are expected to play a dominant role in wood waste management and stimulate the competition between material recycling and energy recovery. However, incentives to use waste wood as a renewable energy source might hinder the 70% recycling target, as energy recovery is not included in the target. This issue is amplified in countries where wood represents an important fraction of the C&D waste stream (e.g. northern European countries).

8. Material focus: GYPSUM

Applications in the construction sector	Buildings
Production in the EU-27	Total: about **44 Mt** - Natural gypsum (extracted): about 28,878 Mt (2008) - Synthetic gypsum: 15,200 Mt (2005 forecast for EU-25)
Waste generation in the EU-27	A minimum of 4 Mt

Treatment options	**Landfill**	**Recycling into new plasterboards**	
		In substitution of natural gypsum	**In substitution of synthetic gypsum**
Current rates	Gypsum demolition waste: 100% Gypsum construction waste: N/A	Gypsum demolition waste: **n/a**[123] Gypsum construction waste: estimation of **3 to 10%** of waste gypsum from plasterboards	
Potential rates	N/A	**25 to 30%** of waste gypsum from plasterboards	
Environmental impacts	Production of the toxic gas H_2S if plasterboards are landfilled in inert landfills (EU legislation requires specific cells in inert landfills to avoid H_2S emissions but implementation is not always correct) Land-use, transportation	**Few significant net benefits** Potential energy and local pollution savings in dense areas (shorter transportation) Resource use Avoiding extraction activities (land use and biodiversity)	**Higher net benefits** (a higher energy consumption is associated to the manufacturing of plasterboards from synthetic gypsum due to its higher moisture content)

Barriers to re-use and recycling of the waste	- High availability and low cost of raw material - Selective deconstruction techniques are already designed but are not implemented because too costly - In most countries, landfill taxes are too low to encourage the development of recycling - Export of gypsum wastes for backfilling (e.g. former salt mines in DE) - The manufacturing processes currently do not allow the re-introduction of a higher recycled gypsum powder content
Existing and potential drivers to re-use and recycling of the waste	- Sorting at the construction site and at the demolition phase of a building to increase the quantity of C&D waste to be recycled. At the demolition phase, deconstruction should be encouraged (also financially) instead of demolition - Characterisation of gypsum waste: specifications for recycled gypsum - Collection systems to collect a higher amount of gypsum waste - R&D to adapt the manufacturing processes in order to allow the re-introduction of a higher recycled gypsum powder content - Higher and harmonised landfill taxes across the EU to push for other alternatives - Availability of public amenity sites/public waste recycling centres

[123] Current deconstructed buildings contain plaster but not plasterboard (as many buildings over 40 years old in Europe contain little plasterboard). Plaster is uneasy to recycle due to the fact that it sticks to the bricks. It then goes to mixed C&D waste inert landfills. Therefore, current recycling rates are low.

8.1. PRODUCT DESCRIPTION AND APPLICATIONS

There are two types of gypsum: natural gypsum (which is directly extracted) and synthetic gypsum.

Gypsum[124] is a rock-like mineral commonly found in the earth's crust and produced from open-cast or underground mines. In Europe, the principal gypsum deposits are located in France, Germany, Italy, Poland, Russia, Spain, the UK and Ukraine[125]. Gypsum is generally screened to remove 'fines' (mainly mudstones), then crushed and finely ground.

Gypsum is used mainly in the manufacture of non load-bearing building elements for setting the ceiling on and dividing the interior space. The gypsum industry is therefore principally driven by the construction activity and the demand for new and refurbished housing.

Gypsum based applications range from complex high-tech systems to easy to install products:

- Plasterboard: used for partitions and the lining of walls, ceilings, roofs and floors. The properties of plasterboard can be modified to meet specific requirements, such as fire resistance, humidity resistance, shock resistance, etc. More than 1.6 million m^2 of European interior surfaces are covered with plasterboards every year.
- Decorative plaster: plaster powder, mixed with water, manually or through the use of silo-supplied spray systems, is used to create lining for brick, block walls and for ceilings. More than 5 million tons of plaster is used in Europe for interior lining.
- Building plaster: used for walls and ceilings.
- Plaster blocks: used for partitions and gypsum tiles for ceilings. More than 20 million m^2 of European interior walls are separated using plaster blocks.
- Gypsum based self levelling screeds: anhydrite or alpha-Hemihydrates are used in the production of self-levelling floor screeds.
- Gypsum fibreboards: used for partitions and the lining of walls, ceilings, roofs and floors. Standard gypsum fibreboard offers good performance when it comes to shock resistance, sound insulation and humidity resistance.

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[124] Natural gypsum is formed geologically from the evaporation of seawater. It is composed of calcium sulphate (calcium, sulphur, and oxygen) with two molecules of water, CaSO4.2H2O. Gypsum is usually white, colourless or gray, but can also be shades of red, brown and yellow. When calcined, it is partially dehydrated and becomes a white fine powder called Anhydrite or more commonly "plaster of Paris"

[125] www.eurogypsum.org

Gypsum is used in all construction types (residential, non-residential, new or refurbished). For instance, the applications of plasterboard split into the three traditional sectors approximately as follows:

- House building: 30%
- Commercial and industrial building: 30%
- Repair, Maintenance, Improvement: 40%

Plasterboard usage and market only gained widespread acceptance in Europe in the 1970s-1980s. Even now in Southern Europe more traditional ways of partitioning and finishing interior space still prevail. This means that many buildings over 40 years old contain little plasterboard.

One of the main substitutes to natural gypsum is FGD gypsum (Flue Gas Desulphurisation Gypsum) which is generated by coal-fired power stations during the process designed to clean sulphur from the exhaust gases.

FGD gypsum is produced in most Western European countries, but output is concentrated in Germany where around half of the production is located. The large area of use for FGD gypsum is the production of plasterboards, gypsum blocks and floor screeds.

FGD gypsum basically changed the scene in the European gypsum industry. Indeed, the electricity industry became an important supplier of raw material and an essential partner in the technological development of the FGD production and establishment of quality criteria for FGD gypsum. Financial investment on both sides has been significant to bring this product (manufactured within the fence of the power plant stations) to its maturity.

In the past, plasterboards production facilities were located close to natural gypsum deposits and the market for building materials. An increasing number of production facilities are now being established across Europe in close proximity of large power plant stations. New gypsum markets also opened up as FGD gypsum can be more easily transported by barges and trains across Europe than natural gypsum. Belgium and the Netherlands, with no natural gypsum deposits, import FGD gypsum by inland waterways from coal power plant stations in Germany. According to the electricity industry, the production of FGD gypsum is expected to increase in all the European countries.

However, there are currently EU and national political debates about sustainable energy (EU commitment to reduction of CO_2 emissions); about secure energy supply (with the need to rebalance the energy mix); about the growing need to use renewable energy sources and the existence of new efficient technologies of power stations. These elements might change the scene for the production of FGD gypsum and also make it difficult to give a long term reliable prognosis on the future production of future FGD gypsum.

As already mentioned above, gypsum-based products and solutions have numerous qualities in construction such as:

- Gypsum is non-combustible and able to delay a fire's spread up to 4 hours by acting as a fire barrier.
- Gypsum acts as a sound regulator by providing a physical barrier to sound. These solutions are applied for the interiors of homes, offices, schools, shops, cinemas, airports, etc.
- Gypsum acts as a thermal insulator for the inside of buildings when combined with insulating materials thanks to its low thermal conductivity.
- Gypsum equilibrates humidity and heat peaks.
- Gypsum is impact resistant thanks to its high degree of hardness equivalent to a thick wall heavy masonry construction.

8.2. QUANTITATIVE ANALYSIS

8.2.1. PRODUCTION DATA

With a turnover of over 10 billion Euros**,** the European Gypsum and Anhydrite Industries operate 160 quarries and some 200 factories**.** The European gypsum industry generates employment directly to 28,000 people and indirectly to 85,000 people (plasterers and plasterboard erecters) through the whole life-cycle of the product: from the extraction of mineral gypsum to the manufacture of added-value products used mainly in construction[126].

Thirty years ago, the gypsum industry was made up of many SMEs mainly producing building plaster and stucco for local markets. The emergence and growth of the plasterboard market in the 1980s, therefore requiring high capital investments, equipment and R&D, led to the emergence of three main operators who cover 80% of the gypsum product market. In Spain, the most important producer of natural gypsum, SMEs are very active, with a direct employment of more than 2,300 employees, operating 26 quarries and 33 plants (powder plant, plaster blocks and ceiling tiles). There are also SMEs active in plaster block and plaster powder markets in other European countries.

The available production quantities of natural gypsum at the national level within the EU-27 are summarised in the following table.

[126] www.eurogypsum.org

Table 29 – Production of natural gypsum for 2005 and 2008 in tonnes [BGS, 2008][127]

Country	2005	2008	Production per capita in 2008	% share	Growth rate 2005/2008
Austria	911,162	1,022,983	0.1228	3.5%	12.3%
Belgium	N/A	N/A	N/A	N/A	N/A
Bulgaria	187,700	234,300	0.0307	0.8%	24.8%
Cyprus	21,5500	412,000	0.4791	1.4%	91.2%
Czech Republic	24,000	35,000	0.0034	0.1%	45.8%
Denmark	N/A	N/A	N/A	N/A	N/A
Estonia	N/A	N/A	N/A	N/A	N/A
Finland	N/A	N/A	N/A	N/A	N/A
France	4,902,498	2,339,380	0.0367	8.1%	-52.3%
Germany	1,644,000	2,112,000	0.0257	7.3%	28.5%
Greece	865,216	830,000	0.0738	2.9%	-4.1%
Hungary	19,000	15,940	0.0016	0.1%	-16.1%
Ireland	700,000	600,000	0.1364	2.1%	-14.3%
Italy	1,600,000	1,600,000	0.0267	5.5%	0.0%
Latvia	220,000	230,000	0.1018	0.8%	4.5%
Lithuania	N/A	N/A	N/A	N/A	N/A
Luxembourg	N/A	N/A	N/A	N/A	N/A
Malta	N/A	N/A	N/A	N/A	N/A
Netherlands	N/A	N/A	N/A	N/A	N/A
Poland	1,048,000	1,499,901	0.0393	5.2%	43.1%
Portugal	389,180	400,000	0.0377	1.4%	2.8%
Romania	532,867	832,248	0.0387	2.9%	56.2%
Slovakia	107,500	152,000	0.0281	0.5%	41.4%
Slovenia	N/A	N/A	N/A	N/A	N/A
Spain	14,453,053	15,000,000	0.3313	51.9%	3,8%
Sweden	N/A	N/A	N/A	N/A	N/A
United Kingdom	1,700,000	1,700,000	0.0278	5.9%	0.0%
Total/average EU-27	29,519,676	28,878,952	0.0583	100.0%	-1.7
World total	145,000,000	N/A	N/A		

With a total production of at least 29.5 million tonnes of natural gypsum in 2005 (considering the lacking data for some MS), the European production represents more than 20.3% of the world total production (145 million tonnes). The major producers of natural gypsum are Spain (52%), France (8.1%), Germany (7.3%), the United Kingdom (6%), Italy (5.5%) and Poland (5.2%) with 24 million tonnes produced in 2008 accounting for 84% of the EU-27 total production.

[127] US Geological Survey (http://minerals.usgs.gov/minerals/), N/A : no reported gypsum production

These figures show a slight decrease on the EU-27 scale (-1.7%) with large discrepancies between countries.

Moreover, the fact that gypsum is a globally traded natural resource needs to be highlighted. Indeed, the amounts that are exchanged on the market vary greatly depending on several factors such as the demand of the construction sector and the actual production capacity added to the availability of the material in the natural resources of the MS.

At last, data about the overall trade situation with gypsum are lacking as large quantities of synthetic gypsum compete with natural gypsum. In 2005, 15.2 million tonnes of synthetic gypsum where estimated to be produced at the EU level[128].

8.2.2. WASTE GENERATION AND TREATMENT DATA

Gypsum waste statistics are available neither at the European level nor at the national one because they are not identified within the amount of C&D waste that is generated. By now, in most cases they are mixed to other C&D waste such as inert materials, paper, cardboard etc. In this context, recycling rates cannot be calculated and are therefore lacking at the EU-27 level[129].

Three sources of gypsum waste exist: production waste, construction waste and demolition waste.

Even though gypsum is considered to be “fully and eternally recyclable”[130] by the gypsum industry, only production and construction gypsum waste is currently recycled (without further information on the rate).

The recycling rate for demolition gypsum waste is low in many MS given that selective deconstruction is required. Recycling of gypsum products that are collected from demolition and renovation projects can be contaminated with other materials, such as paint, fastenings, screws, wood and insulation materials among others, which can render recycling difficult. This is a result of the prevailing demolition processes that are in place nowadays when a building reaches its end of life and the mixing of all fractions which does not allow further recycling of gypsum. Indeed, it is not always possible for the gypsum plasterboard producers to rely on their recycling facilities that are only suited for uncontaminated production and construction waste[131].

Approximately 10 million tons[132] of plasterboard waste was landfilled around the globe in 2007[133] and about **4 million tonnes of gypsum waste** are landfilled in Europe annually

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[128] [Roskill, 2004]
[129] Interview with Christine Marlet, Secretary General, Eurogypsum (European federation of national associations of gypsum products manufacturers)
[130] [Eurogypsum, 2007]
[131] [Eurogypsum]
[132] [Lund, 2008]
[133] No figure is available at the EU-27 level.

(excluding waste arising at production plants, which amounts to 0.6 to 1.2 million tonnes)[134].

8.3. RECOVERY TECHNIQUES

8.3.1. EXISTING OPTIONS

This sub-section will focus only on gypsum construction waste due to the aforementioned reasons. Gypsum construction waste consists in pieces of plaster and fibreboards that had to be cut off to fit special arrangements in the building, of damaged boards during transportation or because of the weather when they are stored outside. Such waste represents around 5%[135] of plasterboard used on construction sites and is considered to be clean (free of paints and nails) and recyclable into the manufacturing process for the production of new plasterboards as described below.

- **Recycling**

The collected plasterboard stream has to undergo several steps in the recycling process. First, paper layers of the plasterboards are removed as much as possible, then gypsum is crushed into powder and eventually this powder is sent back to plasterboard manufacturers so that they can make new plasterboards from it.

The gypsum powder is estimated to represent 94% of the total plasterboard waste collected[136]. The remaining 6% refer to paper and cardboard (and the related contaminants) composing plasterboards and can be re-used in various ways such as composting (as very little gypsum is left on the paper) or heat generation.

There is always a residual paper fraction that remains in the powder and which hinders the improvement of the introduction rates of recycled powder into the processes that are currently in place. The associated risks are the damage of the manufacture machinery and an effect on the acoustic or thermal quality of the final product.

According to Eurogypsum, between 5 and 10% of gypsum powder resulting from construction plasterboard waste is re-integrated in the closed-loop system. This figure is a European average and huge differences exist between MS. Indeed, recycling practices exist in Denmark, Germany and other Northern European countries while recycling is limited in Greece and Spain or is not applied at all in Eastern Europe countries. In some MS where comprehensive gypsum recycling schemes have been established (e.g. Denmark) overall recycling rates of 65% can be achieved.

[134] [VITO, 2007]
[135] [Eurogypsum]
[136] http://www.gypsumrecycling.biz/6688-1_Why+recycle%3F#Header0

This discrepancy is due to specific national legislation, to mentality aspects and especially to the existence of a market that would encourage the economic activity associated to recycling[137].

8.3.2. Emerging techniques

Only a small quantity of gypsum demolition waste is currently recycled due to challenges surrounding contamination with other materials. This is therefore an area of continuing research and development to improve the manufacturing process by making possible the re-introduction of gypsum with a higher residual paper fraction (therefore a gypsum powder with a higher impurity rate) or enhancing the techniques for the removal of paper from plasterboards.

Other options are considered to partially or fully replace virgin gypsum that is usually used for cement manufacture and for agriculture[138]. They are described below.

- **Recycling as a raw material in the manufacture of cement**

A small percentage of gypsum is usually incorporated into cement in order to modify its setting characteristics and traditionally the gypsum additive was obtained by mining. Gypsum waste could substitute virgin gypsum though WRAP (Waste & Resources Action Programme) has identified significant actual and perceived barriers to the incorporation of recycled gypsum from plasterboard waste into cement mixtures[139].

A study was then undertaken for WRAP to determine how the barriers could be overcome and how the cement industry could maximise the amount of gypsum waste utilised in its products and hence diverted from landfill.

The study has demonstrated through desk studies and practical trials that recycled gypsum, of the quality currently available, can substitute technically for mined gypsum in the production of bagged cements, but that it remains to be proven acceptable to the ready mix market.

- **Recycling as a soil treatment for agricultural benefit**

Gypsum is traditionally added to agricultural arable soils to improve soil condition. For this purpose, gypsum is usually mined or quarried, which depletes natural resources among other impacts. A study was undertaken by WRAP to evaluate whether recycled gypsum produced from waste plasterboard is effective as a soil treatment in commercial potato production[140]. A parallel study with winter wheat was carried out in early 2008. Both studies were undertaken by the research and development department of Velcourt Ltd.

[137] Interview with Christine Marlet, Secretary General, Eurogypsum
[138] Other applications include agricultural fertiliser, sub-soil amendment on new residential construction site and admixture for concrete.
[139] [WRAP, 2008]
[140] [WRAP, 2007]

The main effect on soil condition by adding gypsum are considered to be improved structure, leading to improved drainage, water-holding capacity, aid restoration of calcium and sulphur deficiencies and improve the efficiency of a plant's uptake of inorganic nitrogen fertiliser.

Trials were realised and led to the conclusion that applying recycled gypsum to land used for potato production was beneficial in its effects on the soil and the quality of the crop. The farmer involved in the trial was convinced of the benefits of recycled gypsum and intends to continue its use on his fields when required.

However, farmers have indicated that the complications of applying for an environmental permit for the use of gypsum waste deter them from using cheaper, but equally beneficial gypsum from waste plasterboard[141].

However, this recovery technique might have important impacts on ground water sulphides concentration.

8.4. Environmental and economic impacts of gypsum waste management

8.4.1. Environmental and health impacts

The following table summarises the impacts and benefits of the different end of life options for gypsum waste, which are further detailed below.

Table 30 – Impacts and benefits for each option for the management of gypsum

LANDFILL

Direct impacts	Avoided Impacts	Net benefits
Transportation of waste to the landfill Production of H_2S (bad smell and toxic to human health) when mixed with biodegradable waste (the European legislation requires specific cells in inert landfills to avoid H_2S emissions) Use of land space		- -

[141] www.environment-agency.gov.uk/business/topics/waste/114435.aspx

RECYCLING OF PLASTERBOARDS FOR RE-INTRODUCTION OF THE GYPSUM POWDER INTO THE MANUFACTURING PROCESS

Substitute material (in the same proportion): gypsum powder processed from gypsum minerals extracted from quarries

Direct impacts	Avoided Impacts	Net benefits
Transportation of construction plasterboard waste from the construction site to waste processors	Extraction of raw materials (mineral gypsum): land-use for quarries, production of dust, use of natural resources, energy consumption Transportation of raw materials Consumption of resources Land use and biodiversity issues due to gypsum extraction	**o/+**
Processing of plasterboard waste into gypsum powder: dust production and noise during crushing and sieving steps, additional energy consumption for the removal of paper Transportation of recycled gypsum to plasterboards manufacturers	Processing of raw materials into powder: dust production and noise	

In the previous table, the substitution of natural gypsum by recycling gypsum has been analysed. However, recycled gypsum can also replace synthetic gypsum (FGD). In this case, the net benefits are assumed to be higher due to a more energy intensive manufacturing process to produce gypsum based products from synthetic gypsum compared to natural gypsum (because of a higher moisture content of FGD).

- **Direct impacts of landfilling**

The main environmental issue associated with gypsum waste management is the production of the dangerous hydrogen sulphide (H_2S) gas when plasterboard waste is disposed of in landfills. H_2S gas is a dangerous gas that is lethal in high concentrations and releases odours in low concentrations. The plasterboard waste itself is not dangerous, but when mixed with organic waste, and exposed to rain in an anaerobic environment, H_2S gas can be released. For this reason, the EU has decided that plasterboard waste and other gypsum-based products can no longer be disposed of in simple inert landfills but in controlled cells where no organic waste is accepted. However, this would require gypsum waste to be collected separately or sorted afterwards, which is not always the case. Therefore, in many cases gypsum waste is landfilled under improper conditions thus posing an environmental risk. Moreover, landfills use can also be a problem in some areas (around highly populated urban centres) due to use of land space. At last, transportation of waste to the landfill implies environmental impacts.

Direct impact of reprocessing plasterboards waste collected from construction sites

As developed in section 8.3.1. , the processing of plasterboards waste collected from construction sites need energy-relying steps before further re-introduction into the manufacturing process. Other related impacts include dust and noise production, as well as transportation of construction plasterboard waste from the construction site to waste processors, and of recycled gypsum to plasterboards manufacturers.

Net benefits of recycling gypsum powder resulting from plasterboard waste collected from construction sites

Net benefits are low to medium as the production of plasterboards from recycled gypsum or from virgin material mainly are likely to have similar environmental impacts. The benefits are to avoid the use of natural resources, that is to say virgin mineral gypsum extracted from quarries, avoiding quarrying activities (thus reducing land use and avoiding potential biodiversity losses). Despite gypsum is estimated in good supply presently, there is only a limited amount available within the EU, so steps to preserve the natural gypsum resources should be encouraged.

8.4.2. Economic impacts

Two main economic factors push towards gypsum recycling: raw material price and landfilling costs increase. Both are specified below.

As developed in the above section, gypsum raw material is not threatened by intensive extraction yet but the available amount is finite which is calling for saving measures such as recycling. The first effect is the increasing price of raw gypsum material as observed in some plants where it has gone up with more than 50% the last 3 years[142].

The other economic aspect linked to gypsum waste management is the cost associated with landfilling. The following table is an example in the UK of the increasing landfill taxes for plasterboards waste over the last few years within some EU countries.

Table 31 - Estimated increase in the cost (Euros/tonne[143]) of disposing of plasterboard waste to landfill in the UK [Hollins, 2006]

Year	2004	2005	2006	2007	2008
Landfill Tax	17	21	24	27	31
Landfill Tipping fee	31	86	91	91	91
Transport	19	21	22	23	24
Total	67	127	137	141	146

Between 2004 and 2008 the total landfilling cost increased by 117% from 67 Euros per tonne of gypsum landfilled in 2004 to 146 Euros in 2008. Landfill taxes in other European countries are also increasing fast and are expected to reach more than 70 Euro per tonne in both the Netherlands and the UK in 2011.

142 [Lund, 2008]
143 Used conversion rate: 1£ = 1.1401€ (April 2010)

The effect of the increasing landfill costs is assumed to be the development of recycling practices among gypsum waste producers and gypsum manufacturers. Indeed, in 2007 approximately 7 million Euros were invested in Europe in containers and recycling equipment[144]. Compared to the 10 billion Euros turnover of the gypsum industry, this represent only 0.07% but it is the first step towards a recycling Industry.

8.5. TOWARDS THE 70% TARGET: DRIVERS AND BARRIERS

As developed in the above sections, gypsum C&D waste recycling faces several barriers and the only recycling opportunity accounts for 5 to 10% of gypsum waste from plasterboards. Therefore, to achieve the 70% target, signification actions must be undertaken.

The main barriers are:

- The high availability and the low costs of raw gypsum material
- The low availability of gypsum waste due to unadapted C&D processes. Indeed, though the techniques exist, they are not implemented because they would represent a financial burden to the C&D sectors.
- The lack of knowledge on recycling or other material recovery options. Indeed, manufacturing processes currently in place do not allow the re-introduction of a higher recycled gypsum powder content.

In order to overcome those barriers several options should be considered, the following paragraphs describe potential actions.

Sorting at source: separation for an improved material quality

The recyclability of gypsum-based products and especially plasterboards could be enhanced thanks to deconstruction which would therefore make the sorting process easier. Indeed, gypsum based interior partition elements are easily dismantled and a further effective sorting would produce a higher non-contaminated gypsum C&D waste fraction, make easier the further recycling of this specific waste stream and improve the overall recycling rates.

Therefore, the characterisation of gypsum waste, i.e. the identification of gypsum waste material from other elements is the key point to increase the amount of potentially recycled gypsum.

Gypsum waste collection: increasing the potential for recycling

Actions to ease the gypsum waste collection could also be considered to increase the amounts of C&D waste. As an example, the UK has developed collection systems that are expected to increase the recycling rates. Examples of collection systems[145] are described below:

[144] [GRI, 2007] < www.ciwm.co.uk/mediastore/FILES/14609.pdf>
[145] [Hollins, 2006]

- The bulk bag system has been developed by the British gypsum industry so that gypsum waste is collected by its producer in a closed-loop system. The costs of the collection of plasterboards through this system lays between 49 and 203 Euros per tonne for medium sized bags (able to collect 0.35 tonne and accept a contamination rate up to 30%). The large range of costs depends on the quality of the collected plasterboard and the distance to the manufacturing plant.
- The Skip system is operated through waste contractors and involves the use of skips of various sizes. The waste contractor collects the gypsum waste and stores it until the amount is sufficient to be sent to the closest plasterboard reprocessor.

Building conception: designing for the end of life

Nevertheless, it requires that future buildings will be designed for disassembly, the development of tools for the deconstruction of existing buildings and the training of deconstruction workers. In almost all scenarios, the cost of deconstruction is higher than that of demolition due to the labour intensive nature of deconstruction. Public grants may therefore be necessary to trigger the momentum towards the implementation of the EC Directive and face these additional costs[146].

Some European countries are already leading the way as described below[147]:

- A Dutch scheme, encouraged by stringent recycling legislation, provides for on-site separate storage of gypsum in a special container. The waste, once collected and taken off-site, is stored at a central depot until enough gypsum has been accumulated for transportation to a recycling facility.
- A similar programme was set up in Dublin (Ireland) in spring 2005. The system has been inspected by the Irish Minister of the Environment with great satisfaction. Most customers are from the greater Dublin area, but the coverage of the system is expanding.
- In the UK, plasterboard producers are recycling “clean” building site scrap from some house builders.

Green building systems: promoting the use of former gypsum waste

As for concrete waste, green building systems (e.g. HQE – Haute Qualité Environnementale in France, BREEAM - BRE Environmental Assessment Method in the UK, German Sustainable Building Certificate) can encourage the recycling of plaster elements and the use of plasterboards made of increasing recycled gypsum powder by integrating such criteria in their rating charts. This would influence public perception regarding the quality of recycled plaster elements and promote large possibilities for their use, by specifically addressing the

[146] Interview with Christine Marlet, Secretary General, Eurogypsum
[147] [Eurogypsum]

recycled plaster issue in the system. Recommendations on gypsum products are also provided by the Commission in its GPP background report on wall panels.

In England and Wales, a Quality Protocol has been adopted in January 2010 to raise market confidence in recycled gypsum and increase demand for waste plasterboard. It sets out the end of waste criteria for the production and use of recycled gypsum from waste plasterboard. If these criteria are met, the resulting outputs will normally be regarded as having been fully recovered and to have ceased to be waste[148]. Though producers and users are not obliged to comply with the Quality Protocol, it will potentially boost sales by an estimated £10 million (11.4 million Euros), and could save industries that generate waste plasterboard in excess of £8 million (9.2 million Euros) a year in disposal costs[149] while also saving 46,800 tonnes of virgin raw material[150] by re-introducing gypsum waste into the manufacturing process.

Such measure could be extended to the whole EU to reduce the amount of gypsum waste disposed of in landfills and encourage recycling practices.

- **Increasing landfilling costs: a driver towards the development of alternatives**

Nowadays, the operation of landfills is regulated at the EU level by Decision 2003/33/EC[151] on Waste Acceptance Criteria, which was adopted to strengthen the waste regulations established by Directive 1999/31/EC[152]. This directive requires the implementation of the Waste Acceptance Criteria (WAC) for high Sulphate content products by July 2005 which states that gypsum-based and other high sulphate-bearing materials having more than 10% sulphate in any one load[153] is considered as waste and is therefore accepted in landfills. Moreover, "non-hazardous gypsum-based materials should only be disposed of in landfills for non-hazardous waste in cells where no biodegradable waste is accepted[154]. The limit values for Total Organic Carbon (TOC) and Dissolved Organic Carbon at pH 7 (DOC7) given in section 2.3.2 shall apply to wastes landfilled together with gypsum-based materials[155]." As a direct effect, the inexpensive storage of gypsum waste in inert landfills is no longer allowed.

In the UK for example, there are only one or two landfills currently in operation able to receive high sulphate non hazardous waste such as gypsum and store it in mono-cells, with gate fees ranging from £90 to £135 per tonne (between 100 and 155 Euros). According to the Waste Management Industry, other mono-cells for plasterboards are unlikely to be set up since asbestos is seen as a more lucrative market requiring such facilities[156].

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148 [WRAP, 2010]
149 www.wrap.org.uk/recycling_industry/recycling_industry_2.html
150 www.environment-agency.gov.uk/business/topics/waste/114435.aspx
151 [EC, 2002]
152 [EC, 1999]
153 Specific sampling and testing methods are described in the Council Directive.
154 Also called "mono-cells" which refer to the separate storage of gypsum waste in specific landfill cells to avoid any contact with biodegradable waste.
155 [EC, 2002]
156 [Hollins, 2006]

Increasing landfilling costs would encourage the development of new recycling techniques as waste producers would only be able to sustain such costs to a certain point. In the same way, it will improve the sorting out of gypsum construction waste and produce a higher feedstock for existing options. The recycling of gypsum waste would turn into a business opportunity as the demand for gypsum products is likely to increase with the population and the need for new houses, schools, hospitals, offices and shops.

However, to optimise the effect of such driver, these costs should be harmonised all across the EU. Indeed, in the Netherlands for instance, landfilling in special cells is expensive while it is not in Germany, leading therefore to the shipment of waste to the adjacent country.

- **Promoting R&D initiatives to explore new recycling options**

Concerning construction waste, it is estimated that up to 25% of gypsum virgin material can be replaced by recycled gypsum powder for the production of plasterboards[157]. Therefore the target set at 30% by the European gypsum industry as the percentage of recycled material being re-introduced into the manufacturing process seem to be achievable.

To achieve the 70% target, promoting R&D on production techniques and investments in gypsum facility to increase the amounts of waste gypsum that can be used in the production of new gypsum seem essential in order to improve current processes and allow the re-introduction of a larger part of recycled gypsum in building elements.

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10. CONTACT LIST

Table 32 - Contacts targeted for the study per fraction of C&D waste

Name	Organisation	Position	Location	Fraction	Contacted by email	Feedback obtained
BEUVING Egbert	European Asphalt Pavement Association (EAPA)	Director	Brussels	Asphalt	x	X
CORNTHWAITE Anthony	European Asbestos Services	Business contact	UK	Asbestos	x	
CUPERUS Geert	Fédération Internationale du Recyclage (FIR)		Brussels	General information	x	X
DE GREEF Nadine	European Federation of Waste Management and Environmental Services (FEAD)	Secretary General	Brussels	General information	x	
DUVAL	Syndicat National des entreprises de Démolition (SNED)		Paris	General information		X
ETIENNE Alice	European Builders Confederation (EBC)	Policy Officer	Brussels	General information	x	
JONES Peter		Independent Consultant	UK	ODS	x	X
LINE Véronique	Technical Affairs	Fédération Française du Bâtiment (FFB)	Paris	General information		X
LOBEL Oliver	PU Europe	Secretary General	Brussels	ODS	x	x
MARLET Christine	Eurogypsum (European federation of national associations of gypsum products manufacturers)	Secretary General	Brussels	Gypsum	x	X

Name	Organisation	Position	Location	Fraction	Contacted by email	Feedback obtained
MATHIS Pamela	ICF International	Project Manager	San Francisco	ODS	x	
RIMOLDI Alessio	European concrete platform	Secretary General	Brussels	Concrete	x	X
O'BRIEN Jim	European Aggregates Association (UEPG)	President	Dublin	Aggregates	x	X
SCHROEDER René	European Federation of Waste Management and Environmental Services (FEAD)	Policy co-ordinator	Brussels	General information	x	X
SYKES Christophe	TBE (Tiles and bricks of Europe) & Cerame-Unie (The European Ceramics Industries)	Secretary General	Brussels	Bricks, tiles and ceramics	x	X
VERVOORT Ward	European Confederation of woodworking industries (CEI-Bois)	Senior Environment and Research Advisor	Brussels	Wood	x	X
THUEN Henriette	European Demolition Association (EDA)	General Manager	Copenhagen	General information	x	

Table 33 - Contacts targeted for the case studies

MS	Name	Organisation	Position
Finland	Jorma Kaloinen	Finnish Environment Institute	Expert on C&D waste
	Juha Espo	Statistics Finland	Waste statistician
	Anna-Leena Perälä	Technical Research Centre of Finland	Senior Research Scientist
Flanders	Koen Smeets	OVAM (Public Flemish Waste Agency)	Head of the Department of Waste Statistics ADC
	Janna Vandecruys	OVAM (Public Flemish Waste Agency)	Expert of the Department of Waste Statistics ADC
Germany	W. Sodermanns-Peschel	Deutscher Abbruchverband e.V.	Head of Environment and Technology
	Michael Heide	Bundesgütegemeinschaft Recycling-Baustoffe e.V. (& European Quality Association for Recycling EQAR)	Managing Director
	Gerhard Pahl	Bundesvereinigung Recycling-Baustoffe e.V. (BRB)	Director of the department
	Berthold Schäfer	Deutscher Beton- und Betontechnik-Verein E.V.	Director of the department for environment engineering
Hungary	Katalin Fekete	Ministry of Environment and Water, Department of Waste Management, Waste Treatment Unit	N/A

MS	Name	Organisation	Position
	Tibor Laszlo	Ministry of Environment and Water, Department of Waste Management, Waste Treatment Unit	N/A
	Istvan Varkonyi	Baurec Construction Waste Treatment Coordination Non Profit Ltd.	N/A
	Judit Ratz	HuMuSz (Hulladék Munkaszövetség), Waste Reduction Alliance	N/A
Spain	Carlos Martinez Bertrand	VIAS Y CONSTRUCCIONES, S.A	Chief of Quality, Environmental Management and Technological Innovation
	Jose Blanco	AEDED – Spanish Association Demolition	Secretarial
	Pablo Gonzalez	GERD – Spanish association of C&D waste managers.	Waste and Environment Manager

11. Annex I: OZONE DEPLETING SUBSTANCES

Applications in the construction sector	Blowing agent for plastic insulating material in buildings		
Production in the EU-27	Ban on CFC and HCFC (phase out respectively in 1994 and 2004). However, important banks in pre-2004 buildings: **536,000 to 683,000 tonnes** in 2010 (50% to 80% of the total ODS bank in EU-27)		
Waste generation in the EU-27	Rough estimations of **130,000 to 250,000 tonnes** of waste insulating material containing **11,500 tonnes** of ODS.		
Treatment options	**Landfill**	**Incineration**	**Removal of ODS and recycling or re-use of other materials**
Current rates	N/A High differences between MS.	N/A Ibid. Up to 95 % in municipal incinerators in Germany, the Netherlands, Austria and Denmark[158]. Low rates in most MS.	**Low**
Potential rates	N/A	N/A	N/A
Environmental impacts	Emission of greenhouse gases. Appropriate removal of ODS could save up to **15,406,000 t. CO_2eq** emissions per year (2010). This outweighs any benefits that could be obtained through recycling of foam plastics (potential avoided emissions amounting to 1 million t. CO_2eq) Release of substances depleting the ozone layer		
Barriers to re-use and recycling of the waste	- Costs of ODS removal from insulating foams (approximately 83 € per kg of ODS for collection, recovery and destruction, or 8 € per kg of foam) - Possibly limited technical feasibility, depending on the specific type of product - Low quantities within the C&D waste flow		
Existing and potential drivers to re-use and recycling of the waste	- High environmental impacts associated to the release of ODS in the atmosphere - Most of the EU-27 ODS bank is in insulation foams - 70% target triggering better management of C&D waste in general, involving better characterisation and sorting of demolition waste - Development of alternative recycling techniques		

[158] According to Oliver Loebel, Secretary General, PU Europe

11.1. Product description and applications

Ozone depleting substances (ODS) are synthetic chemicals, including in particular CFCs (chlorofluorocarbons), HCFCs (hydrofluorocarbons) and halons. The production of CFCs began in the 1930s for refrigeration applications. Since then, they have been extensively utilised in air conditioning, as propellants in aerosols, and as blowing agents in plastic insulating foam manufacture. They were phased out in the early 80's and replaced by HCFC for most applications. As regards insulation material, CFCs and HCFCs were mostly used in polyurethane foam (for sandwich panels, boardstock or spray foam) and in extruded polystyrene (XPS) foam[159]. These materials find many applications in the construction sector, for the thermal insulation of roofs, indoor or outdoor walls, foundations, etc.

In 2004, HCFCs have been banned and replaced by HFCs, which have in turn being replaced when possible by other blowing agents, among which mainly pentane and hydrocarbon mixes. Nowadays, over 90% of PU foam is blown with pentane, and less than 10% with HFC. However, HFC is still used in spray foam (pentane cannot be used for this application for safety reasons), and some small producers still use HFCs as they cannot afford the investment in pentane-using equipment.

11.2. Quantitative analysis

11.2.1. Current and forecasted ODS banks

The use of CFCs and HCFCs in insulation foams and other applications is banned; however, large quantities are banked in products and equipment, and particularly in insulating materials used in buildings constructed before the phase-out of these substances (respectively 1994 and 2004 for CFCs and HCFCs).

A study prepared by ICF International for the European Commission[160] proposes estimations and projections of the ODS bank in EU-27. The applications of ODS in buildings insulation foams covered by this study are:

- PU sandwich panels (continuous)
- PU sandwich panels (discontinuous)
- PU and PIR boardstock
- PU spray foam
- XPS foam boards

Estimated ODS and HFC banks in EU-27 in 2010 are presented in the table below. Differences between the bottom-up[161] and top-down[162] approach are mostly due to a reallocation of

[159] [USEPA, 2004]
[160] [ICF, 2010]
[161] The Bottom up approach projects HFC growth assuming an increasing push to climate-friendly alternatives [ICF, 2010].

some of the above foam applications to sectors other than construction, based on confidential data. However, both approaches give similar results when taking into account all sectors where insulating foams are used.

Table 34: Estimated ODS and HFCs building insulation foam banks in EU-27 in 2010 [ICF, 2010]

Blowing agents	Bottom-up estimation	Top-down estimation
CFC	456,829 tonnes	370,083 tonnes
HCFC	226,570 tonnes	165,464 tonnes
HFC	84,112 tonnes	55,092 tonnes

The bottom-up estimates proposed by ICF will be used as the reference data for the purpose of this report.

The ODS banks in building insulation foams are therefore estimated between **536,000 tonnes and 683,000 tonnes in 2010**, which represents between 50% and 80% of the total ODS banks in EU-27.

11.2.2. Waste generation and treatment data

The amounts of ODS contained in insulating foams reaching their end-of life is projected to be around **5,300 tonnes** in 2010, and 4,300 tonnes in 2020[163].

These estimations consider an average life-time of 50 years for these products. This assumption is subject to discussion, as most of ODS containing insulating foams is in non-residential buildings, that usually have shorter lifespan[164]. Indeed, research by the Building Research Establishment [BRE] in the UK and similar European studies suggest that over 80% of the bank of ODS building foams is in industrial and commercial buildings and this type of building is likely to have a shorter life span[165]. The above quantities might therefore be underestimated.

Not the entire blowing agent content remains in the insulating foam over time. Depending on the type of product, the losses account for to 5% to 15% during year 1, and then 0.25% to 1.5% per year. The average amounts of ODS remaining in foams at the end-of-life are presented in the following table.

[162] The Top down model projects future HFC growth based on historical trends [ICF, 2010].
[163] Calculation BIOIS, based on quantities technically recoverable estimated by ICF 2010.
[164] Interview with Peter Jones, 2010
[165] Ibid.

Table 35: Blowing agent remaining in different types of construction foams at their EOL [ICF, 2010]

Application	Blowing agent remaining at EOL
PU Rigid: Sandwich Panels - Continuous	71%
PU Rigid: Sandwich Panels - Discontinuous	67%
PU & PIR Rigid: Boardstocks	57%
PU Rigid: Spray foam	31%
XPS Foam Boards	13%

There is some uncertainty linked to these values. There are some concerns that the percentage of blowing agent remaining at end of life in sprayed foam could be underestimated, though test results are not available for a comparison.

Based on the losses factors described above, and on the estimate that the amounts of ODS in building foams reaching their EOL will be 5,300 tonnes in 2010, it can be estimated that the amounts of ODS reaching their end of life in 2010 correspond to an original amount of **13,800 tonnes** of ODS (at the time the time the foams were produced). With amounts of blowing agents per weight of foam estimated at 12% for CFCs and 10% for HCFCs[166], this corresponds to a total amount of ODS-containing waste of approximately **113,800 tonnes**. This amount is a rough estimate, and is likely to be an underestimation, as this does not take into account the metal or other elements, apart from foam, present in insulation material. An upper estimate can be obtained by considering 5% blowing agent per weight for both CFCs and HCFCs; with this hypothesis, the amount of waste insulating material containing ODS reaches almost **220,000 tonnes.** Several elements would be necessary to model such a waste flow with more precision: the types of products that used CFC or HCFC, the loss rate during the life time and the life span of the products among others. Such a study has not been done to any degree of accuracy, the figures are therefore uncertain.

According to Regulation 1005/2009, ODS in construction foams "shall, if technically and economically feasible, be recovered for destruction, recycling or reclamation, or shall be destroyed without prior recovery".

Regulation 1005/2009 allows two options for the destruction of foams (classified as dilute sources in Annex VII): rotary kiln incineration or municipal solid waste incineration. If ODS are present in concentrations above 0.1%[167], the waste is classified as hazardous and treatment options are restricted to facilities that have a permit to accept this category of hazardous waste. As a consequence, they have to respect stricter environmental standards. Moreover, the Waste Incineration Directive sets specific requirements for facilities treating hazardous waste with a content of more than 1 % of halogenated substances (Art. 6.1).

[166] The foam Industry estimates that the blowing agent content varies between 5 and 15% depending on the application.
[167] [EC, 2000]

There is currently no data on treatment of ODS containing insulating foams, but experts indicate that actual recovery of foams is not generally practiced, with the exception of some reported cases in Germany[ICF, 2010]. As a result, it might be landfilled (i.e. not complying with legislation) or incinerated in a municipal waste incinerator (which is compliant if the facility has the required permit and complies with the provisions of the Waste Incineration Directive, see above). Although the respective shares of landfilling and incineration with or without energy recovery are unknown, the current recycling rate (after removal of blowing agents) can be assumed to be very low.

11.3. Recovery techniques

11.3.1. Existing options

Foam is not typically separated from other materials and recovered at end of life. In some countries, the lack of enforcement and control procedures results in few or no actual separation and controlled treatment of this waste. In countries and regions where a ban on landfilling of recoverable or mixed C&D waste has been enacted (e.g. Germany, Flanders, the Netherlands or Austria), ODS-containing insulation foams are typically incinerated in municipal solid waste (MSW) or hazardous waste incinerator. As a result, landfilling and incineration in municipal waste treatment plants are still the main destinations for ODS containing insulation material. It is important to note that landfilling is not an option permitted by regulation 1005/2009.

Classifying ODS containing substances as hazardous or prohibiting landfill or such materials has not efficiently triggered the recovery of ODS from foam prior to the recycling of other material, as thermal destruction often remains the most cost-effective technique. If not properly managed, separation of ODS entrapped in the foam matrix before destroying them may result in their release to the atmosphere and require more energy (greater combustion temperature) than when directly incinerated with mixed MSW.

Indeed, the co-combustion of building insulation foams with MSW[168] would ensure the safe destruction of CFCs by using the embodied energy of the plastic material, while avoiding crushing to reduce the density of the material prior to its disposal in landfills and the associated release of ODS to the atmosphere. Experiments carried out showed the efficiency of the co-combustion on the destruction of CFCs: more than 99.9% at 900°C for CFC-12 while CFC-11 is destroyed at low temperature. Moreover, no significant increase in dioxins and furans' levels are detected when foams containing flame retardants are incinerated. Finally, acid gas removal is operated through scrubbers reaching concentration far below the German Emission Directive[169]. However, incineration with MSW might raise other issues, and the comparison between these two options is not yet feasible, and would require a complete comparative life-cycle analysis.

[168] [Vehlow]
[169] Directive 17 BimSchV: HCl < 10 mg/m^3, HF < 1.0 mg/m^3

As demonstrated by ICF 2010, the percentage of ODS technically recovered at the EOL of insulation products varies greatly depending on the type of product.

Table 36: ODS potentially recovered at the end of life of insulating foams [ICF, 2010]

Application	ODS potentially recovered
PU Rigid: Sandwich Panels - Continuous	64%
PU Rigid: Sandwich Panels - Discontinuous	63%
PU & PIR Rigid: Boardstocks	32%
PU Rigid: Spray foam	6%
XPS Foam Boards	8%

The low levels of potentially recovered ODS from XPS foam boards and PU spray foam can make the recovery of ODS from these products less of a priority. However, there is a high recovery potential from sandwich panels, and to a lesser extent from boardstocks which therefore represent the best opportunity for ODS recovery, in terms of technical feasibility.

11.3.2. Emerging techniques

The demolition industry is facing the challenge of developing methodologies that can safely and effectively disassemble insulating panels and separate ODS foam insulation.

An alternative option to incineration is the recovery of ODS from foams (for destruction), prior to the recycling or recovery of the other materials composing the panels. The provisions of EC Regulation 1005/2009, stating that such recovery is an option “if technically and economically” feasible, has led to a discussion on whether this was actually an option from a technical and economical point of view.

- **Removal of ODS blowing agents from sandwich panels at refrigerator recycling facilities**

Sandwich panels can be manually removed from buildings and treated in facilities that handle refrigeration equipment. One current limitation of this treatment option is the size of the panels that can be processed and therefore the size of the existing machinery. Indeed, it often exceeds the typical sizes for household appliances. The cutting process introduces risks of releasing some of the blowing agent; therefore this step has to be conducted carefully. Installations capable of handling such waste do exist, for example recycling plants that have installed a band saw to cut panels operating in low pressure conditions. This allows the recovery of ODS releases during the cutting process. Plants handling large appliances such as commercial refrigerators and freezers might also be suited for most sandwich panels. Otherwise, existing plants should be modified to be able to treat panels and ODS foam insulation.

This application requires to take precautionary measures as the ODS contents of refrigerators are much lower than insulation panels used in the construction sector. Modifications to the process may therefore be necessary. Moreover, it may be difficult to ensure a continuous flow of waste insulation panels to the refrigerator recycling plant.

- **On site "vacuum" technologies**

According to the US National Demolition Association[170], a potential technology to recover ODS from insulation materials are "vacuum" technologies, typically used to recover asbestos from buildings. However, this would require a significant investment in research and development to adapt the process and the recovered material would need to be incinerated.

- **Recycling or re-use of material composing insulation panels**

Although it is not current practice, the recycling of PS and metals after recovery and destruction of ODS blowing agents is a feasible option.

The recycling of PU foam is less feasible as PU cannot be melted or reprocessed. However, other options such as the use of shredded foam[171] in replacement material for wood, or chemical recycling (thermal glycolysis of PU[172]) represent promising technological developments.

- **Closed loop recycling**

A company, Kingspan Insulated Panels, has developed a process which will potentially allow for a totally closed loop for their products once they have reached the end of their useful life. The company says this means that all insulated panel waste from Kingspan's manufacturing process will be completely recycled. However, the aim is for the company to be able to recycle panels from deconstructed buildings in the future, allowing a truly 'closed loop' scenario where all material is recovered and recycled at end of life. The company has a similar process for boardstock[173].

11.4. ENVIRONMENTAL AND ECONOMIC IMPACTS

11.4.1. ENVIRONMENTAL IMPACTS

The major environmental issue related to the end-of-life of ODS-containing insulation material is the potential release of these substances into the atmosphere, as they significantly contribute to the destruction of the ozone layer and to global warming.

As mentioned above, building insulating foams may contain 50 to 80% (some sources estimate this share up to 90%) of the total ODS bank in Europe. Therefore, systematic destruction of ODS contained in foams(with or without prior recovery) at their end of life represents high environmental benefits, both in terms of ozone layer depletion and greenhouse gases emissions, but with also potential significant costs [ICF 2010].

[170] Personal communication with Mike Taylor on behalf of the National Demolition Association, reported in ICF 2010
[171] www.puren.com
[172] www.rampf-ecosystems.de
[173] Interview with Peter Jones, 2010

This issue remains with non-ODS substances that are still widely used as blowing agents such as pentane and HFC to a lower degree, which are also greenhouse gases as well as a VOC (Volatile Organic Compound) for pentane.

The comparison of environmental costs and benefits related to the two options allowed in Regulation 1005/2009 (recovery or destruction without recovery) was not performed in the context of this study, and would require a complete life-cycle analysis, taking into account the current recovery and/or destruction rates in existing facilities, transportation distances to recovery/destruction facilities, treatment of bottom ashes in MSWI, potential environmental benefits of recycling other materials contained in foams, etc.

The potential environmental savings, in terms of GHG emissions, associated with the full destruction (and thus the avoidance of release into the atmosphere) of the fraction of ODS and HFC present in insulating foams at the end of their life, is presented in the following table.

Table 37: Emission savings potential (in ktonnes CO_2 eq.) through the destruction (with or without prior recovery) of CFCs, HCFCs and HFCs in building insulating foam [ICF, 2010]

Application	CFC	HCFC	HFC
PU Rigid: Sandwich Panels - Continuous	3 992	827	135
PU Rigid: Sandwich Panels - Discontinuous	1 937	207	180
PU & PIR Rigid: Boardstocks	4 541	350	10
PU Rigid: Spray foam	489	54	124
XPS Foam Boards	2 710	299	26
Total	13 669	1 737	475

The total destruction of ODS contained in insulation foams at the end of their life in 2010 would represent a total of **15,406,000 tonnes CO_2 eq**. This amount reaches 15,881,000 t. eq. CO2 when HFC is accounted for.

IPCC and TEAP predict that total direct emissions of emitted from banks could erase all of the reductions in global warming gas emissions achieved under the Kyoto Protocol. Therefore, the treatment of ODS banks are considered of major importance by the United Nations and the EU.

As a comparison, the emissions associated to the production of PU rigid foam are 4.3 t. CO_2eq. per tonne of PU. With the high estimate of 250,000 tonnes of waste foam per year, this would be equivalent to a potential of 1,075,000 t. eq. CO2 avoided impacts through recycling or re-use.

11.4.2. Economic impacts

As previously stated, according to EC regulation 1005/2009, the recovery of ODS from insulation foam prior to appropriate treatment of other materials is mandatory "if technically and economically feasible". The question of treatment costs of ODS contained in insulation foam has therefore been raised and evaluation of these costs are available and presented in the following table.

Tableau 38: Average costs for EOL treatment of ODS contained in sandwich panels

Activity	Costs per kg of ODS[174]
Segregation/collection	55 €
Transport	5 €
Recovery processing	20 €
Destruction	3 €
Total	**83 €**

The cost of destruction of ODS with prior recovery from sandwich panels (possibly the most feasible type of construction foam to recover) is estimated at €83/kg of ODS, around 8€ per kg of foam with the assumption that the ODS content is 10%. Costs without prior recovery of the blowing agent are likely to be significantly lower (at least by 20€ per kg of ODS). Costs for recovery of ODS from boardstocks, spray foam or XPS foam are likely to be much higher, as this material is not easily identified and sorted out during demolition. However, given the limited field experience to date at recovering construction foam, it is difficult to assess the economic feasibility with certainty.

11.5. RELEVANCE TO THE 70% TARGET

As shown previously, ODS containing foam represent a relatively small fractions of C&D waste (less than 0.05%). Although few specific data is available on this fraction in the studied MS, this is confirmed by data from Germany, where all insulation materials are estimated to represent 0.1% of the total weight C&D waste entering waste management facilities.

Technical and economical analysis shows that the recycling of plastics and metals from insulation materials is likely to be very costly, because of the necessity to remove and destroy ODS prior to any further treatment. In many cases, incineration is the most cost-effective treatment. However, this analysis is based on very limited experience of insulation foam recycling, as this practice is currently almost non-existent.

Given the relatively small amount of ODS when compared with other CDW streams, the re-use, recycling and recovery target established in the Waste Framework Directive is not the main driver for a secure disposal of ODS. However, the 70% target could indirectly influence ODS recovery and foam recycling, as it can act as a trigger to incentivise selective demolition or deconstruction, better reporting and characterisation of the C&D waste flow, which are keys to the appropriate sorting of C&D waste fractions

[174] [ICF, 2010], based on TEAP 2009

12. APPENDIX I: HAZARDOUS SUBSTANCES PRESENT IN C&D WASTE

In this appendix, five main hazardous substances were identified as possible contaminants of C&D waste fractions and hinder their recovery: asbestos, lead based paints, phenols, polychlorinated biphenyls (PCB) and polycyclic aromatic hydrocarbons (PAH). These substances are presented in appendix contrary to the other fractions that can be found in the C&D waste stream because of the general lack of information. Indeed, even if organisations have been initially identified and contacted, they turned out to be either not concerned by the issue or did not answer.

12.1. Asbestos

12.1.1. Definition

Asbestos refer to six fibrous minerals that are part of two major mineral groups:

- Chrysotile, known as white asbestos, is part of the serpentine mineral group. It represents approximately 90% of worldwide asbestos usage (even 95% in the USA).
- Amosite, crocidolite, anthophyllite, tremolite and actinolite, known as brown or blue asbestos, are part of the amphibole mineral group. Amosite is the second most likely type of asbestos to be found in buildings.

These minerals have extraordinary tensile strength, conduct heat poorly and are relatively resistant to chemical attack. Natural sources are important, because asbestos minerals are widely spread throughout the earth's crust and are not restricted to the few mineable deposits.

12.1.2. Applications

At the beginning of the 20th century, the process for combining asbestos fibres with cement to produce asbestos-cement was invented. Asbestos-cement is a material which had excellent technical properties and could be used for a wide range of applications which took advantage of its durability, fire resistance, and ease in processing, forming, installing, and overall economic benefits. These special chemical and physical properties, which make it virtually indestructible, accounted for its popularity in the building industry.

Asbestos was widely used in Europe between the 1940s and 1980s in thermal insulation, fire protection and a whole array of building materials such as: siding shingles, flat sheets, roofing shingles, and corrugated sheets[175]. These asbestos-cement products lent themselves to rapid

[175] www.nps.gov/history/hps/tps/recentpast/asbestosarticle.htm

construction techniques and, therefore, were particularly useful for lightweight housing and industrial buildings. The following table summarises the very large array of products that are made of asbestos in the construction sector.

Table 39 – Asbestos containing building materials

Acoustical plaster	Flexible fabric connections
Adhesives	Flooring backing
Asphalt floor tile	Heating and electrical ducts
Base Flashing	High temperature gaskets
Blown-in insulation	HVAC duct insulation
Boiler Insulation	Joint compounds
Breaching insulation	Laboratory gloves
Caulking/putties	Laboratory hoods
Ceiling Tiles and Lay-in	Table tops
Panels	Packing materials
Cement pipes	Pipe insulation
Cement siding	Roofing felt
Cement wallboard	Roofing shingles
Chalkboards	Spackling compounds
Construction Mastics/	Spray-applied
Adhesives	Insulation
Decorative Plaster	Taping compounds (thermal)
Ductwork	Textured paints/ coatings
Electric wiring insulation	Thermal paper
Electric panel partitions	Products
Elevator brake shoes	Vinyl floor tile
Elevator equipment	Vinyl sheet flooring
Panels	Cooling towers
Fire blankets	Vinyl wall coverings
Fire curtains	Wallboard
Fire doors	
Fireproofing materials	

12.1.3. Legal aspects

Since January 1st 2005, the use of asbestos is banned within the entire EU[176].

Asbestos is restricted in the EU through specific legislation and the new chemical policy for the European Union, known as REACH (Registration, Evaluation and Authorisation of Chemicals). The following table summarises the ban years at the national level for the EU-27. Most MS (16 in total) have acted before the decision was taken at the European level to ban chrysolite[177] with the effective deadline set for January 1st, 2005. The use of asbestos has been banned ever since for the construction of new projects.

[176] Substitute materials include: fibreglass insulation (the most common insulation material, which may have a similar toxicity as asbestos), stone and glass wool, polybenzimidazole fibre (often used by fire departments and space agencies). Asbestos-cement is replaced by organic fibres reinforced concrete.

[177] It was already illegal to place on the market and use all types of asbestos fibres other than chrysotile, including 14 categories of chrysotile-containing products within the EU.

Table 40 – Chronology of national asbestos bans
(Source: International Ban Asbestos Secretariat[178])

Country	Asbestos ban year	Comments
Austria	1990	on chrysolite
Belgium	1998	on chrysolite
Bulgaria	January 1st 2005	on imports, production and use of all asbestos fibres
Cyprus	January 1st 2005	on chrysolite under EU deadline[179], other forms of asbestos having been banned previously
Czech Republic	January 1st 2005	Ibid.
Denmark	1985	all forms of asbestos
Estonia	January 1st 2005	on chrysolite under EU deadline, other forms of asbestos having been banned previously
Finland	1992	on chrysolite with exceptions
France	January 1st 1997	on all types of asbestos
Germany	1993	on chrysolite with minor exceptions
Greece	January 1st 2005	on chrysolite under EU deadline, other forms of asbestos having been banned previously
Hungary	January 1st 2005	Ibid.
Ireland	2000	on chrysolite with exceptions
Italy	1992	on chrysolite with some exceptions until 1994
Latvia	2001	on asbestos with exemption for asbestos products already installed that must be labelled
Lithuania	January 1st 2005	on chrysolite under EU deadline, other forms of asbestos having been banned previously
Luxembourg	2002	on chrysolite, crocidolite and amosite having been banned under earlier EU directives
Malta	January 1st 2005	on chrysolite under EU deadline, other forms of asbestos having been banned previously
Netherlands	1991	the first of a series of bans (with exceptions) on various uses of chrysotile
Poland	1997	on asbestos
Portugal	January 1st 2005	on chrysolite under EU deadline, other forms of asbestos having been banned previously
Romania	January 1st 2005	Ibid.
Slovakia	January 1st 2005	Ibid.
Slovenia	1996	on asbestos-cement products
Spain	2002	on chrysolite, crocidolite and amosite having been banned under earlier EU directives
Sweden	1986	the first of a series of bans (with exceptions) on various uses of chrysotile
United Kingdom	1999	on chrysolite with minor exceptions

178 www.ibasecretariat.org/chron_ban_list.php
179 Commission Directive 1999/77/EC [EC, 1999]sets the deadline for the prohibition of chrysotile use, with one minor derogation, as January 1, 2005

As a consequence of the ban, there is no more production and consumption in Europe today.

The decrease of the European consumption was progressive. In 1983, the asbestos consumption in Europe was of 4 million tonnes[180], mainly chrysolite (only 5% of the total asbestos production was in the form of amphibole asbestos[181]). In 1999, following the bans in many MS anticipating the European decision, the same consumption decreased to 60,000 tonnes, which represented 3.2% of the total worldwide consumption (1.849 million tonnes)[182] (Greece itself was producing 83% of this amount with 50,000 tonnes). This consumption reached 13,000 in 2003, 4,000 tonnes in 2004 and 0 in 2005. All industrial use of asbestos have ceased ever since within the EU.

In many industrialised countries most asbestos was used in the building sector. In most Western European countries, the building sector represented between 70 to 90% of the total usage of asbestos.

Though asbestos is banned at the European level, it is still used in other parts of the world such as developing countries. In 2006, 2.3 million tons of asbestos were mined worldwide, in 11 or 12 countries. Russia was the largest producer with about 40.2% world share followed by China (19.9%), Kazakhstan (13.0%), Canada (10.3%), and Brazil (9.9%)[183].

12.1.4. WASTE GENERATION AND TREATMENT OPTIONS

No statistics about demolition asbestos waste (quantities and destinations) are available at the EU-27 level.

Asbestos waste from construction activities is not generated anymore as asbestos has been banned since January 2005. However, asbestos has been widely used in the past for the construction of all kinds of buildings which are gradually reaching their end of life. As a consequence, modification, repair, maintenance and demolition activities are generating asbestos waste that raises major concerns and have to be handled and managed according to stringent specifications.

Asbestos is classified as hazardous waste. According to the List of Waste, a waste is classified as hazardous if one or more substances classified[184] as very toxic at a total concentration superior or equal to 0.1 % is present. Asbestos containing waste is therefore classified as hazardous if it contains more than 0.1% asbestos.

Demolition asbestos waste is mainly disposed of in landfills or treated through thermal destruction.

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180 www.euro.who.int/document/aiq/6_2_asbestos.pdf

181 [Brondeau, 2009] <www.inrs.fr/inrs-pub/inrs01.nsf/IntranetObject-accesParReference/FT 145/$File/ft145.pdf>

182 [Salvatori]<www.actuaries.org/ASTIN/Colloquia/Berlin/Salvatori_Santoni_Michaels.pdf>

183 [BGS, 2008]

184 Referring to [EC, 1967]

Though asbestos is classified as hazardous waste, it may be landfilled in non-hazardous landfills as stated in Council Decision 2003/33/EC[185]. The recent implementation of section 2 on establishing criteria and procedures for the acceptance of waste at landfills has permitted (from 16th July 2005) the landfilling of construction materials containing asbestos and other suitable asbestos waste in landfills for non-hazardous waste. The following requirements must be fulfilled by those landfills:

- the waste contains no other hazardous substances than bound asbestos, including fibres bound by a binding agent or packed in plastic,
- the landfill accepts only construction material containing asbestos and other suitable asbestos waste. These wastes may also be landfilled in a separate cell of a landfill for non-hazardous waste, if the cell is sufficiently self-contained,
- in order to avoid dispersion of fibres, the zone of deposit is covered daily and before each compacting operation with appropriate material and, if the waste is not packed, it is regularly sprinkled,
- a final top cover is put on the landfill/cell in order to avoid the dispersion of fibres,
- no works are carried out on the landfill/cell that could lead to a release of fibres (e.g. drilling of holes),
- after closure a plan is kept of the location of the landfill/cell indicating that asbestos wastes have been deposited,
- appropriate measures are taken to limit the possible uses of the land after closure of the landfill in order to avoid human contact with the waste.

No limits are specified regarding the amount of this waste type that can be disposed of. No information of the actual implementation of these requirements could be gathered for this report.

Recycling through thermal destruction (also referred as vitrification of asbestos waste[186]) seems to be the only recycling technique currently available and is described below. Asbestos can be recycled by transforming it into harmless silicate glass. A process of thermal decomposition at 1000–1250 °C produces a mixture of non-hazardous silicate phases, and at temperatures above 1250 °C it produces silicate glass (asbestos is supplied to the furnace and withdrawing molten glass is withdrawn). The furnace is advantageously operated at a pressure less than atmospheric pressure. No quantitative data on the importance of recycling was identified.

Microwave thermal treatment can be used in an industrial manufacturing process to transform asbestos and asbestos-containing waste into porcelain stoneware tiles, porous single-fired wall tiles, and ceramic bricks.

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185 [EC, 2002]
186 www.freepatentsonline.com/EP0145350.html

12.1.5. ENVIRONMENTAL AND HEALTH ISSUES

The main concerns linked to asbestos contaminated C&D waste treatment are linked to human health.

- **In general**

Asbestos started to be recognised as a cause of occupational disease in the 1920s, but it was only in 1960 that a Welsh researcher studying mesothelioma[187] cases among workers of an asbestos mine in South Africa, finally proved the direct link between asbestos and mesothelioma, now known to be a "signature disease" of asbestos (i.e., it is presumed to occur only after exposure to asbestos).

All six forms of asbestos are classified as class 1 carcinogens, namely substances that can lead to cancer. Inhaling asbestos fibres can result in asbestosis[188], which is scarring of the lung tissue, lung cancer and mesothelioma, which is cancer of both the membrane sacs housing the lungs and the membrane lining of the abdominal cavity. With lung cancer, 95 % of patients are incurable, and no treatment is available for mesothelioma.

According to the association of asbestos exposure and malignant mesothelioma, approximately 80% of mesothelioma patients have a long history of asbestos exposure.

Health risks were shown to be greater during mining and production processes, but minimal during installation and use of asbestos-cement products. The following table estimates the risk of developing lung cancer linked to asbestos related activities.

Figure 9 - Increase in the relative risk of lung cancer depending on the type of activity (Source: www.euro.who.int/document/aiq/6_2_asbestos.pdf)

K_L per 100 F*year/ml	Type of activity
0.04	mining and milling
0.045	mining and milling
0.06	friction material
0.1	factory processes
(M) 0.4-1.1	factory processes
(F) 2.7 [a]	factory processes
0.2	asbestos-cement
0.07	textiles (before 1951)
0.8 [a]	textiles (after 1950)
6(M) 1.6 [a]	textiles
1.6	textiles
1.1	insulation products
1.5	insulation

The risk of exposure depends on both the concentration of fibres in a product and how 'firmly bound' the material is. The bound being released when breaking the asbestos based products during the demolition process.

[187] Rare form of cancer that develops from the protective lining that covers many of the body's internal organs, the mesothelium. It is usually caused by exposure to asbestos
[188] Slowly developing form of lung cancer by the inhalation of asbestos dust and/or long exposure

According to the International Labour Organisation (ILO), around 100,000 people[189] worldwide still die from exposure to asbestos every year and projections estimate to up to 250,000 asbestos-related deaths in Europe in the next 25 to 30 years[190].

The EU has passed several pieces of legislation focusing on the issue of exposure when working with asbestos:

- Directive 83/477/EEC on the protection of workers from the risks related to exposure to asbestos at work, passed in September 1983, stated that the 'limit values pertaining to in-air concentrates are. For chrysotile: 0.60 fibres per cm^3 for an eight-hour reference period; for all other forms of asbestos: 0.30 fibres per cm^3 for an eight-hour reference period'.
- In 1991, Directive 91/382/EEC amended the earlier directive to make the limit values more stringent.
- In 2003, Directive 2003/18/EC prohibited the extraction of asbestos as well as its manufacture and processing from April 2003.

In particular in the demolition sector

A high risk of exposure is present for workers in the demolition sector in the course of demolition, maintenance, renovation work and waste disposal[191].

Indoor asbestos dust originates from insulation material sprayed on steelwork or ceilings, asbestos plasters and low-weight insulation plates. In the case of asbestos-cement, the release of fibres to the environment is limited since the fibres are essentially "locked" in the cement matrix.

For demolition workers, it is important to follow recommended safety precautions by wearing approved facemasks and breathing instruments that filter out the asbestos fibres, by being certain that all areas of the body are covered and that extra care is taken to minimise contact with the outside of the clothes when working with asbestos.

Identification of asbestos containing constructions is crucial in order to avoid spreading asbestos into recycled products. Asbestos can be present in some asphalt materials, at least in asphalt products before its ban. This makes recycling of this asphalt impossible, with the additional difficulty that asbestos-containing asphalt cannot be easily identified. LBP (lead based paints)

12.1.6. Definition

LBP contain lead, a heavy metal, which is used as pigment. Lead (II) chromate (PbCrO4, "chrome yellow") and lead (II) carbonate (PbCO3, "white lead") are both utilised but the last one being the most common.

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[189] [EC DG, 2006]
[190] [Salvatori]
[191] [EC DG, 2006]

12.1.7. Applications

Lead was added to paint as pigment but also added to speed drying, increase durability, retain a fresh appearance and resist moisture that causes corrosion.

For the vast majority of uses, lead pigments have been replaced with titanium dioxide (which is also used in food colourings as well as in sunscreen).

12.1.8. Legal aspects

The use of LBPs in residential applications was officially banned under EU Council Directive 89/677/EEC[192] amending Council Directive 76/769/EEC[193].

Council Directive 98/24/EC[194] on the protection of the health and safety of workers from the risks related to chemical agents at work sets binding occupational exposure limits for lead and its ionic compounds in blood. Prior to this, lead-based paints were banned years before by national legislation in some MS.

12.1.9. Waste generation and treatment options

As LBPs were commonly applied on walls, C&D waste contaminated with lead based paints is mostly mixed with the inert fraction during the demolition process.

The treatment of LBP waste is associated to the management options for inert waste such as concrete. This waste stream is disposed of in lined landfills to prevent the potential release of pollutants to the environment.

Prior to demolition, existing techniques to remove LBP include thermal, chemical or mechanical scouring.

12.1.10. Environmental and health issues

Lead causes nervous system damage, stunted growth, and delayed development. It can cause kidney damage and affects every organ system of the body. It also is dangerous to adults and can cause reproductive problems for both men and women and even be lethal.

Lead contamination has been spread throughout the world by industrial emissions, gasoline and paints. This means that everybody on earth already has some level of lead contamination from environmental exposure.

Construction workers exposed to lead and their families are at risk of lead poisoning. The long-term effects of lead exposure are irreversible and are much more damaging to children than to adults.

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[192] [EC, 1989]

[193] This Directive prohibits the use of lead carbonates and lead sulphates in paints except for the restoration of works of art and historic buildings.

[194] [EC, 1998]

Lead dust or fumes are created when lead-based paint is dry scraped, dry-sanded, or heated during renovation or maintenance. Dust also forms when painted surfaces bump or rub together through normal use. Lead chips and dust can get on surfaces and objects that people touch. Settled dust can re-enter the air when people vacuum, sweep, or walk through it.

Some MS have drafted guidelines explaining the measures to be taken in order to protect health of construction workers dealing with lead contaminated materials[195]. Potentially contaminated buildings can be identified based on the construction date or using XRF technology. The uses of appropriate decontamination techniques, as well as wearing protective equipment, are crucial in order to avoid risks.

12.2. Phenols

12.2.1. Definition

Phenol is both a natural and man-made chemical in the form of a white crystalline solid which dissolves to form a corrosive solution.

The main chemical derivatives of phenol are bisphenol-A (BPA) (used to make polycarbonate PC) and epoxy resins (phenolic resins, caprolactam, alkylphenols, aniline and adipic acid).

12.2.2. Applications

The largest market for phenol is BPA which accounts for around 45% of demand[196]. The BPA market has been driven by the strong growth in polycarbonate resins, accounting for two-thirds of BPA demand.

BPA's other main application is epoxy resins which are used in high performance coatings, electrical-electronic laminates, adhesives, flooring and paving applications, and composites. In the long term the growth is expected to be 3% per year at the global scale.

The second largest outlet for phenol, accounting for 28% of demand, is phenolic resins which are largely used as durable binders and adhesives in structural wood panels and as binders in mineral wool insulation in the construction industry. A long term global growth of 3%/year is expected despite the economic decline in the construction sector.

Phenol is also used in foam insulation for its fire and thermal performance, its resistance to moisture, its strength while being light[197]. It is used for a large range a building applications such as roofing, cavity board, external wall board, plasterboard dry lining, systems, wall insulation, floor insulation and as a sarking board, therefore having a growing market share.

[195] http://www.oppbtp.fr/content/download/13475/87842
[196] www.icis.com/V2/Chemicals/9076136/phenol/uses.html
[197] [EPA] < www.epfa.org.uk/Pdfs/eng.pdf >

12.2.3. Legal aspects

Regulation (EC) 1488/94 sets out the risk assessment on substances of the European Priority lists among which phenol by assessing in priority the risks posed by the priority chemical to man.

The European producers of phenol have launched a consortium to register phenol and derivative substances under the REACH Regulation by December 2010[198]. Substances covered targeted are phenol, acetone, cumene, alpha-methyl styrene, acetophenone, di-isopropyl benzene, CHP and 'high-boiler'.

12.2.4. Waste generation and treatment options

Major releases of phenol are from industrial processes using or manufacturing phenol, as a component in certain industrial wastes, for example, coal tar products, and from the use of phenol-containing preparations.

Treated wood and insulation panels containing phenol can be treated by removing the contaminated surface area and then recycled by reintroducing them in the manufacturing process as developed in the dedicated chapter for each fraction. Other phenol contaminated C&D waste is disposed of in landfills.

Phenol is found occasionally in landfill leachate which may affect the groundwater quality through percolation. If e.g. phenolic foam is landfilled there will be some un-reacted phenols and acid that can be leached. Incineration of phenolic foam can also form toxic smoke.

12.2.5. Environmental and health issues

Phenol occurs naturally at low concentrations in the environment. Phenol is rapidly broken down in air (half is destroyed in under a day) and soil (usually completely destroyed in 2-5 days), but it can persist in water for longer than 9 days. Elevated concentrations of phenol may be found in air or water after releases from industry or the use of phenolic products. Water contaminated by landfill leachate may contain high concentrations of phenol. Typical concentrations for waters is below 100 parts per billion (ppb), but less than 1 ppb may be found in unpolluted surface and ground waters.

Phenol is toxic to aquatic animals and in general fish appear to be the most sensitive. Contamination of water by phenol could therefore harm aquatic organisms and ecosystems. Phenol does not appear to bio accumulate, i.e. there is little if any evidence that its concentration increases up the food chain. As a VOC it can be involved in reactions with other air pollutants that form ground-level ozone, which can cause damage to crops and materials as well as having potential effects on human health.

Phenol may cause genetic damage. Excessive exposure may affect the brain, digestive system, eye, heart, kidney, liver, lung, peripheral nerve, skin and the unborn child. The

[198] www.petrochemistry.net/phenol.html

inhalation, ingestion, or skin contact with phenol may cause severe injury or death. It is combustible and produces irritating, corrosive and/or toxic gases when burning.

12.3. PCB (Polychlorinated Biphenyls)

12.3.1. Definition

PCBs are a group of synthetic organic chemicals known as chlorinated hydrocarbons which include any chemical substance of the biphenyl molecule that has been chlorinated to varying degrees.

PCBs show extraordinary chemical stability and heat resistance.

12.3.2. Applications

PCBs were commercially produced world-wide on a large scale between the 1930s and 1980s (the end of the production of PCBs in industrialised Western countries). It is estimated that approximately 1.5 million tonnes of PCBs have been produced worldwide[199]. It is difficult to provide consistent quantitative data as uncertainties prevail regarding the imported amounts, the quantities still contained in equipments, buildings and other appliances.

Applications of PCBs are classified into two categories:

- Closed uses: dielectric fluids in electrical equipment such as transducers, capacitors (big industrial capacitors, but also small capacitors in household electrical appliances), heat transfer, hydraulic systems and power supply blocks of fluorescent lamps.
- Open uses: sealant industrial oils, plasticiser in paints and cements, stabilising adhesives, plastics, flame retardants and de-dusting agent.

Among all these applications, the major concerns for the construction sector are sealants used in a large variety of concrete buildings between 1955 and 1975: schools, gymnasium, swimming pools, hospitals, public and individual dwelling buildings, shopping malls and other business and industrial buildings[200].

Another important issue is related to PBCs as retardant in building foam. Brominated flame retardants (BFRs) are a group of chemicals which are added to many plastic products for the purpose of fire prevention. There are also additive flame retardants such as tris[1,3-dichloro-2-propyl] phosphate [TDCPP] and triphenyl phosphate [TPP], which are not chemically bonded to the products they are intended to protect.

[199] www.parlament.ch/f/suche/pages/geschaefte.aspx?gesch_id=20083926
[200] www.bag.admin.ch/themen/chemikalien/00228/00512/index.html?lang=fr

12.3.3. Legal aspects

In the 1970s, several countries limited the use of PCBs. In 1985, the use and marketing of PCBs in the European Community were very heavily restricted.

Directive 96/59/EC[201] requires the environmentally sound disposal of equipment containing PCBs before the 31st of December 2010 (with the exception of transducers with liquids containing between 50 and 500 parts per million of PCBs in mass). MS have to make an inventory of equipments containing PCBs and to adopt a disposal and decontamination plan for inventoried and non inventoried equipments.

The Commission has adopted a Community Strategy on Dioxins, Furans and PCBs to reduce their release to the environment and their introduction in the food chains.

12.3.4. Waste generation and treatment options

No sound and systematic data is available regarding the amounts of PCBs that are decontaminated and disposed of within the EU.

Disposal of waste products containing PCBs include:

- Decontamination i.e. decolouration, which is the treatment for the chemical decomposition of chlorine molecules
- C&D waste contaminated with PCBs can also be incinerated (with special flue gas treatment)
- Storage

The owners of equipment containing PCB have to treat them accordingly to the MS legal obligations.

12.3.5. Environmental and health issues

Incorrect disposal of equipment containing PCBs can result in continued release to the environment due to leakage and spills (for instance from landfill), therefore adding to the existing levels which are the consequence of past releases. Also incineration could create toxic flue gases.

Once released, PCBs can be transported over long distances through the atmosphere, persist in the environment and is able to concentrate through the food chain as they are liposoluble (accumulation in the fat) and resistant chemicals. PCBs have been detected in all environmental media (indoor and outdoor, surface and ground water, soil and food).

PCBs are classified as probable human carcinogens and produce a wide spectrum of adverse effects in animals and humans, including reproductive toxicity, teratogenicity and immunotoxicity. PCBs are toxic to fish and other aquatic organisms. Reproductive and developmental problems have been observed in fish at low PCB concentrations.

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[201] [EC, 1996]

12.4. PAH (Polycyclic Aromatic Hydrocarbons)

12.4.1. Definition

PAHs are a group of organic chemicals comprising two or more fused benzene rings. They are ubiquitous environmental contaminants formed mainly by the incomplete combustion of carbon-containing fuels such as wood, coal, diesel, and oil. Only anthracene and naphthalene are intentionally produced.

12.4.2. Applications

In the construction sector PAHs are included in wide array of products:

- concrete additives
- celluloid (plastic)
- solvents
- wood preservatives
- lacquers
- specialist paints
- coal tar epoxy paints
- coal tar polyurethane sealers
- damp-proofing materials
- waterproof membranes

For instance[202], in waste coming from insulation boards or sandwich panels for roof construction, PAHs can be found in bitumen, tar and asphalt that have been used as a waterproof layer in the production of those products. PAHs can also be found in chimneys or other smoke evacuation conducts, and contaminate the building materials.

12.4.3. Legal aspects

Regulation (EC) No 1881/2006[203] sets the maximum levels at EU level for PAH and in particular for benzo(a)pyrene.

Regulation (EC) No 333/2007[204] gives provisions for sampling and analysis methods for the official control of benzo(a)pyrene levels.

[202] Interview with expert Peter Jones, Independent consultant
[203] [EC, 2006]
[204] [EC, 2007]

12.4.4. Waste generation and treatment options

Such waste are generally mixed with other products during the demolition step and landfilled.

PAH contaminated C&D waste are disposed of in hazardous waste landfills. Leachate from landfills may contain PAH and are treated to avoid contamination.

C&D waste contaminated with PAH can also be incinerated (with special flue gas treatment).

12.4.5. Environmental and health issues

PAH are strongly adsorbed on the particulate matters of soils, sludge or sediments because of their strong hydrophobicity which makes them less bioavailable, thus limiting their bioremediation[205].

PAHs are known to be carcinogenic[206], mutagenic[207], and teratogenic[208]. Humans can be affected by breathing fumes from a hazardous landfill where PAH are disposed of, by eating contaminated food, or through skin contact[209].

12.5. General conclusion and recommendations

The amounts and nature of dangerous substances contaminating C&D waste are not well known at the present time, and an estimation of the total quantities and the related potential hazards is not possible. It is however clear that action is needed, as these substances might not only represent a threat to the environment and human health, but also, as a contaminant of C&D waste, hinder its recyclability. The 70% target itself might itself trigger better identification of these contaminants, as clean material is needed for most application of recycled C&D waste. Separation of waste streams at source could thus indirectly contribute to a better management of hazardous substances. These effects could be improved by addressing individually some of these contaminants and by improving controls by the authorities.

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205 cat.inist.fr/?aModele=afficheN&cpsidt=18791329
206 Quality of an agent that is likely to cause cancer
207 Quality of an agent that can induce or increase the frequency of mutation in an organism
208 Quality of an agent able to disturb the growth and development of an embryo or foetus
209 www.epa.gov/osw/hazard/wastemin/minimize/factshts/pahs.pdf

13. APPENDIX II: CASE STUDY GERMANY

Amounts of C&D waste	72.4 million tonnes of mineral waste in 2004 (883 kg per capita) Source: based on the monitoring reports of the construction industry (ARGE KWTB) that are derived from the general federal statistics and are said to be a reliable source.			
Waste factors	m³ of C&D Waste per m² of dwelling/usable space			1,17 m³/m²
	Gross density of C&D waste			2,0 t/m
Material composition of the C&D waste stream	Building demolition waste including concrete, bricks, tiles or mixtures thereof			69.8%
	Road way rubble			27.2%
	Construction site waste (including wood, glass, plastics, metals, insulation materials, mixtures of materials)			2.6%
	Gypsum based waste			0.4%
	Total			**100%**
	Source: based on the monitoring reports of the construction industry (ARGE KWTB)			
End of life options	Recycling	Other forms of material recovery (including backfilling – reported as "reuse" in German statistics)		Disposal
Rates	68.5%	22.9%		Landfill: 8.6%
	Source: based on the monitoring reports of the construction industry (ARGE KWTB)			
Past trends	Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal (1994) was crucial for the beginning of harmonised waste reporting and collection of data. Since then recycling and re-use rates have been high.			
Analysis of the current state	High recycling and re-use rates. Low landfill rates. However, monitoring of re-use of C&D waste on landfills difficult. Material that is reported as being re-used could also be landfilled.			
Towards the 70% target	The 70 % target is even exceeded by 10 % by the German draft for a new Act for Promoting Closed Substance Cycle Waste Management. Main challenges towards reaching the target: • Regulations (strict limits for concentration of certain substances in groundwater>limiting reusability of materials) • Lack of market demand for recycling material and low prizes			

13.1. SOURCES OF INFORMATION

- Reports and articles

  Arbeitsgemeinschaft Kreislaufwirtschaftsträger Bau (ARGE KWTB), 2007. 5. Monitoring-Bericht Bauabfälle

  Bernd Kirschbaum, 2008. Protokoll des Fachgesprächs, Geringfügigkeitsschwellenwert Vanadium“

  BRB, 2006. Richtlinien Recycling-Baustoffe

  Dr. Rolf Bracke, 1999. Arbeitshilfe zur Entwicklung von Rückbaukonzepten im Zuge des Flächenrecyclings

  BayLfU, 2003. Kontaminierte Bausubstanz Erkundung, Bewertung, Entsorgung

  TuTech Innovation, 2006. C&D Waste Management in Germany

  Senatsverwaltung für Gesundheit, Umwelt und Verbraucherschutz, 2009. Abfallwirtschaftskonzept für Siedlungs- und Bauabfälle sowie Klärschlämme Planungszeitraum bis 2020.

  Statistisches Bundesamt, 2007. Abfallentsorgung

  Statistisches Bundesamt, 2005. Abfallentsorgung

- Websites

  Arbeitsgemeinschaft Kreislaufwirtschaftsträger Bau, www.arge-kwtb.de/

  Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), www.bmu.de/english/waste_management/aktuell/3865.php and www.bmu.de/files/pdfs/allgemein/application/pdf/krwg_eckpunkte_bf.pdf

  Fachagentur Nachwachsende Rohstoffe e.V. (FNR), www.bio-energie.de/gesetzeslage/altholzverordnung.html

  Umweltbundesamt, www.umweltbundesamt.de/abfallwirtschaft-e/abfallstatistik/index.htm

  Umweltkolleg, www.umweltkolleg.de/index-ateien/umweltkollegErsatzbaustoffV.htm

13.2. CONTACTS

Table 41 – Identified contacts for the case study on Germany

Full name	Name of organisation	Type of organisation	Function
W. Sodermanns-Peschel	Deutscher Abbruchverband e.V.	Federation for demolition waste	Head of Environment and Technology
Michael Heide	Bundesgütegemeinschaft Recycling-Baustoffe e.V. (& European Quality Association for Recycling EQAR)	Federation for recycling of building material	Managing Director
Gerhard Pahl	Bundesvereinigung Recycling-Baustoffe e.V. (BRB)	Federal Union of Recycling Building Materials	Director of the department
Berthold Schäfer	Deutscher Beton- und Betontechnik-Verein E.V.	German Concrete Union	Director of the department for environment engineering

13.3. CONTEXT

The territory of Germany covers 357,021 km^2 and houses a population of around 82 million people. It consists of 16 states (Bundesländer).

Figure 10 – Germany and the Länders (Source: http://www.th-o.de/bundeslaender/)

Construction Sector

Product stewardship is the basis of waste management policy in Germany. Thus, producers and distributors must design their products in such a way as to reduce waste occurrence and allow environmentally sound recovery and disposal (cf. BMU). In order to collect all waste separately and to reintroduce it into the economic cycle the Closed Substance Cycle and Waste Management Act was enforced in the mid-90s.

As the end of 2007, 250,000 people in Germany worked in waste management, the annual turnover of that sector exceeding 50 billion Euros (cf. BMU).

There is a clear shift in waste volumes with regard to disposal and recovery. The recovery rate of C&D Waste is very high and makes up for a huge share in the total volume of waste which is recovered (BMU). This is partly due to Germany's high material, energy and labour, and waste disposal costs but also to its regulations, that focus on the complete material cycle, working towards a closed loop substance cycle in C&D, known as "Kreislaufwirtschaft" (cf. TuTech Innovation). Furthermore, everybody involved in designing and constructing buildings is obliged to consider the entire life cycle of materials.

In Germany, the primary responsibility for ensuring the proper treatment of C&D waste is in the hands of local authorities. Meanwhile, the Länder are responsible for the implementation and enforcement of regulations meant to achieve C&D waste goals set by higher levels of government, particularly the Federal government of Germany and the EU.

Germany's Ministry of the Environment, Nature Conservation and Nuclear Safety in cooperation with the Federal Environmental Agency, is responsible for legislation on C&D waste at the national level. This includes the provision of technical instructions regarding the disposal of waste, the setting of targets and goals and transposition of EU Directives. In case of conflicts, all federal level legislation overrules regional and local legislation (cf. TuTech Innovation).

The states or "Länder" are responsible for the implementation and specifications of federal legislation at their level. They are also in charge of the enforcement of regulations on C&D waste and of supervising the proper operation of waste treatment and disposal facilities.

At the local level, the municipalities take care of administration and issue demolition and construction permits. Those sometimes include detailed deconstruction plans and recycling specifications of the building's materials. While household waste and its collection, recycling and the provision of the disposal infrastructure falls under the local authorities' responsibility, commercial waste such as C&D waste is solely the responsibility of the waste's owners. The local authority ensures this task is performed according to federal and state legislation and is responsible for initiating prosecution against offenders (cf. TuTech Innovation).

13.4. POLICY AND STANDARDS OVERVIEW

13.4.1. KEY EUROPEAN POLICY DRIVERS

For Germany, the Directive 2008/98/EC can be considered a driver on national waste policies. The European directive triggered the draft for a new Act for Promoting Closed Substance Cycle Waste Management, which is still under discussion. This draft transposes the European Directive on Waste into German law and harmonises the definitions of waste terminology between the EU and Germany. It can be considered an overhaul of a similar law from 1994. The European target set by Directive 2008/98/EC of recycling at least 70% of C&D waste generated for 2020, is even exceeded by 10% in the draft.

13.4.2. KEY NATIONAL AND REGIONAL POLICY DRIVERS

In a voluntary commitment of 1996, the German construction industry, Arbeitsgemeinschaft Kreislaufwirtschaftsträger Bau (ARGE KWTB) promised the Federal Environment Ministry that it would cut in half the amount of landfilled yet recyclable construction waste by the year 2005. The reference year was 1995, when the recyclable construction waste that was landfilled accounted for 60 % of the total mineral waste (excluding excavation material). That means that only 40 % of the total amount (51 million tonnes) was re-used or recycled in 1995.

In the following ten years, ARGE KWTB produced 5 biannual monitoring reports in which the development of mineral C&D Waste was documented. The last report was published in 2007 and is based on figures from 2004. It also provides a summary of the whole project.

The report stated an over-accomplishment of the objectives. In other words: to comply with the commitment, it would have been sufficient to reduce the landfilled recyclable material to 30 % of the total 78.6 million tonnes mineral waste and recycle 70 %. However, the average recycling rate was slightly higher than 70 % and it was complemented by another 18.6 % re-use rate for the material. Thus, on average only 11.3 % (i.e. 8.9 million tonnes) of mineral waste were landfilled during the project phase.

As such, the recovery ratios promised in the voluntary commitment can be considered to have been met.

This seems to be a remarkable accomplishment in the sector. It still needs to be underlined that the landfilled material could also potentially be recycled and that this achievements excludes excavation material (139.4 million tonnes per year on average) and any other non-mineral construction material such as glass, metal etc. Moreover, the evolution that took place has to be put in perspective with the lack of high quality data until 1995 (cf. Schäfer). In fact, a serious collection of data according to a coding system started only after 1995 when the Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal had been enforced. Before that, a proper compilation of data was not possible. The relatively high amount of landfilled material might not have reflected reality. It might have been the case that even before 1995 much more material was re-used or recycled, but that this was not properly documented (cf. Schäfer).

A formal continuation of this initiative is not planned at the moment.

13.4.3. Legal documents

Table 42 – Legal documents dealing with waste management

Legislation	Year of implementation	Legal requirements
Kreislaufwirtschafts- und Abfallgesetz (Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal)	1994	The law set principles for the development of waste management towards a closed loop economy (Kreislaufwirtschaft). It established a new hierarchy for waste treatment where the avoidance of waste is better than the recycling of waste, but recycling is more preferable to the disposal of waste. The disposal of waste is only permitted when recycling is much more expensive or impossible and the waste is unavoidable. Environmentally compatible disposal of waste shall be assured. Besides, this Act also established the responsibility of the producers for the waste arising from their products.
Untergesetzliches Regelwerk zum Kreislaufwirtschafts- und Abfallgesetz (Legislative Provisions that Implement the Closed Substance Cycle and Waste Management Act)	1996	This provision complete the above mentioned law from 1994 and includes 1) Ordinance on the European Waste Catalogue 2) Ordinance on the Furnishing of Proof 3) Ordinance on Transport Licences 4) Ordinance on Specialised Waste Management Companies
Gewerbeabfallverordnung - Verordnung über die Entsorgung von gewerblichen Siedlungsabfällen und von bestimmten Bau- und Abbruchabfällen (Commercial Wastes Ordinance - CWO)	2003	Regulates the separation of certain waste types from commercial enterprises that is suitable for recycling and the construction waste sector.
Verordnung zur Vereinfachung des Deponierechts (Ordinance Simplifying Landfill Law)	2009	The Ordinance aimed at simplifying existing legislation and transposing of the corresponding European requirements into national law, by respecting the principle to landfill only biologically in-active waste. The Ordinance regulates the construction, operation, closure and aftercare of landfill sites. Thus, only specific kinds of (non-hazardous) types of waste can be land filled. In the Ordinance the responsibility of the waste producer was strengthened significantly, compared to older requirements. The operator of the landfill site therefore assumes the role of controlling the declaration made by the waste producer. The Ordinance also roughly prescribes ways of required sealing and closure techniques aiming at preventing harmful emissions into the environment, particularly ground water.

Legislation	Year of implementation	Legal requirements
Entwurf der Verordnung über den Einbau von mineralischen Ersatzbaustoffen in technischen Bauwerken - Ersatzbaustoffverordnung (Draft Ordinance on substitute construction materials)	second draft 2010 (implementation date not yet determined)	This Ordinance will determine the harmless re-use of excavation material, mineral waste and recycling material.
Entwurf des Kreislaufwirtschafts-Gesetzes (Draft for a new Act for Promoting Closed Substance Cycle Waste Management)	draft 2010 (implementation date not yet determined)	The general idea of the new legislation is to: 1) keep the established structures and elements of the Act of 1994 2) transpose the European Directive on Waste into German law and harmonise the definitions of waste terminology between the EU and Germany 3) to improve resource efficiency of the Closed Substance Cycle Waste Management The last point is of vital importance and under discussion between politicians and stakeholders. In order to improve resource efficiency, it is intended to increase recycling rates. Until 2020 the re-use quota (excluding energetic re-use) should be 80 % (instead of 70 % required by the EU). Policy makers argue that the highly developed structures of waste disposal in Germany allow for this ambitious goal (cf. http://www.bmu.de/files/pdfs/allgemein /application/pdf/krwg_eckpunkte_bf.pdf) The industry, however, is concerned because for them high recycling quotas stand in contradiction to environmentally strict rules for recycling; exclusion of certain substances in recyclable material, for instance (cf. interview Sodermanns).

13.4.4. Standards

Table 43 – Standards in place in the construction sector

Standard	Legally binding	Requirements	Source
Das deutsche Gütesiegel nachhaltiges Bauen (German Sustainable Building Certificate)	Voluntary	It rates the ecological and economic sustainability but also the socio-cultural and process quality of a building design. Criterion 42 has particular relevance for C&D Waste. It focuses on prevention, dismantling and recycling of (waste) materials in buildings. The certificate also considers including criteria for the building site (such as reduction of noise and dust in criterion 48).	Deutsche Gesellschaft für Nachhaltiges Bauen e.V German Sustainable Building Council: http://www.dgnb.de /fileadmin/downloads/DGNB_Handbuch_44S_20090423_online_DE.pdf
Technische Liefer-bedingungen für Mineralstoffe im Straßenbau (Gesteinskörnungen und Werksteine im Straßenbau) - TL Min–StB 2000 (Technical delivery conditions for mineral materials in road construction)	Mandatory	The "Technischen Lieferbedingungen für Mineralstoffe im Straßenbau" (TL Min–StB) contains construction related requirements for natural and artificial aggregates and stones used for the constructions of roads. They also contain information for water quality management and control.	FGSV-Verlag: http://www.strassenbaudigital.de /inhalt/beispiele/docs/2413/2413.html
BRB-Richtlinien (Recycling Building Materials guidelines)	Voluntary	The guidelines aim at assuring the quality of the recycling material so that it can fulfil the required functions. They also document the technical applications of these products while considering environmental and constructional rules.	Bundesvereinigung Recycling-Baustoffe e.V. -BRB (Office Federal Union of Recycling Building Materials):http://www.recyclingbaustoffe.de/pdf/BRBRichtlinien-neu.pdf
Multiple DIN standards in the construction sector	Mandatory	Establishing prestandards and/or standards for construction materials and components including standards for methods of test, planning and design (e. g. Eurocodes for structural engineering).	Building and Civil Engineering Standards Committee - NABau (a division of the DIN Deutsches Institut für Normung e. V.): http://www.nabau.din.de/cmd?workflowname=committeeDinSpecSearch&level=tpl-spec&committeeid=54738847&search_grem_akt=54738847&search_level=d|i&searchDisplay=-tabelle&languageid=en

13.5. QUANTITATIVE DATA

13.5.1. TOTAL C&D WASTE ARISING AND CHARACTERISATION

Table 44 - C&D waste input for waste management plants – 2005 & 2007(Source: Statistisches Bundesamt)

C&D waste fractions (in 1000 t)	2005	2007
Total C&D Waste arising	**38,940**	**42,656**
Total non-hazardous C&D waste	**31,634**	**36,746**
Bricks, tiles and ceramics	4,705	4,380
Concrete	607	619
Other mineral waste (stone, sand, gravel and other aggregates)	3,012	2735
Bituminous mixtures, without coal tar	351	316
Wood	2,514	2,798
Plastics	64	64
Metal	4,367	6,179
Glass	101	203
Gypsum	103	218
Excavation material	15,755	19,169
Insulation materials	56	66
others	N/A	N/A
Total hazardous C&D waste	**6,638**	**5,909**
Contaminated excavation material	4,539	3,664
Mixtures of, or separate fractions of concrete, bricks, tiles and ceramics containing dangerous substances	1,003	919
Glass, plastic and wood containing or contaminated with dangerous substances	537	578
Coal tar and tarred products	143	176
cables containing oil, coal tar and other dangerous substances	2	4
metal waste contaminated with dangerous substances	2	4
Gypsum-based construction materials contaminated with dangerous substances	413	566
Hg containing waste	N/A	N/A
Other	N/A	N/A

In Germany, gathering of data on waste is managed in a decentralised way, by the Länder. The processing and publication of data is then done in cooperation between the federal and the states statistical offices.

Regularly, operators of waste management plants are asked about the origin, the nature and the disposition of the waste treated. The yearly input of the C&D Waste into these plants for 2005 and 2007 is displayed in the table above.

The table displays only one fraction of the annual C&D waste. It excludes material used for landfill construction, material that is used in mining, and it also excludes material going to asphalt production plants, for instance.

The relatively high amounts of wood and metal in the table might seem surprising. One explanation for this phenomenon is that the operators of waste management plants do sometimes not strictly adhere to coding the treated waste according to the origin, but only look at the material itself. As a result, the statistics for wood and metals can include waste coming from other industrial sectors, as well.

The aforementioned construction industry group, ARGE KWTB, is issuing regular monitoring reports in which very reliable statistics on the generation and the recycling of construction waste can be found. In this report ARGE KWTB make reference to non-hazardous C&D Waste splitting it up into the following categories:

Table 45 – Waste categories included in the C&D waste stream

Waste category	Codes included
Debris (building demolition waste including concrete, bricks, tiles or mixtures thereof)	17 01 01 17 01 03 17 01 02 17 01 07
Road way rubble	17 03 02
Excavation*	17 05 04 17 05 06 17 05 08
Construction site waste	17 02 01 17 02 02 17 02 03 17 04 17 06 04 17 09 04
Gypsum based waste	17 08 02

*Excavation material is included in the table for the definition of waste, but excluded from the pie charts below.

For Germany, no uniformly used definition on C&D waste could be found.

However, one possible definition for C&D waste is based on the establishment of the 5 waste categories mentioned. It includes mostly mineral waste – the main component of C&D waste (cf. Bracke).

Figure 11 - Origin of total C&D waste in Germany for 2004, excluding excavation material (Source: Monitoring-Bericht Bauabfälle)

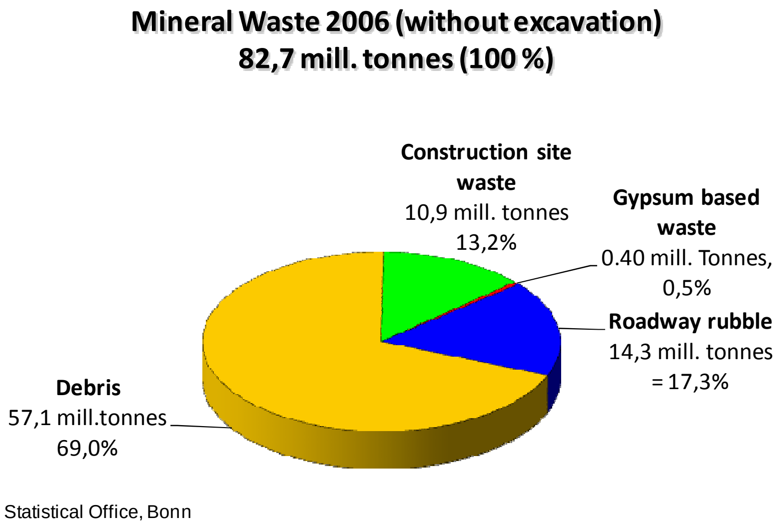
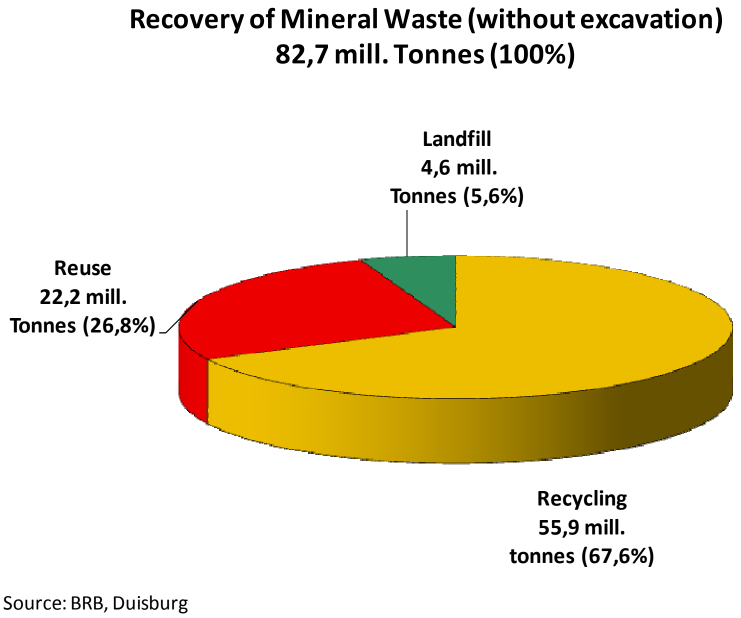


Figure 11 shows the repartition of mineral C&D Waste by origin and it becomes clear that debris and roadway rubble represent the major part of this waste. How they are recovered (recycled, re-used) can be seen below.

13.5.2. Recycling and recovery of C&D Waste

Figure 12 - Recovery of total C&D waste in Germany for 2006, excluding excavation material (Source: Monitoring-Bericht Bauabfälle)



As it can be observed in the above figure, more than 90% of the mineral waste are recovered, i.e. either re-used or recycled, whereby recycling means that the mineral waste undergoes a treatment in special plants (sorting, washing, crushing etc.) so that it can be re-used afterwards. Figure 4 and 5 show which amounts and percentage of the biggest components of the mineral waste, i.e. debris and roadway rubble, are re-used for mining, for landfills and by public authorities. It also shows the amount landfilled and recycled. Public authorities often use debris for the construction of infrastructure such as roads, for the construction of landfills and for landscaping. The re-use of material in landfills refers to building operations done on landfills, for example: construction of roads and trails or dams. Backfilled material is accounted for in the category “re-used” in the framework of restoration measures.

Figure 13 - Re-use and Disposal of Debris in Germany for 2004 (Source: Monitoring-Bericht Bauabfälle)

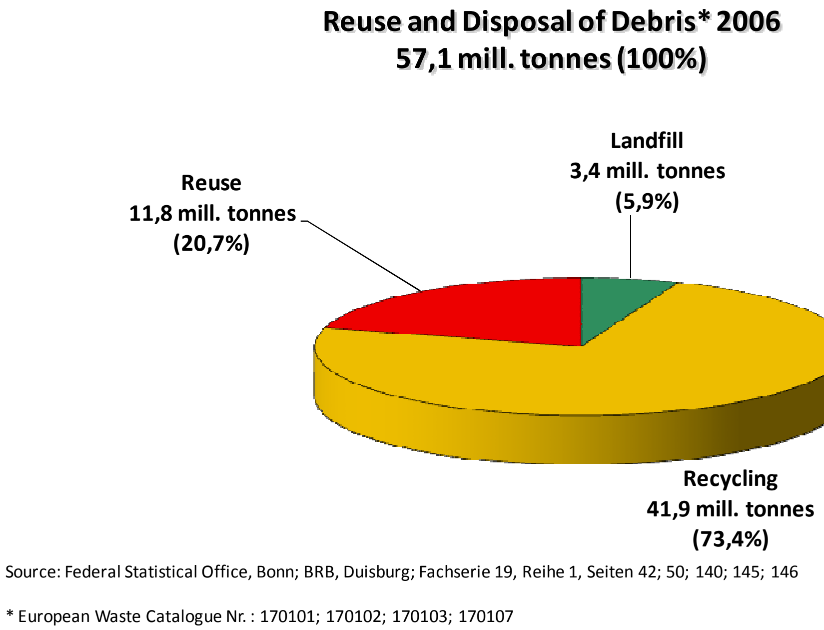
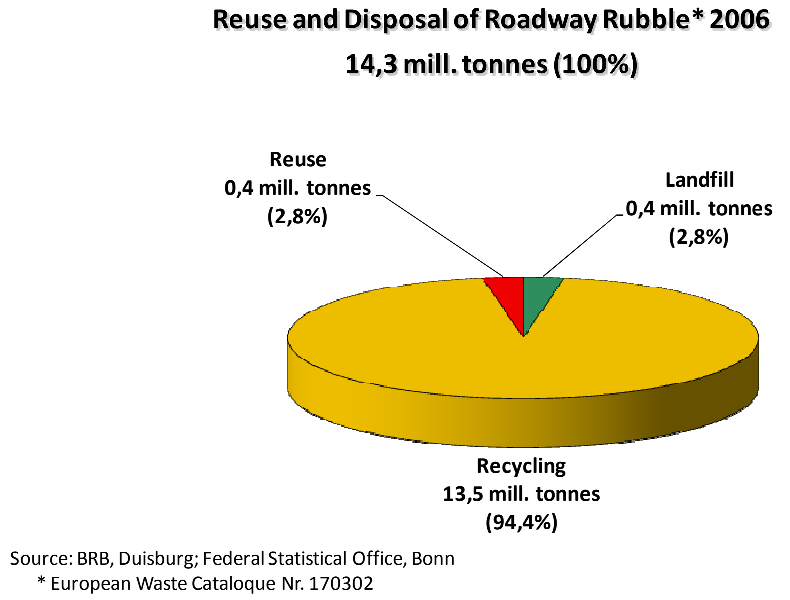


Figure 14 - Re-use and Disposal of Roadway Rubble in Germany for 2004 (Source: Monitoring-Bericht Bauabfälle)



The detailed repartition between re-use and disposal of construction site waste and gypsum based waste are not shown here since they only represent very small fractions of the total mineral waste.

13.6. PRACTICES IN C&D WASTE MANAGEMENT

13.6.1. CURRENT PRACTICES IN C&D WASTE MANAGEMENT

One of the most frequently used waste management practices in Germany, is the so called "**controlled deconstruction**" (kontrollierter Rückbau), sometimes also referred to as systematic, selective or recyclable demolition. No financial incentives for deconstruction were identified.

This treatment requires the removal of contaminated material before demolition. The goal is the re-use of a high percentage of the material. Therefore windows, doors, heating systems etc. are taken out of the building and can sometimes be re-used as such. Furthermore, the building materials are correctly sorted by material (bricks, concrete, wood etc.) on site.

Before controlled demolition is carried out, a detailed planning including a concept for controlled demolition and disposal or recovery has to be performed.

Figure 15 - Controlled deconstruction (Source: Kontrollierter Rückbau / BayLfU 2003)

This practice that replaced the traditional wrecking ball is very common in Germany and other German speaking countries, such as Austria, Switzerland or in parts of northern Italy. Those countries and particularly Germany have very high quotas in this technique (although no quantitative data is available).

13.7. Past and future trends of C&D waste, drivers and barriers

13.7.1. Trends in C&D waste generation and composition

No quantitative statement on the future waste generation and composition for Germany as a whole can be made at this point.

However, a report from the Senate of Berlin allows for a summary of the past and a tentative outlook on the future and states that the capital generally reflects the country as a whole.

A strong trend in the past was the decrease of material that ended up in landfills. Since 1996, the percentage of Berlin's C&D waste that was re-used in some way has continually grown and maintains a 98% level since 2000.

The total generation of C&D waste was and is dependent of the economic activity in the construction sector. The percentage of landfilled waste will depend on the market demand for recycling material and the development of techniques for (better) waste separation and waste treatment. (It will also depend on specific regulations, which are described in 1.7.2.)

The report forecasts that in 2020 the C&D waste occurring in Berlin will be around 5 million tonnes, i.e. approximately 1.5.tonnes per capita. Potential for development for the capital is seen in the way material is re-used, for example, using material in buildings rather than for land restoration or backfilling.

13.7.2. Barriers to the 70% goal

With over 90% of preparation for reuse, recycling and other forms of material recovery, Germany is one of the countries that have already achieved the targets set by the WFD.

- **Contradictory Regulations**

According to the draft for the new Act for Promoting Closed Substance Cycle Waste Management (cf. section 1.4.3.) recycling rates of C&D Waste will increase in the future. From the current 70 % approximately, they will have to go up to 80 %, if the requirements of the law should be fulfilled.

However, there are some concerns that the new “Grundwasserverordnung” (Ordinance on ground water) and the draft for the “Ersatzstoffverordnung” (Ordinance of substitute construction material) stand in contradiction to these ambitious recycling goals (cf. Heide and Sodermanns).

The Ordinance on ground water transposes the corresponding EC Directive into Germany law, but requests stricter limits for certain substances in Germany than requested by EU legislation. The Ordinance on substitute construction material builds upon the Ordinance on ground water and has very severe limits, as well. Certain material that could currently be recycled would be excluded from recycling if those ordinances were enforced. One example is bricks or brick chippings that often contain vanadium. Vanadium can have harmful toxic effects if occurring in an increased concentration, for example in ground water. It is however questionable that vanadium from recycling material would find its way into the ground water because depending on the soil type much of it could be absorbed. Furthermore, vanadium is a ubiquitous substance and therefore present in nature anyway. There are also debates about the concentration that needs to be reached for vanadium to become harmful (cf. Kirschbaum).

For the recycling industry, a threshold value of this substance would cause substantial problems. As explained above, vanadium occurs in bricks and brick breakings. If those products were downgraded from category I recycling material to category II recycling material because of their vanadium content, this would affect the market demand for recycled brick products negatively. Furthermore, if bricks or parts of bricks cannot be used in recycled material anymore, serious problems concerning the storage of the huge amounts of bricks from the C&D sector would occur (cf. Heide).

- **Market demand and prizes**

Another barrier for the increase of recycling rates is the general market demand – even for category I recycling material. Often, public authorities, who are the main costumer of construction material, do not specifically ask for recycling material in their call for tenders. This can be due to negative experiences with non-certified low-quality material (cf. Heide).

At the same time, prices for not-recycled material do not yet reflect the environmental disadvantages (use of resources) that occur during their production. Therefore they are often less expensive than recycled material which have to undergo complex processes to become qualitatively valuable.

13.7.3. Conclusion

Germany presents one of the highest recycling rates for C&D waste in Europe, and has already achieved the target set by the WFD directive. As a result, the 70% target itself does not drive towards higher recycling rates, and national targets set by the draft for the new Act for Promoting Closed Substance Cycle Waste Management already exceed 70%.

However, important amounts of C&D waste are backfilled in mines in Germany (including imports from other EU countries, such as Denmark and the Netherlands), which shows the importance of a clearer definition of this option, and raises the question of whether a hierarchy between management options within the target is possible. In the case of Germany, the quality of recycling applications (and their respective environmental impacts) represents the main challenge.

There are some concerns that the 70 % target, which is even exceeded by 10 % by the German draft for a new Act for Promoting Closed Substance Cycle Waste Management, could be endangered because current environmental requirements (under the Ordinance of substitute construction material, for example) could lead to the downgrading of half of all recycled material and to a restriction of its use to specific construction projects only.

Until now 90 % of the recycling material is classed category I which corresponds to unrestricted use (cf. Kirschbaum). If downgraded to restricted use, market demand would drop remarkably and the production of recycling material would not be profitable anymore.

A balanced solution between appropriate environmental protection and recycling targets will need to be found in the future. Public authorities play an important role in the system since they have the power to decide which material to buy.

14. APPENDIX III: CASE STUDY FLANDERS

<table>
<tr><td rowspan="1">Amounts of C&D waste</td><td colspan="3">From 9.6 million tonnes in 2005 (1.583 kg per inhabitant) to 8.5 million tonnes in 2007 (1.385 kg per inhabitant). C&D waste peaked in 2006 with 1.772 kg per inhabitant. It is expected that C&D waste generation may continue to grow at a moderate step, together with the growth of the total waste generation in Flanders.
Source: OVAM, 2009, overzicht bedrijfsafval 2004-2007.xls, on www.ovam.be, future projections are uncertain.</td></tr>
<tr><td>Waste factors</td><td colspan="3">Waste factors are not applicable, as the Flemish statistics on C&D waste are not based upon estimates or modelling, but on direct reporting by the waste generating companies, and for secondary waste by the waste collecting and treating companies.</td></tr>
<tr><td rowspan="12">Material composition of the C&D waste stream</td><td>Fraction</td><td>2000</td><td>Recent estimates</td></tr>
<tr><td>Concrete rubble</td><td>41%</td><td rowspan="3">+/- 80%</td></tr>
<tr><td>Masonry rubble</td><td>40%</td></tr>
<tr><td>Ceramic (tiles)</td><td>3%</td></tr>
<tr><td>Asphalt</td><td>12%</td><td>+/- 15%</td></tr>
<tr><td>Wood</td><td>1,8%</td><td rowspan="6">+/- 5%</td></tr>
<tr><td>Gypsum</td><td>0,3%</td></tr>
<tr><td>Metal</td><td>0,2%</td></tr>
<tr><td>Plastics</td><td>0,1%</td></tr>
<tr><td>Bituminous materials</td><td>0,1%</td></tr>
<tr><td>Other (not specified)</td><td>1,6%</td></tr>
<tr><td colspan="3">Source: the figures for the year 2000 are based on reporting on the results of the sector plan C&D waste 1995. The recent estimates for aggregate fractions are published on www.ovam.be</td></tr>
<tr><td></td><td colspan="3"></td></tr>
<tr><td>End of life options</td><td>Preparation for re-use, recycling and material recovery</td><td colspan="2">Disposal</td></tr>
<tr><td>Rates</td><td>89,2% (all but final disposal)</td><td colspan="2">Landfill: 10,8%
Incineration (energy recovery) is negligible</td></tr>
<tr><td></td><td colspan="3">Source: Recycling rate calculated based on C&D waste generation and treatment figures 2007, assuming a conservative average of 10 % residue from recycling operations.</td></tr>
<tr><td></td><td colspan="3"></td></tr>
<tr><td>Historical waste management</td><td colspan="3">Flemish waste policy started with the Flemish waste Decree of 1981, which includes C&D waste as a special waste requiring specific follow up and policy measures. These were covered from the start of the environmental planning.
Waste treatment data from 1992:
recycling: 48%
pre-treatment (crushing, sorting etc.. usually leading to recycling):18%
landfill: 33%
incineration negligible</td></tr>
<tr><td>Analysis of the current state</td><td colspan="3">The current state of high recycling rates in the Flemish region results from the growing environmental awareness and various policy actions. Final disposal -landfill- of C&D waste has been made unattractive (landfill levies and scarcity, i.e. fewer limited permits for landfills) or impossible (landfill ban for recyclable fractions). Waste can easily be applied as secondary raw material. Existing quality standards (e.g. Copro) ascertain the quality of the material creating a competitive position and market for this secondary raw material (scarce primary raw materials).</td></tr>
</table>

Towards the 70% target	In Flanders the 70% re-use has been reached before the year 2000. Key drivers: - Implementation of some (then) innovative policy instruments and a specific C&D waste action plan - Making final disposal (landfill) unattractive - Turning waste into valuable raw material. The latter can only happen with proven quality, as far as concerns both environmental and construction technical properties. - Key objectives for further improvement: - Sorting at source, broadening the scope to the smaller (non-stony) fractions - Selective demolition of (larger) buildings - Closed material loops for smaller fractions, e.g. gypsum, cellular concrete, roofing bitumen and rock wool.

14.1. SOURCES OF INFORMATION

- Reports and articles

OVAM, December 2008, Bedrijfsafvalstoffen. Cijfers en trends voor productie, verwerking

OVAM, February 2008, Bedrijfsafvalstoffen. Cijfers en trends voor productie, verwerking, invoer en uitvoer.

OVAM, March 2005, Bedrijfsafvalstoffen. Cijfers en trends voor productie, verwerking, invoer en uitvoer – including decoupling indicators

OVAM, 2009, overzicht bedrijfsafval 2004-2007.xls, op www.ovam.be

OVAM, 2009, Inventarisatie huishoudelijke afvalstoffen 2008

OVAM, 2009, Bedrijfsafvalstoffen productiejaar 2007 (uitgave juli 2009)

OVAM, 2007, Milieuverantwoord materiaalgebruik en afvalbeheer in de bouw, Sectoraal Uitvoeringsplan

OVAM, 2003, Positionering van het Vlaams beleid inzake bouw- en sloopafval t.o.v. de omringende afvalmarkten

OVAM, 2003, Bedrijfsafvalstoffen. Cijfers en trends voor productie, verwerking, invoer en uitvoer – including figures down to 1992.

OVAM, 1995, uitvoeringsplan bouw- en sloopafval

OVAM, 2008, Presentation Nico Vanaken, workshop ODE, Mogelijkheden van houtstromen en wettelijke klassering

OVAM, 2009, Voortgangsrapport Uitvoeringsplan Houtafval 2008

MIRA, 2007, Milieurapport Vlaanderen, achtergronddocument thema beheer afvalstoffen

VITO, BBT Kenniscentrum 2001. Voorbehandeling, sorteren van bouw- en sloopafval

VITO (in Milieudirect): Hernieuwbare warmte uit biomassa in Vlaanderen?

- Websites

Public Flemish waste agency, www.ovam.be

Webservice consolidated Flemish environmental legislation navigator.emis.vito.be

VAL-I-PAC site for collection of packaging foil at construction wharfs http://www.cleansitesystem.be/_htmnl/how.htm

14.2. CONTACTS

Tableau 46 - Identified contacts for the case study on Flanders

Full name	Name of organisation	Function
Koen Smeets	OVAM (Public Flemish Waste agency)	Head of department waste statistics ADC
Janna Vandecruys	OVAM (Public Flemish Waste agency)	Expert department waste statistics ADC

14.3. CONTEXT

14.3.1. INSTITUTIONAL CONTEXT

Belgium is a largely federalised country, where a majority of competences have been attributed to its different autonomous regions; the Flemish and Walloon region and the Brussels capital Region.

The northern part of Belgium is the Region of Flanders, the southern part is the Region of Wallonia, and the city of Brussels has a specific statute as Capital Region. Belgium knows a, in a European context rather exceptional, far reaching division of competences on environmental issues. All three regions are fully competent on environment and therefore also on waste. They can and do create their own legislation, which is not coordinated or harmonised. Every region can follow its own policy options when applying European Directives. Some large differences in approach exist on environmental permits and on internal waste transport. One of the few residual competences for the Belgian level is transit of waste. For some environmental issues the three regions search for cooperation and harmonisation on a voluntary basis.

All regions are of course largely implementing the same European Directives and therefore often but not always use comparable strategies. In any case they serve the same goals that are defined at a European level. Flanders was chosen as a case study to illustrate how high recycling rates for C&D waste can be achieved.

14.3.2. FLEMISH WASTE LEGISLATION

Main instruments in the Flemish legislative framework are:

- The Flemish waste decree and its implementation order VLAREA
- The Flemish decree on the environmental permit and its implementation orders VLAREM I and VLAREM II
- Specific legal instruments on e.g. polluted soil, animal waste, packaging waste (interregional cooperation protocol), toxic waste objective liability, … and directly applicable European Regulations on e.g. trans-border movement of waste, …

14.3.3. Flemish waste administration

The main competent authorities on waste are:

- OVAM, the public Flemish waste agency, for all waste topics except permits for installations
- LNE, department on environment, nature and energy, for permits for installations and inspection
- VLM, the Flemish land agency, for manure
- VREG, the Flemish Regulation Entity for the Electricity and Gas market, for green certificates for renewable energy from waste
- The provinces (Flemish Brabant, Antwerp, Eastern Flanders, Western Flanders, Limburg) for first line environmental permits.
- The 308 municipalities for local issues (e.g. collection and treatment of household waste) and first line environmental permits for small installations.

14.4. Policy and standards overview

14.4.1. Key European policy drivers

For the Flemish region, the European policy instruments and the European directives have only played a secondary role as a policy driver for the development of the specific Flemish regional policy instruments for C&D waste.

- The policy instrument on secondary raw material has been introduced in the Flemish legal framework from 1997 onwards, while the end-of-life policy is newly introduced in the European legal frame in the new Waste framework directive of 19 November 2008.
- The landfill prohibition for waste materials separately collected for recovery and for waste materials coming into consideration for recovery for reasons including their nature, quantity and homogeneity was introduced in 01.07.2000. The 70% recycling target of C&D waste is introduced at a later data. The recycling target of 70% has in practice been reached even before the year 2000.
- The general concept of the waste treatment hierarchy (Lansinks Ladder), as first introduced in European policy documents and later fully deployed in the Waste Framework Directive, has inspired Flemish legislation and has been included in the Waste Decree since 29-04-1994.

14.4.2. KEY NATIONAL AND REGIONAL POLICY DRIVERS

- **Executing plan C&D waste of 1995**

This first policy plan for C&D waste introduced policy targets for the period 1995-2000. The major aspects were:

- Recovery of 75% of all C&D waste generated in 2000. This target has been reached as in 2000 85% of all C&D waste was recovered or recycled.
- Prevent the generation of C&D waste for a medium long period with 25%. This target has not been reached as the generation of C&D waste keeps increasing.
- Sort in 2000 at least 85% of all generated C&D waste in recyclable waste, recycling residue and hazardous waste. This target has been reached.
- Treat in 2000 at least 85% of all generated C&D waste to allow recovery or recycling, generating 10% or less recycling residue.
- Generate sufficient market demand for the recycled C&D waste.

- **Environmentally responsible material use and waste management in the construction sector, sector executing plan.**

Although the previous plan was very successful in diverting C&D waste from landfill and in reaching a high level of recycling of C&D waste, it did not succeed in preventing the generation the waste or in influencing its composition. The new plan focused on:

- Material specific environmental profile of construction materials, in order to allow the Flemish Government to develop and impose material use prescriptions.
- Promoting selective demolition with standardised specifications
- A global management system for rubble granulates (no additional information on this management system was provided)
- Promote further re-use of the stony fractions of C&D waste (no concrete initiative was identified)
- Promote recycling of specific waste fractions cellular concrete, gypsum, plastics, flat glass, mineral insulation materials and roofing bitumen.

14.4.3. Legal documents

Tableau 47 - Legal documents dealing with waste management

Legislation	Year of implementation	Legal requirements
Decree concerning the Prevention and Management of Waste-materials	2 July 1981	Basic legislation of waste prevention and waste management, establishing the frame for a.o. • The legal destinations of household and industrial waste • The end-of-waste provisions for secondary raw materials • The provisions on the transportation of waste • The provisions on separate collection of wastes • The provisions on environmental levies.
Order of the Flemish Government for the establishment of the Flemish regulations relating to waste prevention and management (VLAREA)	5 December 2003	Regulation implementing the Flemish waste Decree.
Decree of the Flemish Council concerning Environmental Licences	28 June 1985	Basic legislation on permitting procedures and exploitation conditions of installations considered as a nuisance to man and the environment
VLAREM I Order of the Flemish Government concerning Environmental Licences	6 February 1991	Regulation implementing permitting procedures and classification of installations considered as a nuisance to man and the environment
VLAREM II Order of the Flemish Government concerning General and Sectorial provisions relating to Environmental Safety	1 June 1995	Regulation implementing exploitation conditions of installations considered as a nuisance to man and the environment

14.4.4. Standards

Tableau 48 - Standards in place in the construction sector

Standard	Legally binding	Requirements	Source
Use conditions for a secondary raw materials used as a construction material	Mandatory	• Specific use conditions for the use of a secondary raw material as construction material • Limited list of nature of waste, source, and specific use conditions • Concentration limits for 8 heavy metals, 5 monocyclic aromatic hydrocarbons, 10 polycyclic aromatic hydrocarbons, 6 other parameters for organic substances • Supplementary leachate conditions for non formed[210] construction materials • Emission limits of heavy metals for soils	• VLAREA art 4.2.2.1 to 4.2.2.4 • VLAREA annex 4.1 part 2 • VLAREA annex 4.2.2A • VLAREA annex 4.2.2B • VLAREA annex 4.2.2C
COPRO standards	Voluntary Mandatory if requested for use as secondary raw material	The main objective of COPRO is to organize, coordinate, harmonize and encourage quality in the construction sector. Concretely, this objective can be realized by means of controls of quality on construction products as on their integration on sites. According to the Belgian decree on general building conditions the task to control quality is delegated to the impartial organism COPRO.	COPRO documents, on http://www.copro.eu/3_30_0.aspx
QUAREA standards	Voluntary Mandatory if requested for use as secondary raw material	Quarea offers an alternative control system to COPRO to be applied in judging the quality of secondary raw materials	CERTIPRO certification system managed by VITO, on www.vito.be Ministerial Decision (MB) 2 December 2005 declaring the Quarea control system equivalent to the COPRO system.

[210] Where pollutants are not strongly bound in a matrix

14.5. QUANTITATIVE DATA

14.5.1. TOTAL C&D WASTE ARISING AND CHARACTERISATION

Table 49 - Waste amounts arising for 2006 and 2007 (Source: OVAM 2009, *overzicht bedrijfsafval 2004-2007.xls, www.ovam.be)*

C&D waste fractions	2005 (tonnes)	2007 (tonnes)
Total C&D Waste arising[211]	**9,622,258**	**8,536,636**
Total non-hazardous C&D waste	9,159,227	8,494,505
Primary C&D waste	8,265,836	7,211,957
Secondary C&D waste	1,356,422	1,324,679
Municipal C&D waste	475,299 (2006)	502,205
Wood[212]	1,268,524	1,523,403
Plastics[213]	348,769	388,195
Metal[214]	1,902,894	3,855,782
Glass[215]	156,509	160,934
Gypsum[216]	439,342	285,429
Excavation material[217]	2,359,648	2,550,702
Total hazardous C&D waste	463,031	42,132
Asbestos containing waste[218]	31,719	68,690

- C&D waste is defined as the group of following EWL codes: 101310, 101311, 101314, 170101, 170102, 170106, 170107, 170302, 170507, 170508, 170603, 170604, 170901, 170902, 170903, 170904
- Soil is defined as: 170503, 170504, 191301, 191302, 200202
- Secondary C&D waste is waste defined as C&D waste, but originating from waste treatment operations, in accordance with the definition of the OECD/EUROSTAT joint questionnaire: Waste from secondary sources, i.e. waste generated in a process that is known as a waste treatment operation. It includes residual

[211] Excl C&D waste from municipal or household origin
[212] All wood waste except packaging waste. This fraction is larger than wood waste from C&D sector. No detailed information is available on the wood of other fractions in C&D waste, but separate fractions from the C&D sector are usually reported as wood, plastics… waste. No detailed data on wood from C&SD sector is available in the public domain.
[213] All waste reported as plastic waste, see also footnote 212
[214] All waste reported as metal waste, see also footnote 212
[215] All glass waste except packaging waste, see also footnote 212
[216] Reported gypsum partially is C&D waste, but the major sources are phosphoric acid preparation and flue gas desulphuration.
[217] Soil reported as waste
[218] Includes C&D waste but also other asbestos containing equipment or waste streams

materials originating from recovery and disposal operations, such as incineration and composting residues. OVAM uses waste generated by following NACEBEL-codes as a proxy for secondary waste: 37.000, 37.200, 51.570, 90.002, 90.003, 90.004, 90.005. In 2007 11% of the secondary waste is C&D waste. This is waste that has gone through a further step of sorting, as simply crushed waste is included in the primary waste (see second question part 2). The waste treatment sector remains one of the largest sources on industrial C&D waste. The construction sector is responsible for 37% of all primary industrial waste. Secondary C&D waste is mainly broken inert waste for use as secondary raw material. Other sorted out fractions are usually reported under their specific material name.

14.5.2. Recycling and recovery of C&D Waste

Table 50 - Waste production and amounts that are treated through the different options

C&D waste fractions	Preparatory activities (tonnes)	Preparation for re-use *(tonnes)*	Recycling *(tonnes)*	Other material recovery *(tonnes)*	Backfilling *(tonnes)*	Energy recovery *(tonnes)*	Disposal *(tonnes)*
Total C&D Waste arising	6,251,170	2,177,864	1,152,727	-	0	990	39,507
Wood	507,903	23,980	447,161	-	0	289,137	342
Plastics	160,525	2,975	119,825	-	0	12,844	52,600
Metal	959,641	691	933,325	-	0	174	9,064
Glass	77,964	4	76,890	-	0	155	1,496
Gypsum	14,160	0	1,265	-	0	0	423,917
Excavation material	2,092,764	229,878	16,821	-	0	616	18,627
Asbestos containing waste[219]	7,925	0	2	-	0	3	23,789

In addition to the waste treatment activities as included in the waste treatment hierarchy and the waste Framework Directive, a category with 'preparatory activities' is included. This contains all activities transforming a waste in another waste, with different properties and possibly no longer a C&D waste, e.g. sorting, physicochemical pre-treatment activities. Waste being pre-treated will end up in one or more of the other mentioned waste treatment categories, but possibly not under the denominator C&D waste, but as plastics, wood, RDF and often mixed up with waste with the same nature but a different origin (packaging, mixed industrial waste, municipal waste fractions, etc.) For this reason the total of pre-treated C&D waste can be larger than the total of finally treated C&D waste. The same phenomenon occurs with different waste streams, like household waste or mixed waste. EUROSTAT has conducted pilot studies in line with annex II section 8 point 3 of the Waste Statistics Regulation 2150/2002/EC. OVAM anticipated on the results and the implementation of the results of these pilot studies and has introduced since 2002 a comprehensive waste statistics

[219] Includes C&D waste but also other asbestos containing equipment or waste streams

approach taking consideration of the issue of pre-treatment and consequent change in nature and composition of waste streams during their treatment chain.

The category preparation for re-use includes all waste reported as re-uses and used as a secondary raw material. All incineration is energy recovery, all disposal activities is landfilling. Recycling includes composting.

14.6. PRACTICES IN C&D WASTE MANAGEMENT

In the Flemish region, legislative requirements and (planned) targets concerning C&D waste management have been approached in the consecutive (sectorial) executing plans. The main objectives of these plans have already been listed in section 14.4.2. on national and regional policy drivers.

The 1995 C&D waste executing plan proved successful in reaching a high level of recycling. The new sectorial executing plan of 2007 on environmentally responsible material use and waste management in the construction sector determines the policy for the period 2007-2010 and principally aims to address the opportunities identified in the evaluation of the first plan:

- Quantitative and qualitative prevention (e.g. composition) of C&D waste
- High end re-use of C&D waste

Section 14.6.1. further clarifies current practices and operations in the Flemish region while paragraph 14.6.2. provides a brief overview of the opportunities and the possible evolution in C&D waste management practices in Flanders.

14.6.1. CURRENT PRACTICES IN C&D WASTE MANAGEMENT

Over 90 % of the C&D waste in Flanders consists of stony material. The non-stony or residual fraction is often referred to as mixed C&D waste or container waste. This waste contains e.g. glass, wood, metals, plastics, etc.

C&D waste is minimally sorted (at source) in a hazardous and a non-hazardous component. Non-hazardous waste is usually further sorted in stony waste, glass, metals and a residual mixed fraction.

Stone fraction

The dominant stony fraction in the C&D waste stream can be subdivided in an inert fraction (concrete and masonry rubble, ceramics, natural stone, etc) and a smaller fraction of asphalt rubble. Asphalt is not classified as inert waste as it contains hydrocarbons.

The inert fraction and asphalt rubble (not contaminated with other wastes) goes to permitted crushers. Over 75% of the inert fraction is actually granulated. The remainder can be used e.g in hydraulic works, on condition that the non-granulated rubble has a COPRO or QUAREA-certificate. The waste arriving at crushers generally originates from large demolition works or road construction and the composition is rather homogeneous, especially compared to waste destined for sorting installations. Crushing installations can range from simple crushers with sieve to fully equipped installations with pre- and post-sorting devices, magnets.

Contaminated stony waste must go through a physical-chemical treatment process before it can be further recycled. Acceptance criteria in landfills for inert waste create incentives for re-use when economically and technically feasible. The new sectorial executing plan of 2007 on environmentally responsible material use and waste management in the construction sector has set up the objective to landfill maximum 5 % of C&D waste.

Use of inert granulates

These granulates can only be used as construction material. Use as a construction material requires functional application e.g. as a foundation or base (layer) in new works. The use of these granulates as soil is not permitted. All inert stony fractions and granulates of asphalt must be certified by COPRO or QUAREA and be classified as secondary raw materials.

To obtain these certifications, certain conditions for the material and the treatment process must be met. This quality guarantee must build up confidence in the secondary materials and create incentives for re-use:

- The origin of granulates is known: permitted crushers, treatment and sorting installations, usually certified by COPRO or QUAREA.
- The rubble can contain only up to 1% (mass and volume) non-stony and non-hazardous other materials like gypsum, rubber, plastics, isolation, roofing, …
- The rubble can contain only up to 1% (mass and volume) organic wastes (wood, plants, …)
- The rubble is not contaminated with free asbestos fibres or dust (with a target value of <1000 mg/kg dry material)
- The rubble is at least yearly inspected by a laboratory certified by OVAM on possible pollutants (heavy metals, PAH, mineral oil, …)

Granulates are generally re-used as foundation for (road) construction. Concrete granulates can also be re-used in new lean mixed concrete.

Use of asphalt granulates

Like inert granulates, asphalt rubble granulates can only be re-used as construction material.

Asphalt granulates are tested on the presence of tar by a simple spray test. The use of the different types, tar-containing or not, is defined in VLAREA. The use of tar-containing granulates is limited to cold applications in a foundation of asphalt granulate cement in larger works > 1500 m³ (with made up inventory). Warm treatment has to be avoided.

Sieve sand and sand from crushing

Sieve sand is a by-product from the sorting and crushing of (stony) C&D waste. Distinction is made between sieve sand (before crushing) and sand from crushing.

Sieve sand can be used as construction material (COPRO or QUAREA certificate) and as soil (use certificate as a secondary raw material issued by OVAM). The use as soil is rare as the supply of soil in the Flemish region surpasses demand. Sand from crushers is only permitted to be used as construction material. The grain size of this type of sand is larger with higher technical quality. VLAREA aims at a high quality re-use of the material.

Sieve sand can also be further differentiated whether it originates from crushers or sorting installations. Sand from sorting installation is usually more polluted as their input flux (mixed fractions) is highly heterogeneous. When analysing samples from container and sorting companies, following issues were raised:

Masonry rubble, by far the largest input fraction for these installations, is usually more contaminated than concrete rubble.

- The quality of the resulting granulates is merely influenced by the type and equipment of the sorting installation. The quality of the recycled material is mainly depending on the input material.
- Sand and granulates from sorting installations contain more heavy metals (e.g. zinc and lead from paints, gutters, piping, etc). They also have higher concentrations of mineral oil.
- 60 % of the controlled samples have a too high percentage of paper, plastics and wood. 75% of the samples show traces of asbestos (cement).
- Sulphate concentrations are higher than for crushers, due to the presence of gypsum and cellular concrete. This presence limits the technical capacity of the recycled material, e.g. the ability for re-use in (recycled) concrete.

In the Flemish region, there are currently no sorting installations with operational further cleaning or separation of these impurities.

Mixed fraction

The mixed fraction (less than 10 %) of C&D waste is destined to permitted sorting installation. The majority of the mixed waste going to sorting installations is masonry / brickwork rubble from small works and households (e.g. through the municipal waste collection points). The composition of fluxes arriving at sorting installations is therefore highly heterogeneous.

Sorting processes in the different companies in the Flemish region follow a similar pattern. Storage of the input waste requires dry conditions to increase the sorting performance of the installation. Large pieces of waste (wood, large bricks) are pre-sorted before the waste is fed to the installation. The installation first sieves the finest sand particles. In a next step, the ferrous metals are removed by means of a magnet. Wind-sifting further separates the lightest fractions of the waste (paper, foils, polystyrene…). The remainder of the waste stream is manually sorted on one or several belt conveyors (particle size). In this final step, wood, plastics, gypsum and non-ferrous metals are further separated.

Sorting installations target to obtain “uncontaminated” new fractions of stony inert material, plastics, metals, wood, etc. that are further treated in specified recycling facilities. No specific information was obtained regarding the management of possible hazardous contaminants present in C&D waste.

Wood

Re-use and recycling depends on the type of wood. Wood waste classification counts three classes: type A (large pieces of untreated wood, e.g. pallets, plates, raw wood), B (doors, (old) furniture), and C (heavily treated wood).

Type A can possibly be recycled to plywood sheets. Type B mixed wood from doors, furniture and fibreboard will be recycled to split-wood or chipboards. Heavily treated wood is considered hazardous waste and must be separated at the source. Due to the high caloric value, wood waste serves as biomass for energy recovery. In 2002, nearly 80% of heat production from biomass came from wood waste. Around 30% of the Flemish green energy originates from wood waste. Wood waste is also frequently exported to trans-border treatment installations.

Today, major drawbacks for wood recycling and valorisation are:

- The supply of wood waste is highly variable, e.g. due to fluctuations in the economic climate. Today’s supply is not sufficient for all installed and permitted facilities (recycling and energy recovery)
- Wood waste as biomass potentially conflicts with recycling and composting objectives. Furthermore, it also makes it more difficult to comply with the NEC-directive.

14.6.2. Emerging management practices

One of the key aspects in the Flemish policy on C&D waste, next to prevention, is the high end re-use / valorisation of recycled waste. Possible bottlenecks in the re-use of wastes are mainly assigned to problems with:

- the purity or homogeneity of input wastes; the quality of recycled materials
- the installation and management of collection system
- the technical and economical feasibility of the recycling process

Possible ways of overcoming these barriers are under discussion in the Flemish region.

Sorting at source

The most effective manner to obtain clean waste fractions is sorting at source.

The Flemish region has integrated specifications for selective demolition in the building permit for works of a certain size (see paragraph 0). This obligation will increase the practise of sorting at the source, but also allow a better monitoring of the waste streams in order to avoid illegal disposal and improve the possibilities for environmentally friendly recycling.

Quality of secondary raw material

The use of recycled material in new applications is beneficial for the environment as the need for primary resources is lowered. On the other hand, the secondary raw material must possess the required technical properties and must be fit for its intended use. Waste as secondary raw material must be able to compete with primary raw materials in order to create sufficient demand.

The global management system and COPRO or QUAREA-certification for granulates has already been established for a long time and obtained good results: the use of secondary (recycled and certified / approved) instead of primary raw material yearly amounts to over 11 million tonnes.

OVAM is currently investigating the possibility to consider purified glass cullet as a product fulfilling end-of-waste criteria. A similar management system and minimum requirements could contribute to high end valorisation of glass waste.

Recycling technology

The problem of pollution in sieve sand, mainly in sorting installations is mentioned above. In the Netherlands, cleaning or washing of these polluted sands is already operational. The current standard equipment of wind-sifters, magnets and sieves must be expanded with e.g. washing drums, flotation basins and spiral separators. These techniques are operational in Flanders for soil recycling in specialised companies.

Roofing bitumen is currently incinerated or landfilled. According to VLAREA, the waste could be re-used in new roofing or as a construction product (roofing bitumen free of tar). Recycling in Flanders is however very limited as the quality of the input waste is highly variable. A project is now running on the use of granulated roofing bitumen together with asphalt rubble granulates to produce new asphalt. Additional research for the technical and economical feasibility for re-use is needed.

Closed loop material

A principal objective of the Flemish executing plan of 2007 on environmentally responsible material use and waste management in the construction sector is the high end valorisation of recycled waste. This was described previously for the largest fraction (granulates) but is equally valid for the smaller fractions (gypsum, metal, glass…). Focus on these fractions can increase the quality of the stony waste fraction and create opportunities for recycling.

Some specific actions have been set up to install the cradle-to-cradle principle for some of these smaller fractions. Key aspects to be approached in these systems are centralized collection systems and the recycling and treatment potential (with the producer). The usefulness of producer responsibility is also evaluated.

Gypsum

The use of gypsum products in the construction sector is on the rise. Recycling of gypsum waste has only very recently been operational in Flanders (since 2009), with one operational recycling facility in the port of Antwerp.

The recycling process treats gypsum waste to a clean gypsum powder that can be re-used in the production of new gypsum board. Gypsum from C&D waste can be recycled in this installation as long as the contamination with other materials is limited. The gypsum sector is now investigating opportunities and the economic feasibility to cooperate with a Danish enterprise that already operates a process to purify all kinds of gypsum fractions.

Collection of the gypsum waste is mainly executed through waste sorting companies and the municipal collection points.

The collection and recycling of gypsum is a key example of global chain management in order to close the material loop for gypsum. At the end of 2009, all enterprises actively involved have signed a cooperation agreement with the Flemish ministry of the environment and OVAM, the Flemish waste Agency:

- Producers design their products more environmentally friendly and easy recyclable. They also commit to use recycled gypsum (powder) in new gypsum board.
- Dismantling and demolition companies commit to sort at source while collection and sorting companies increase their efforts to separate the gypsum from C&D waste.
- Recycling companies provide sufficient treatment capacity
- OVAM takes up the coordination of the agreement

In 2010, the Flemish region targets to recycle 25.000 tonnes gypsum waste or 40 % of the total gypsum waste. By 2015, 80% of all gypsum waste should be recycled and re-used as input material in new gypsum boards.

Cellular concrete and roofing bitumen

Currently the Flemish region is investigating similar cooperation initiatives as for gypsum.

For cellular concrete 100 % recycling is feasible provided that the collected waste is uncontaminated. One recycling option is milling the cellular concrete to powder that can replace sand in the production of new cellular concrete products. At the moment, around 8% of recycled material is used in the production of new concrete blocks. It is technically feasible to increase that fraction to about 20%.

A collection system has been set up and tested at regional scale. Uncontaminated cellular concrete waste is collected through the network of construction product dealers in numbered big bags. The bags are numbered to trace the source of the waste, as the treatment costs for contaminated cellular concrete waste will be invoiced to the “polluter”.

In the future it is planned to integrate contaminated waste from C&D as fractions of plasterwork or glue are not expected to cause problems for the recycling process nor the quality of the recycled product.

- **Rock wool**

Rockwool is equally collected through a system of payable bags or containers (large quantities). The collection system is not free but competitive with traditional ways to dispose of the waste. In the latter case, the rock wool waste is likely to end up in landfills.

Cutting residues and used rock wool qualify for recycling, if the waste is dry, chemically clean and free of other wastes (packaging material, plaster, etc). The recycled material is transformed to new products through heat treatment in furnaces. This process can be repeated without loss of quality of the end-products.

14.7. Past and future trends of C&D waste, drivers and barriers

14.7.1. Trends in C&D waste generation and composition

- **Generation**

In 2007 28% of all Flemish non-household waste is C&D waste, and a supplementary 10% is soil. C&D waste is the largest waste fraction, soil is the second largest fraction, and mineral waste[220] (often comparable with C&D waste) is the fourth largest fraction (6%).

In 2007 11% of the secondary waste is C&D waste. This is waste that has gone through a further step of sorting, as simply crushed waste is included in the primary waste (see second question part 2). The waste treatment sector remains one of the largest sources on industrial C&D waste.

The construction sector is responsible for 37% of all primary industrial waste.

Major sectors generating C&D waste are, based on data for 2006:

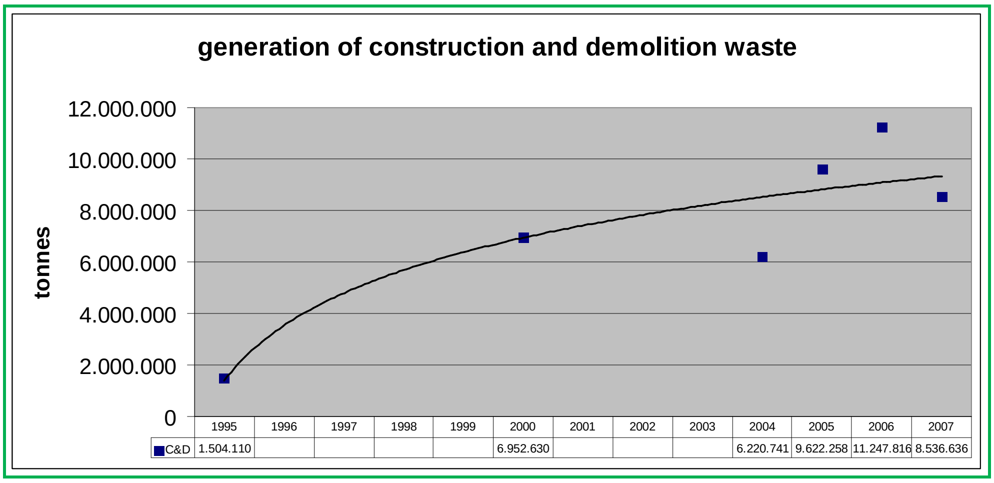
- construction sector 79% of 8130 ktonnes = 6,422.7 ktonnes
- waste treatment industry; 25% of 12.863 ktonnes = 3,215.8 ktonnes
- shipment of goods on land; 67% of 328 ktonnes = 219.8 ktonnes [221]
- agriculture; 39% of 297 ktonnes = 115.8 ktonnes

[220] Mineral waste is defined as: 010101, 010102, 010304, 010305, 010306, 010307, 010308, 010309, 010407, 010408, 010409, 010410, 010411, 010412, 010413, 010504, 010506, 010507, 010508, 020401, 020402, 030309, 080202, 080203, 100125, 100321, 100322, 100905, 100906, 100907, 100908, 100911, 100912, 101005, 101006, 101007, 101008, 101011, 101012, 101103, 101109, 101110, 101113, 101114, 101201, 101208, 101211, 101212, 101301, 101304, 101306, 161101, 161102, 161103, 161104, 161105, 161106, 170103, 190802, 190901, 191209

[221] A large fraction of secondary C&D waste is reported by container companies, which are often registered as transport companies.

Total generated in 2006[222] is 10,839 ktonnes spread over 37 of the 61 economic sectors defined by OVAM.

Figure 16 – Evolution of C&D waste amounts between 1995 and 2007



The fraction C&D waste has strongly risen since 1995, due to better collection and separation/treatment infrastructure. No further growth can be expected from ameliorated collection, as the maximum seems to be reached. The fraction of C&D waste will remain at 28% of the total non municipal waste generated in Flanders. Together with the expected growth of the total waste generation in Flanders, C&D waste generation may continue to grow at a moderate step.

In 2005 OVAM published a decoupling indicator[223] for C&D waste. A negative value shows negative decoupling, meaning that waste grows even faster than the economy. A negative decoupling of C&D waste has been observed for the period 1995 to 1999. Ever since, although negative decoupling tends to decrease, it cannot be expected that positive decoupling, where waste with statistical surety grows less fast than the economy, can be expected in the near future. This supports the above mentioned assumption that the generation of C&D waste will continue to rise.

Composition

The collection coverage for C&D waste will hardly grow in the coming years because a large coverage has already been reached. However, the quality of the collected waste still can improve due to source separated collection or through ameliorated sorting techniques. The new sectorial plan for waste in the construction sector foresees selective demolition techniques ensuring higher quality and more homogeneous C&D waste.

VLAREA has been amended with article 5.2.2.1 § 4 stating:

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[222] Although 2007 is the year for which the most recent data are available, the level of detail requested for, this paragraph is only available for the year 2006.
[223] Waste generated by the construction sector (NACE 45.1 and 45.2) compared with GVA of the construction sector: 1995-1999, 2006-2000, 1997-2001 and 1998-2002

"The holder of an urban planning licence will have an architect or an expert appointed by the principal write up a waste materials demolition inventory when demolishing or dismantling industrial buildings and buildings of which all or part had a function other than residential and a construction volume in excess of 1000 m^3, and when allocating demolition or dismantling work. The holder of the urban planning licence is responsible for choosing an architect or expert who has sufficient knowledge of the waste materials that will be released during selective demolition or dismantling and who is able to estimate the quantities of these waste materials.

The waste materials demolition inventory will identify the site and the waste materials expected to be produced. It will give the name of each waste material, as well as the relevant code found in Appendix 1.2.1.B, the expected quantity in cubic metres, in tonnes, the place in the building at which the waste material is found, and its form. A template of the waste materials demolition inventory relating to the demolition and dismantling work will be made available to OVAM.

Before demolition or dismantling work is assigned, the completed waste materials demolition inventory will be handed to the executor of the demolition and dismantling work and the safety officer.

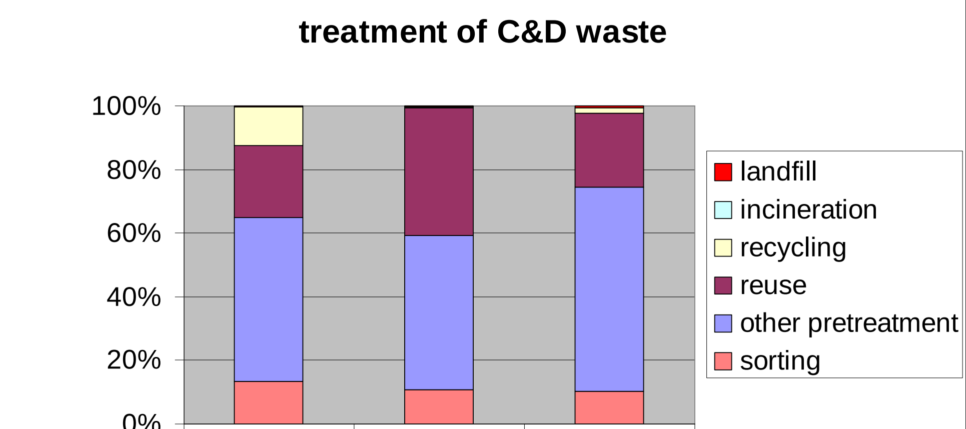
The architect, or the expert appointed by the principal, will monitor the waste shipments, adjust them where necessary, and keep a copy of the transport documents. Copies of the transport documents and acceptance slips relating to waste materials removed will be handed to the holder of the urban planning licence before completion of the demolition or dismantling works.

The holder of the urban planning licence will file the transport documents and acceptance slips for a period of five years".

This demolition register will become an instrument that enhances selective demolition and the generation of more homogeneous and high quality C&D waste fractions.

14.7.2. Trends in C&D waste management techniques

Figure 17 – C&D waste management options and rates achieved between 2005 and 2007



	2005	2006	2007
landfill	0,41	0,40	0,59
incineration	0,01	0,01	0,01
recycling	11,98	0,10	1,56
reuse	22,63	40,32	23,44
other pretreatment	51,62	48,39	64,20
sorting	13,35	10,77	10,21

The Flemish figures on treatment of C&D waste display a clear view:

- C&D waste is either re-used or recycled.
- By far the largest fraction has to go through a prior pre-treatment activity before it can be recycled or re-used.
- Sorting before recycling is slowly diminishing due to better sorting at source not requesting sorting further on in the treatment chain.
- Other pre-treatment phases like crushing, conditioning, washing, cleaning remain indispensible for a high quality further treatment or recycling. It becomes increasingly important throughout the years, which proves that the treatment chain with successive pre-treatment steps becomes longer before a waste reaches its final recycling step.
- Pre-treatment leads to recycling, but often under the denominator of wood, plastics, glass, metals….or other waste streams more defined than C&D waste.
- Pre-treatment also leads to use as a secondary material, which is not always included in the reported statistics. For both reasons the percentage for sorting and pre-treatment can be higher than the sum of the final treatment options (recycling, re-use, energy recovery or landfill) of C&D waste.
- Re-use includes the application of the Flemish end-of-waste criteria for the application of a secondary raw material.

- Landfill and incineration, as well as direct recycling, are rather marginal treatment options for C&D waste.

  Main drivers for the evolution away from final treatment haven been and still are:

- The easy application of the waste as a secondary raw material
- The ascertained certified quality and the competitive position of this secondary raw material compared to increasingly more scarce primary raw materials.
- The high costs for landfilling, based on the high landfill levies and the created scarcity of landfill capacity for inert waste.

14.7.3. Towards 70% re-use, recycling and recovery

In Flanders the 70% re-use has been reached before the year 2000 based on the successful implementation of a rather straightforward action plan and some (then) innovative policy instruments. The Flemish case learns that some keys towards a high level of recycling and re-use at European level can be found in:

- Straightforward landfill bans for recyclable fractions of C&D waste
- High levies on landfilling C&D waste, generating an economic driver for alternative treatment options
- Application of end-of-waste criteria to facilitate the use of the material as a secondary raw material, but taking into account its environmental and its construction technical properties.
- Actively limiting the treatment capacity for disposal of C&D waste

The Flemish experience also learns that these measures are not sufficient to generate a decoupling of the C&D waste generation from the economic growth, and that other measures are needed for a successful quantitative and qualitative prevention. It still has to be proved that the measures included in its second C&D executing plan are as successful as the primary plan.

15. APPENDIX IV: CASE STUDY SPAIN

Amounts of C&D waste	**35 Mt** in 2005(810 kg per capita), Projected **40 Mt** (850 kg per capita) in 2010. Source: based on regional reporting; according to Spanish experts, unreliable because of the lack of standardised methodology	
Waste factors	Works on new buildings	120.0 kg/m^2 built
	Rehabilitation works	338.7 kg/ m^2 rehabilitated
	Demolition works	1,129,0 kg/ m^2 demolished
	Partial demolition works	903.2 kg/ m^2 demolished
Material composition of the C&D waste stream	Ceramics	54%
	Concrete	12%
	Mineral waste (stone)	5%
	Mineral waste (sand, gravel and other aggregates)	4%
	Wood	4%
	Glass	0.5%
	Plastics	1.5%
	Metal	2.5%
	Asphalt	5%
	Gypsum	0.2%
	Paper	0.3%
	Others (Garbage)	7%
	Others (Non specified)	4%
	Source: based on a waste characterisation campaign performed in Madrid in 2005: no national data available.	
End of life options	Recycling	Disposal
Rates	7.5%	Controlled landfill: Uncontrolled landfill:
	Source: based on a limited survey on waste treatment plants; partial, unreliable data.	
Analysis of the current state	Lack of enforcement of existing policies (uncontrolled landfills), low prices of landfill disposal and high local variations of landfill taxes, low capacity and geographical coverage of C&D waste treatment plants have hindered recycling.	
Towards the 70% target	National C&D waste management plan being revised, setting intermediate targets towards the WFD 70% target. Recycling: 10% by 2012, 20% by 2015 Other forms of material recovery: 25% by 2012, 40% by 2015 Main challenges towards reaching the target: • Better enforcement of existing regulation (stricter control of unauthorised landfills) • Harmonisation of landfill taxes between regions • Development of recycling market (e.g. promotion of recycled aggregates through the introduction of standards on recycled materials for use in construction)	

	• Harmonisation of reporting mechanisms and methodologies among regions

15.1. SOURCES OF INFORMATION

- Reports and articles

M. del Río et al. 2010. La regulation Juridica de los residuos de construcción demolición (C&D waste) en España. Caso Comunidad de Madrid,

Carlos Martinez Bertrand. Gestión de residuos de construcción y demolición (RCDS): importancia de la recogida para optimizar su posterior valorización

Toni Floriach Puig. La Problemática de la Gestión de los Residuos de Construcción: Una aproximación al estado actual de la cuestión.

Ministerio de Fomento, Ministerio de Medio Ambiente, Centro de Estudios y experimentación de obras públicas, 2009. Ficha Técnica de Residuos de Construcción y Demolición.

Ministerio de la Presidencia España, 2008. Decreto Real 105 2008.

Andrés Macho, 2009. Ppt document: Aplicación del RD 105/2008 y nuevo PNIR.

Adolfo García Alonso, 2009. Ppt document: El proyecto de demolición

Gobierno de España, Ministerio de Medio Ambiente, 2008. Plan Nacional Integrado de Residuos (PNIR).

ITeC- Instituto de Tecnología de la Construcción de Catalunya, 2000. Proyecto Life. Situación actual y perspectivas de futuro de los residuos de la construcción.

Consejería del Medio Ambiente y Ordenación del Territorio, Comunidad de Madrid, 2006 – 2016. Estrategia de residuos de la Comunidad de Madrid 2006 – 2016.

- Websites

Magazine on line “Waste Ideal”, waste.ideal.es/inertes.htm

Ministerio del Medio Ambiente y Medio Rural y Marino, www.marm.es

Instituto de Tecnología de la Construcción de Catalunya, www.itec.es

AEDT - Asociación Española de Demolición Técnica Cote y Perforación, www.aedt.es

Asociación Española De Empresas de Demolición, www.aeded.org

Instituto nacional de Estadística, www.ine.es

ISR - Instituto para la sostenibilidad de los recursos, www.isrcer.org

GERD - Gremio de Entidades del Reciclaje de Derribos, www.gerd.es

15.2. Contacts

Table 51 - Identified contacts for the case study on Spain

Full name	Name of organisation	Type of organisation	Function
Carlos Martinez Bertrand	VIAS Y CONSTRUCCIONES, S.A	Construction Company	Chief of Quality, Environmental Management and Technological Innovation
Jose Blanco	AEDED – Spanish Association Demolition	Association	Secretarial
Pablo Gonzalez	GERD – Spanish association of C&D waste managers.	Association	Waste and Environment Manager

15.3. Context

The Territory of Spain has an area of 504,645 km^2 and houses a population of 46,745,807 inhabitants. The Territory is divided into 17 Autonomous Communities (CCAA) and 2 autonomous cities, each of which has executive competency and legislative autonomy, as well as the capacity for self-administration by its own representatives.

Figure 18 - Map of Regions in Spain (Source: www.aspariegos.com/comunidades_autonomas.html)

The construction sector has a remarkable social and economic relevance in Spain, which has been growing in the beginning of the century. The construction activity has reached remarkably levels of production, until the emergence of the economic crisis, which has led to a phase of depression.

However, this recent trend towards a building boom has generated significant growth in the volume of waste.

According to the PNIR (Integrated National Plan of Waste) 2008-2015, it has not been possible to define the exact amount of C&D waste produced in Spain. However, the plan estimates that C&D waste production in 2005 reached around **35 million tonnes**. This figure does not include the landfilling surplus of land and clean rock, which although usually exploited in the same work sites, in many occasions does not find a secondary use and is therefore destined for disposal in landfills.

It is important to keep in mind that this number is based on several sources (Autonomous communities, Ministry of Environment indicators…) usually considered not reliable because of the difficulty of data collection and consolidation.

It is estimated that the production of C&D waste in Spain has grown over the period from 2001 to 2006 at an average rate of 8.7% per year[224]. This trend was reversed in 2007, with negative waste growth rates after 2008 as a result of the reduction in the construction activity, which is particularly pronounced in residential construction.

Besides the intense production of C&D waste there is also a high percentage (about 62.5%) of C&D waste that has been subject to uncontrolled discharge without previous treatment. 12 million tonnes (about 30%) of C&D waste is sent to authorised landfills directly, with only 3 million tonnes per year treated as recycled aggregate (7.5%)[225].

All these factors, coupled with the low prices of C&D waste admission in landfills, have hampered the sustainable and profitable operation of C&D waste treatment plants, which have been experiencing difficulties in their operations, especially since the amount of C&D waste generated began to decrease significantly.

This is why the administration has been supporting the implementation of new infrastructure dedicated to the treatment of such waste, as well as controlled landfills.

Indeed, motivated in part by expectations that caused the adoption of new policies, there is now a wide range of C&D waste treatment plants, although their distribution is not homogeneous on the Spanish territory or within each region, with, in particular, a lack of infrastructure in those areas with a greater dispersion of population. These stationary plants are often lacking treatment capacity and sometimes have problems with the disposal of recycled products (recycled aggregates and other materials). In contrast, other regions experience an excess of treatment capacity.

[224] PNIR (Integrated National Plan of Wastes 2008 – 2015), Annex 6 II PNRCD.
[225] Teresa Martínez Flores, CARRIGUES Medio Ambiente.

Regarding landfill capacity, there is a general lack of adequate facilities that meet the requirements of current legislation (RD 1481/2001).

To solve this situation, the Autonomous Communities (CCAA) in Spain have developed proactive C&D waste policies, including the application of landfill taxes. The result of these policies from the point of view of environmental performance has been unparalleled. One can highlight the case of certain regions as Catalonia, which has achieved a good control of the C&D waste flow and experienced the virtual disappearance of uncontrolled discharges into its territory, as a result of the implementation of C&D waste policies since 1994.

15.4. POLICY AND STANDARDS OVERVIEW

15.4.1. KEY EUROPEAN POLICY DRIVERS

In Spain, two factors have been the precursors to the development of national policies regarding the management of C&D waste (C&D waste).

First, the extraordinary increase in waste generation from the construction sector and secondly, European policies such as Directive 99/31/EC on landfill, the old waste framework Directive 2006/12/EC and the revised waste framework Directive 2008/98/EC. The combination of these two factors has generated a better control of C&D waste, the emergence of a new recycling infrastructure and a better control of unauthorised landfills.

However, prior to the adoption of Directive 2006/12/EC, Spain had already become aware of the importance of C&D waste management and had developed the National Plan for C&D Waste (PNRCD) 2001 -2006, which set out the objectives and mechanisms for C&D waste management. This Plan was updated and incorporated into the Integrated National Waste Plan (PNIR) 2008-2015. There is currently a second draft version of the C&D waste Plan (II PNRCD).

Likewise, the target set by Directive 2008/98/EC of recycling at least 70% of C&D waste generated by 2020, has induced Spain, like other MS, to set targets for recycling C&D waste. Thus, the PNRCD sets qualitative and quantitative targets for C&D waste recycling for 2015 (see 15.4.2.).

15.4.2. KEY NATIONAL AND REGIONAL POLICY DRIVERS

- **PNIR - Integrated National Waste Plan 2008-2015**

This Plan sets out the objectives of reduction, re-use, recycling, other forms of recovery, and disposal, as well as outlines the means to achieve these objectives, including the financing system and the revision procedure.

It also provides the possibility for local authorities to develop their own plans for urban waste management in accordance with the relevant legislation and the plans of each of the Autonomous Communities.

This plan has been developed to improve the management of all types of waste generated in Spain, to encourage the different authorities and officers involved in achieving ambitious environmental goals, and to comply with the laws cited below. The plan is divided into categories of waste, including C&D waste.

- **National Plan of C&D waste - PNRCD (Plan Nacional de Residuos de Construcción y Demolición 2008 – 2015)**

The objective of the Second National Plan on C&D Waste is to establish objectives of prevention, re-use, recycling, other forms of recovery and disposal of C&D waste in Spain, and outline measures to achieve these objectives, including the financing system and the revision procedure.

The Second PNRCD benefited from the development and implementation experience of the first PNRCD 2001-2006. The new plan is based on the major plans of the Autonomous Communities and local authorities on C&D waste, and the results of the "Study on the generation and management of C&D waste in Spain" (Ministry of Environment, 2006).

Among the qualitative targets are: the reduction of waste at the source, the correct management of all hazardous waste and the closure of landfills which do not meet the requirements of current legislation (RD 1481).

Regarding the quantitative targets, there are slight differences between the first (I PNRCD) and the second draft version of the C&D Waste National Plan; the second one (II PNRCD) sets more realistic goals with regard to C&D waste recycling:

Table 52 - Quantitative objectives for 2015 (Source: I PNRCD National Plan of C&D Waste)

I PNRCD 2006 – 2015 (Current)	2010	2012	2015
Separation and environmentally correct management of Hazardous C&D Waste (HW) (%)	100	100	100
C&D waste: Recycling (%)	15	25	35
C&D waste: Other methods of C&D waste recovery including Backfilling (%)	10	15	20
Disposal – Landfill (%)	75	60	45

Table 53 - Quantitative objectives for 2015 (Source: II PNRCD National Plan of C&D Waste)

II PNRCD 2008 – 2015 (Draft)	2010	2012	2015
Separation and environmentally correct management of Hazardous C&D Waste (HW) (%)	80	95	100
C&D waste; Recycling (%)	-	10	20
C&D waste: Other methods of C&D waste recovery including backfilling (%)	-	25	40
C&D Packaging Waste Recovery (%)	-	40	70

- **Environmental Sustainability Report (ISA)**

This report presents the background on waste planning which was analysed and taken into account in the development of the PNIR (Integrated National Waste Plan).

- **Catalogue of recycled waste used in construction**

The aim of this paper is to contribute to public awareness of waste that can be used in construction. It describes the volume of C&D waste generated their physical and chemical characteristics as well as includes case studies on the usage of recycled waste used in construction.

- **Project: Spanish Guide on Recycled Aggregates from C&D Waste, "GEAR"**

This ongoing project's objective is to develop standardised guidelines for recycled aggregates from C&D waste, and their use in public and private works. The guide includes, beyond regulatory requirements, a set of specific technical requirements for the main applications of recycled aggregates, particularly in roads, with the intention of ensuring the environmental safety and quality of recycled aggregates employed in these applications.

- **Project: Life 98/351**

This Project aims to promote separate collection, usage of recovery techniques, and achieve a minimisation of waste generated in C&D sector.

15.4.3. Legal documents

Table 54 - Legal national documents dealing with waste management

Legislation	Year of implementation	Legal requirements
Law 10/98	April 21, 1998	General scheme on waste.
Royal-Decree 952/1997.	June 20, 1997	General scheme on hazardous waste.
Royal-Decree 1481/2001	December 27, 2001	Regulates the disposal of waste by landfilling.
Law 34/2007	November 15th, 2007	Law regarding air quality and protection of the atmosphere. The First Disposition: Empowers the Government to regulate the terms and conditions related to the obligation of the owner of C&D waste to separate them by type of material.

Royal-Decree 105/2008	February 1st, 2008	Decree regulating the production and management of C&D waste (C&D waste):
		- Does not set any quantitative targets for prevention, recycling or disposal of C&D waste
		- Applies the principles of producer responsibility, waste prevention and shared responsibility between all actors involved in the production chain and the process of management of C&D waste.
		- The Decree establishes three types of actors that have different obligations according to their responsibility in C&D waste generation and management: the C&D waste producer, being the owner of the property where the construction or demolition activity will take place (who makes the decision of performing a construction or demolition activity), the C&D waste holder, being the performer of the construction or demolition activity and who has the physical control of the C&D waste; and the C&D waste manager, who is responsible for the final waste treatment or disposal. The obligations for each of the actors involved in the production and management of the C&D waste are:
		  - For the C&D waste producer: To develop a waste management study prior to the construction or demolition activity, containing an estimation of the amount of C&D waste that will be generated on site, a set of prevention measures and an expected final destination for the C&D waste. If there are any previsions of hazardous waste they should be accounted for (through an inventory), sorted and finally disposed of with an authorized body.
		  - For the C&D waste holder: To present a waste management plan that complies with the findings in the study and other obligations such as the sorting and proper disposal or delivery of C&D waste to a waste manager.
		  - For the C&D waste manager: To keep a record of the amount of waste handled in weight (tonnes) and volume (m3), the type of waste according to the list of categories published in the "Orden MAM/304/2002", the C&D waste producer and

Legislation	Year of implementation	Legal requirements
		holder information, the type of treatment and the destination of products or residues resulting from the treatment. This record must be kept for 5 years but there is no obligation to report it unless required by the public administration. In the case of HW, if the waste manager does not have authorisation to treat it, a handling treatment should be in place to ensure that all HW will be properly stored and delivered to an authorised body.
Order MAM/304/2002	February 8^{th} , 2002	Contains the definitions of recovery and disposal operations of waste and the European Waste List.

Table 55 - Legal regional documents dealing with waste management (Source: Beatriz Hernandez Cembellin, 2008. Los residuos de la construcción)

Region	Legislation	Legal requirements
Andalucía	Decree 218/1999) (Approved by the Decree 218/1999.)	There is no specific legislation. C&D waste is governed by: Territorial Management Plan (Municipal Waste) of Andalucía (1999-2008). There are a number of Provincial Management Plans: Cordoba, Seville, Malaga, Granada.
Aragón	Decree 262/2006.	Approves the national Regulations on the production, storage and management of C&D waste in the Autonomous Community of Aragon.
Islas Baleares	Decree 10/2000.	Dictates the mandatory selective collection and disposal of C&D waste.
	Order of the Ministry of Environment, 2000.	Transitional measures for authorising C&D waste recovery and disposal plants.
Cataluña	Decree 201/1994. (Modified by Decree 161/2001).	Regulation on debris and other construction waste.
	Decree 21/2006,	Regulates the adoption of environmental criteria and eco-efficiency for buildings.
	Law 16/2003.	Regards the financing of waste treatment infrastructure and fees on waste landfilling.
Islas Canarias	Decree 161/2001	Integrated Waste Plan of Canarias (2000-2006).
Cantabria	Decree 22/2007	Waste Plan Cantabria 2006-2010
Castilla y La Mancha	Decree 189/2005.	C&D Waste Management Plan of de Castilla y La Mancha (2006-2015).
Castilla y Leon	Decree 74/2002.	Regional Waste Strategy of Castilla y Leon 2000-2010.
Extremadura	Order, 2001.	Master Plan for Integrated Waste Management from C.A Extremadura. Ministry of Agriculture and Environment.
Galicia	Decree 174/2005	Regulates the legal regime of production and waste management and the General Register of producers and waste managers of Galicia.
Madrid	Law 5/2003	Chapter V: Special rules applying to C&D waste.
	Law 6/2003	Landfill tax.
	Order 2690/2006, of July 28.	Administration of the C&D waste in the Community of Madrid. Ministry of Environment and Spatial Planning.
Murcia	Decree 48/2003	Urban Waste and Non Hazardous waste Plan of Murcia (2001-2006), in Title II of the Law 9 / 2005, has introduced a tax for the disposal of hazardous waste or inert waste in landfills.
Comunidad Valenciana	Decree 200/2004	Regulate the suitable use of inert waste for restoration works, backfilling, or construction purposes.
País Vasco	Decree 423/1994	Decree on inert waste.
La Rioja	BOR nº 153, of December 9, 2000	Waste Plan de La Rioja 2007-2015.

15.4.4. STANDARDS

Table 56 - Standards in place in the construction sector

Standard	Legally binding	Requirements	Source
Declaration ApTO (Apitud Técnica a la Obra) - Itec	Voluntary	Practical and essential requirements: - UNE-EN-ISO 9001 Quality management system. - ISO14001 Environmental system. - OHSAS 18001. This certification of technical and operational capacity of a given company includes a revision of its environmental management system. There is no explicit reference to C&D Waste, but the revision includes compliance with legislation. It can be assumed that if the company is granted the ApTO, all the requirements by law from environmental legislation are fulfilled, including compliance with targets for C&D waste.	www.itec.es

15.5. QUANTITATIVE DATA

15.5.1. TOTAL C&D WASTE ARISING AND CHARACTERISATION

Spanish law qualifies as C&D Waste any substance or object generated in a C&D activity, which meets the definition of waste set out in the Law 10/1998 of 21 April. Therefore, the concept of C&D includes activities involving the construction, repair, alteration or demolition of a property, such as a building, road, port, airport, rail, channel, dam, or recreational sports facility, or another similar facility.

The following types of waste are excluded from the National Management Plan of C&D Waste (II PNRCD):

- Land and stones not contaminated by hazardous substances
- Any waste generated during construction and / or demolition regulated by specific legislation, when not mixed with other C&D waste. This applies, for example to industrial used oil waste, hazardous waste in general, packaging waste, used tires, batteries, electrical and electronic waste.
- Waste covered by Directive 2006/21/EC of the European Parliament and Council of 15 March on the management of waste from extractive industries. In the case of land and stones not contaminated by hazardous substances generated by on-site excavation activities, the reason for exclusion is that these materials can and should be re-used in the same or in other working sites, or in a renovation or backfilling activity, to thereby avoid the potential negative environmental impact of such waste through proper work planning. Hazardous waste is also excluded, because it is subject to a specific regulation.

The types of waste subject to PNRCD II are codified in the European Waste List, approved by Order MAM/304/2002 (BOE No. 43 of 19.02.2002), basically in Chapter 17 (Waste from C&D). This chapter is divided into the following categories.

Table 57 - C&D Waste categories

Code	Waste category
17 01	Concrete, bricks, tiles and ceramics
17 02	Wood, glass and plastic
17 03	Bituminous mixtures, coal tar and tarred products
17 04	Metals (including alloys)
17 05	Soil (including excavated soil from contaminated sites), stones and dredging spoil
17 06	Insulation materials and building materials containing asbestos
17 08	Building materials from gypsum
17 09	Other C&D waste

As indicated in the Integrated National Waste Plan, given the lack of reliable statistics, it is not possible to determine the exact amount of the annual production of C&D waste in Spain. Below are the statistics compiled by the PNIR 2008-2015.

Table 58 - Annual non hazardous C&D waste Generation in Spain – 2005 Year (Source: II PNRCD 2008 – 2015)

Region	Million population	Amount of waste generated in the year 2005 (tonnes)	Estimation of the amount of waste generated in the year 2010 (tonnes)*
Andalucia	7,849,799	5,676,631	6,401,873
Aragon	1,269,027	1,243,264	1,402,733
Asturias	1,076,635	507,449	569,313
Baleares	983,131	624,919	702,828
Canarias	1,968,280	987,077	1,112,694
Cantabria	562,309	523,735	588,602
Castilla-La Mancha	1,894,667	3,152,178	3,556,632
Castilla y Leon	2,510,849	1,151,025	1,295,727
Cataluña	6,995,206	6,696,756	7,538,472
Ceuta	75,276	10,885	12,301
Comunidad Valenciana	4,692,449	4,695,185	5,294,541
Extremadura	1,083,879	575,564	648,403
Galicia	2,762,198	2,141,376	2,409,733
La Rioja	301,084	418,787	472,511
Madrid	5,964,143	3,439,181	3,879,799
Melilla	65,488	26,017	29,400

Region	Million population	Amount of waste generated in the year 2005 (tonnes)	Estimation of the amount of waste generated in the year 2010 (tonnes)*
Murcia	1,335,792	1,465,630	1,623,020
Navarra	593,472	321,721	334,727
Pais Vasco	2,124,846	1,187,941	1,340,832
Total non-hazardous C&D waste	44,108,530	**34,845,320**	**39,272,885**
Total hazardous C&D waste		**20,667**	N/A

* Amount estimated from the waste generated in the year 2005; this number is predicted to increase by 1.62% from the volume of waste generated in 2005.

The average production of C&D waste per inhabitant and per year, according to 2005 data, can be estimated at 790 kg, with a maximum of 1664 kg/ inhabitant/year in Castilla-La Mancha and a minimum of 145 kg/ inhabitant/year in the city of Ceuta. In Castilla-La Mancha, La Rioja, Murcia and Valencia C&D waste quantities produced for 2005 were over 1000 kg/ inhabitant/year.

It has been noted that this information is not reliable, first of all, because not all C&D waste is captured and secondly because there is not a standardised methodology in place for calculating and predicting quantities of C&D waste generated. Several methodologies (IteC or SIDMONS) are applied, using different indicators, which generate unreliable information[226].

Due to the lack of information and the low reliability of the information collected from the different regions, the data presented in the previous table is based on assumptions made in the II PNRCD 2008 – 2015 (National Plan of C&D waste) document and is derived from the following data:

- Rates of C&D waste generation per m^2, used by The Institute of Construction Technology of Catalonia and the Technical Colleges of Architects for the management of works and edification projects.
- Statistics from the Public Works Ministry on Certificates of works in Construction, specifying the following parameters: area to build, area to rehabilitate, area to demolish.

According to this information, the following indicators were established in order to calculate C&D waste generated by each type of construction requiring a construction license:

[226] Carlos Martínez Bertrand, VIAS&CONSTRUCCIONES.

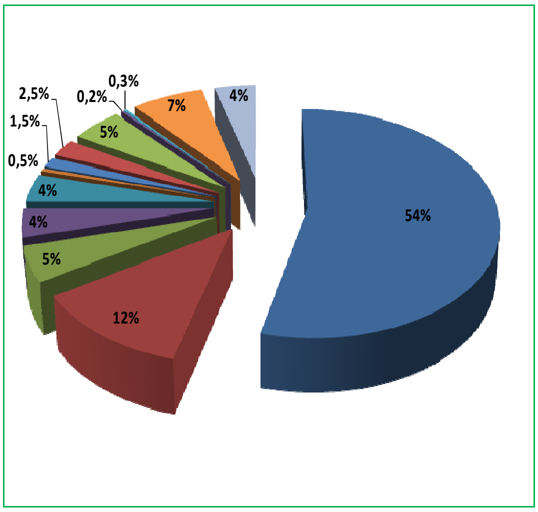
Table 59 - Indicators for the calculation of C&D waste generated (Source: II PNRCD 2008 – 20015)

Construction Type	Amount of C&D waste generated per m²
Works on new buildings	120.0 kg/m² built
Rehabilitation works	338.7 kg/ m² rehabilitated
Demolition works	1,129.0 kg/ m² demolished
Partial demolition works	903.2 kg/ m² demolished

It was assumed in these calculations that the amount of C&D waste generated by construction projects not requiring a construction permit was about 5% of the C&D waste generated by works requiring a construction license. For civil works this ratio is approximately 28%[227].

Given the lack of precise information about the composition of C&D waste in Spain, the figures below present the average composition of the C&D waste in the Community of Madrid, the only data currently available.

Figure 19 – The average composition of C&D waste in Madrid Community (Source: Integrated Management Plan of C&D waste of the Community of Madrid (2002 – 2011))



	Ceramics (54%)
	Concrete (12%)
	Mineral waste (stone) (5%)
	Mineral waste (sand, gravel and other aggregates) (4%)
	Wood (4%)
	Glass (0.5%)
	Plastics (1.5%)

227 II PNRCD (National of C&D waste) 2008 – 2015.

	Metal (2.5%)
	Asphalt (5%)
	Gypsum (0.2%)
	Paper (0.3%)
	Others (Garbage) (7%)
	Others (Non specified) (4%)

15.5.2. Recycling and recovery of C&D Waste

Similar to the limited existence of quantitative data about C&D waste generation in Spain, it also was not possible to find quantitative data on the amount of C&D waste re-used, recycled, used in backfilling or landfilled in Spain. According to estimations furnished by respondents for this study, it appears that only 7.2% of C&D waste is currently recycled and that around 60% of C&D waste is landfilled.

Below are listed the data available in the PNIR 2008-2015. It should be noted that these data have not been collected systematically but compiled through a survey of certain treatment plants, therefore explaining the lack of information for several regions.

Table 60 - C&D waste treatment in Spain in 2005 (Source: Second National Plan of C&D waste (II PNRCD))

Treatment of Non- hazardous waste in C&D sector		
Region	**Recycling (tonnes)**	**Disposal (tonnes)**
Andalucía	83.070	N/A
Aragon	15.383	N/A
Asturias	N/A	250.439
Baleares	N/A	N/A
Canarias	N/A	N/A
Cantabria	7.579	104.533
Castilla-La Mancha	N/A	N/A
Castilla Y Leon	194.120	N/A
Cataluña	465.124	7.248.881
Ceuta	N/A	19.762
Comunidad Valenciana	353.874	N/A
Extremadura	3.750	868.730
Galicia	12.285	N/A
La Rioja	2.390	52.233
Madrid	436.616	N/A
Melilla	N/A	N/A
Murcia	N/A	N/A
Navarra	N/A	N/A
Pais Vasco	195.645	N/A
Total Non-Hazardous C&D Waste	1.769.836	8.544.578

Table 61 - Treatment of Hazardous waste in the C&D sector (Source: Integrated National Plan of Waste (PNIR 2008 – 2015), Annex 2 – II National Plan of Hazardous Waste)

Treatment of Hazardous waste in C&D sector						
Total Non-hazardous C&D waste (tonnes)	RI blending	R3*	R4*	D5 - Landfill	D9 -Physical-chemical treatment*	D10- Incineration without energy recovery
20.667	562	561	3	18.479	503	560

* Definitions according to the Order MAM/304/2002 of February 8, in which are published the waste recovery and disposal operations and the European list of waste:

- **R1:** Principal use as a fuel or other means to generate energy.
- **R3:** Recycling or recovery of organic substances not used as solvents (including composting operations and other transformations biological).
- **R4:** Recycling or recovery of metals and metal compounds.
- **Physical-chemical treatment**: Sanitary waste sterilization.

The calculations used to determine the amount of C&D waste recycled, recovered or landfilled, are based on the following indicators:

- **% of C&D waste recycled**

% of C&D waste recycled = Tonnes of C&D waste subject to recycling operations / Tonnes of C&D waste generated (annual calculation)

- **Tonnes of C&D waste subject to recycling operations:** data measured at C&D waste treatment plants and recycling facilities for materials originating from C&D waste. Only the weight of materials actually recycled are counted, meaning that those products leaving the treatment plant are not included in this calculation
- **Tonnes of C&D waste generated:** data estimated from surveys performed with builders and through an analysis of other sources (building plans, estimations based on sector activity indicators or other indicators).

- **% of C&D waste object of recovery operation, including backfilling**

% of C&D subject to recovery operation, including backfilling = Tonnes of C&D waste subject to a recovery operation other than recycling but including Backfilling / Tonnes of C&D waste generated (annual calculation)

- **Tonnes of C&D waste which are subject to recovery operations other than recycling but including backfilling:** data measured where the recovery operation of the pre-treated final waste occurs, excluding recycling but including backfilling operations.

- **Tonnes of C&D waste generated (annual calculation):** data estimated from surveys of builders and other sources (building plans, estimates based on the sector activity indicators or other indicators).

- **% Tons of C&D waste landfilled (Authorised landfilling)**

> **% Tonnes of C&D waste landfilled (Authorized landfilling) =** 100 – (% C&D waste recycled) – (%C&D waste subject to recovery operations, including backfilling) (annual calculation)

This indicator can be obtained from the two previous indicators or alternatively as a means of verification; it can also be calculated by dividing the tonnes of incoming C&D waste to landfill by the total tonnes of C&D waste generated.

15.6. Practices in C&D waste management

15.6.1. Current practices in C&D waste management

- **Re-use**

Among the treatment alternatives for waste generated at construction sites, the most desirable option is the re-use of products obtained in new constructions.

There are two re-use options:

- Direct re-use in the same working site.
- Re-use in another working site.

The direct re-use in the same working site involves two phases

- Pre-selection of removed material.
- Cleaning of the material.

Once selected and cleaned, the construction residue material is in ideal condition to be re-used. With this approach, the form or the properties of the original products are not altered.

Re-use in other working site

In this secondary option, the situation is very similar to the above solution (with the difference that it is necessary to transport materials to the other working site). However, the situation is very different from an economic point of view, since in this case, the decision on the new destination of the materials to be re-used is linked to the existence of markets for waste products.

While situations vary greatly by location, these secondary markets, are generally scarce. The most common markets are for steel, wood and some specific products such as shingles.

- **Recycling**

This option is the conversion of waste into a new raw material that can be used in the manufacture of new products for use in new constructions.

The recycling activity in Spain, as cited above, is marginal. One factor that has discouraged the recycling of C&D waste has been the low cost of disposal and the lack of control of illegal disposal; however, the current legislation seeks precisely to prohibit uncontrolled landfilling.

The fraction of waste that is currently subject to special attention as a material to be recycled is called “debris” in the National Plan of C&D Waste; these materials represent approximately 75-80% of the C&D waste.

Treatment process

The C&D waste input to the treatment plant is usually mixed, and must be manually screened even before being passed through a sieve and a magnetic separator. These steps are followed by manual separation to eliminate plastics, wood, paper and other non-metallic residue.

The C&D waste mixture is then subjected to a crushing and magnetic separation before being passed through an air separator which removes the light fraction (small pieces of paper or plastics, which slip through the first round of separation).

Some recycling centres also have wood processing and composting plants.

Besides the use of centralised recycling plants, is very common to use mobile plants for the production of secondary aggregates from demolition aggregates. These plants typically complete the process of crushing and screening.

15.7. Past and future trends of C&D waste, drivers and barriers

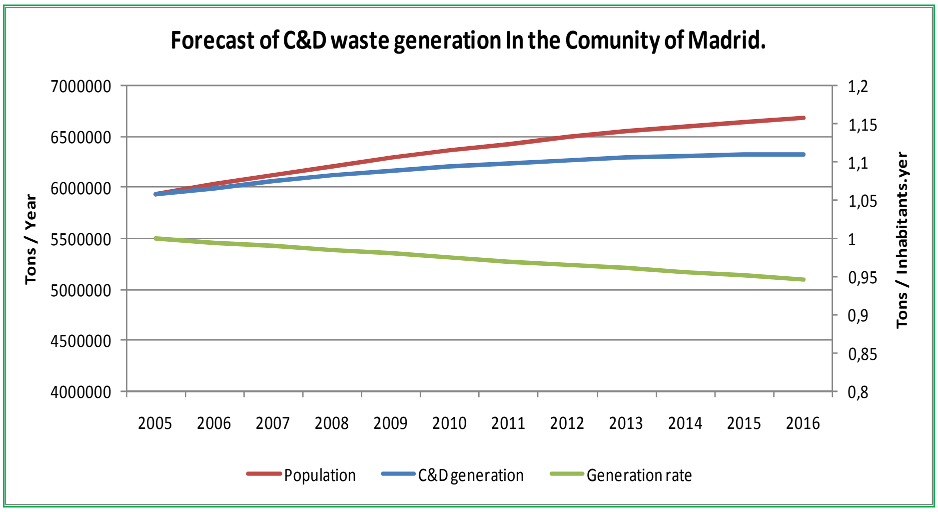
15.7.1. Trends in C&D waste generation and composition

In the beginning of the century and until 2007-2008, the construction sector has reached very high activity levels, making it a key sector for the growth of the Spanish economy. This situation resulted in an unusual increase in waste generation. Although a decrease in the amounts of C&D waste has been observed during the economic crisis, it can be anticipated that, once the crisis has been surmounted, C&D waste generation will again rise.

However, C&D waste generation is highly variable and more complex to quantify than other types of waste. One of the reasons is the important amount of C&D waste that is disposed of in uncontrolled landfills, therefore, making it difficult to obtain reliable statistics. Because of this lack of precise information for Spain, the forecasts made by the Community of Madrid can provide an indication of the future trend:

Note: these data are estimations and therefore must be used with caution[228].

Figure 20 - Forecast of Waste generation for the community of Madrid. Source: Waste strategy of the community of Madrid 2006 – 2016



These statistics have been calculated from official estimates of population trends completed by the Statistics Institute of the Community of Madrid, using the assumptions of an initial rate of 1 tonne per capita per year, and a subsequent moderate decrease. The forecasted decline in the rate of generation is 0.5% per year during the period of 2005-2016; this decrease in the rate of waste generation is assumed in the light of the forecasted decrease in aggregate consumption and the slowdown of the construction sector.

Regarding the composition of C&D waste, an increase in the amount of hazardous waste is expected, since progress in scientific research has uncovered toxic and carcinogenic properties of materials that were not previously considered as hazardous[229].

15.7.2. Trends in C&D waste management techniques

The increased generation of C&D waste, the low price for the disposal of C&D waste compared to the price of waste treatment and the lack of adequate infrastructure for the treatment of C&D waste have so far discouraged the recycling of C&D waste in Spain.

However, the current status of the construction sector could easily absorb the C&D waste currently produced and it is hoped that recycling and re-use operations will increase due to pressure from the administration, the changed attitude of the sector and the closure of unauthorised landfills.

[228] Ministry of Environment and Spatial Planning of the Community of Madrid, Waste Strategy for the Madrid from 2006 to 2016
[229] Jose Blanco, AEDED Association.

Some of the major difficulties impeding the proper management of C&D waste are:

- Lack of awareness and involvement of different stakeholders in the sector.
- Lack of enforcement of existing legislation: ineffective control and prosecution of abusive practices (illegal landfilling, no source separation of materials, etc.).
- Difficulties in the recovery process due to the heterogeneity of the waste.
- Competition with extractive activities; natural aggregates are easily accessible at low costs.
- Current costs of transport and landfilling are too low compared to the cost of treatment operations. Since landfills are under municipal jurisdiction, landfill taxes can vary greatly: from 1 Euro per tonne (Pamplona) to 25.20 Euros per tonne (Madrid)230. Moreover, if we compare the prices of natural aggregate with recycled aggregates, the former may vary between 10 and 20 Euros per tonne, while prices of recycled aggregates are generally lower.

15.7.3. Towards 70% re-use, recycling and recovery

There are some doubts whether the current measures will allow reaching the 70% objective stipulated by the Directive. Despite some projects in Spain where up to 95% of C&D waste[231] have been recycled, significant differences persist between the regions and significant efforts to deploy recycling infrastructure and to control the enforcement of existing regulations will be required in the future[232].

Nevertheless, there is a general consensus on some key points to improve, such as law transposition at the regional and municipal level, better policy enforcement, and the promotion of C&D recycled markets.

To overcome the difficulties faced by the C&D waste recycling sector, it is important to take measures in both the construction and recycling sectors and at the political level (National and European level):

- To promote the development of specific technical regulations for the use of recycled products in construction, in order to overcome the barrier to entry for such products in the construction sector.
- To promote and intensify the training of staff involved in waste management at all levels.
- To promote strategies for buying and selling of C&D waste (markets), thereby increasing C&D waste demand.

[230] Ministry of Development, Ministry of Environment, Centre for Studies and Experimentation of Public Works, 2009, Technical document on C&D waste

[231] Jose Blanco, AEDED Association.

[232] Pablo Gonzalez, GERD Association.

- To promote the demand of products from C&D waste recycling, especially recycled aggregates. This will be achieved through the development of technical and environmental regulations specifying the characteristics of the C&D waste recycled materials which could be used in construction.
- Eradication of illegal landfills of C&D waste and the regulation of landfilling taxes.
- Transposition of the national regulation to all Autonomous Communities.
- Harmonisation of calculation methods to determine the fraction of C&D waste generated which is recycled.

The achievement of the objectives established in Spanish policies should be accompanied by a joint effort between government actors, builders and waste operators.

16. APPENDIX V: CASE STUDY FINLAND

Amounts of C&D waste	Approximately 23 million tonnes (including excavation waste) to which must be added 410,000 tonnes of hazardous waste (Statistics of the Technical Research Centre of Finland, 2006) 1.6 Mt from house building sites (2007): renovation (57%), demolition (27%), and new building sites (16%)	
Waste factors	New construction	1 to 17 kg/r-m^3
	Small renovation	5 to 15 kg/r- m^3
	Middle Size renovations	50 kg/r- m^3
	Full-size renovation	200 kg/r- m^3
	Hazardous waste	2 g/ kg/r- m^3
Material composition of the C&D waste stream	Wood	40%
	Mineral	31%
	Metal	14%
	Others	15%
And of life options and rates	**Construction waste** - Material recovery - Energy recovery - Landfilling	 33% 27% 40%
	Recovery from **demolition waste**	50%
Analysis of the current state	Low material recovery rate; high energy recovery due to the important share of wood waste.	
Towards the 70% target	The National Waste Plan for 2016 sets a 70% target for recycling, re-use and recovery of C&D waste, including energy recovery. Aim for 2016: replace 5% of all gravel and crushed stone used in earthworks (3 to 4 Mt) by C&D waste. By 2016, new construction will probably be replaced by renovation activities. **Main challenges towards reaching the target**: - the calculation of the statistics on re-use and recovery of C&D waste is not currently reliable, the update of building coefficient not being frequent enough - the number of wooden buildings in Finland and the difficulty of recovery and re-use of construction wood waste	

16.1. SOURCES OF INFORMATION

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www.ymparisto.fi/download.asp?contentid=105821&lan=FI

C&D waste website of the Finnish Environment Institute: www.ymparisto.fi/default.asp?node=8478&lan=fi

Amounts of building waste from the website of the Finnish Environment Institute: www.ymparisto.fi/default.asp?contentid=171851&lan=fi

Confederation of Finnish Construction Industries: www.rakennusteollisuus.fi/en/

Waste management Company Ekorosk: www.ekorosk.fi/en/default.html

16.2. CONTACTS

Table 62 - Identified contacts for the case study on Finland

Full name	Name of organisation	Type of organisation	Function
Jorma Kaloinen	Finnish Environment Institute	National Authority	Expert on C&D waste
Juha Espo	Statistics Finland	National Authority	Waste statistics
Anna-Leena Perälä	Technical Research Centre of Finland	National Authority	Senior Research Scientist, MScTech Built Assets and Business Intelligence VTT Expert Services

16.3. CONTEXT

The great distances between building sites and treatment facilities explain the low profitability in recovering C&D waste in Finland. This is the case especially in Northern Finland, where the treatment facilities are rare, as they also tend to benefit from the wastes from the house manufacturing industries. Another feature, typical to Nordic countries, is the high proportion of wooden houses and the difficulties in recovering wooden materials.

16.4. POLICY AND STANDARDS OVERVIEW

16.4.1. KEY EUROPEAN POLICY DRIVERS

The EU waste legislation has been transposed and influences the national waste legislation accordingly but it cannot be seen as a major driver behind the approach taken towards C&D waste.

16.4.2. KEY NATIONAL AND REGIONAL POLICY DRIVERS

Considering non-legal approaches, the most important driver is the National Waste Plan for 2016[233], as it sets actions and targets for reducing C&D waste. The target set for 2016 is that at least 70% of all construction waste will be recovered as material or energy. Therefore, this includes energy recovery which does not necessarily mean that Finland will meet the 2020 target in advance. By 2016, construction practices will probably shift from new construction

233 Ministry of the Environment (2009), *Towards a Recycling Society, The National Waste Plan for 2016,* The Finnish Environment 14/2009

to renovation, which would also mean that most of the construction waste would be generated in connection to renovation. The aim set for 2016 is that approximately 5% (i.e., 3 to 4 million tonnes) of gravel and crushed stone used in earthworks will be replaced by waste generated by industry and mineral extraction.

The two main drivers for recycling and re-use are legal acts: the Environmental Tax Act and the Government Decision on Construction Waste. According to Jorma Kaloinen[234], they both work in synergy and had a profound impact in moving C&D waste away from landfills. They will be described in the next section with more details.

16.4.3. LEGAL DOCUMENTS

Table 63 - Legal documents dealing with waste management

Legislation	Year of implementation	Legal requirements
Waste Act (1072/1993), as amended	1993	Main instrument for the transposition of WFD.
Government Decision on Construction Waste (294/1997)	1997	The purpose of this Decision is to reduce the quantity and harmfulness of construction waste and increase its recovery. The indicative target to be aimed at is that an average of at least 50% of all construction waste, except for soil, rock, and dredging waste, to be recovered by 2000. This Decision applies to construction planning and to waste deriving from it. This Decision does not apply to construction sites where the quantity of resulting waste other than soil, rock and dredging waste is not more than 5 tonnes, or where the quantity of soil, rock and dredging waste deriving from it is not more than 800 tonnes.
Environmental Protection Act 83/2000	2000	States the types of C&D waste and the conditions for which an environmental permit is not required for the treatment.
Government Decree on the Recovery of certain wastes in earth construction (591/2006)	2006	The objective of this Decree is to promote the recovery of waste by determining the preconditions as the result of which, if met, no environmental permit in accordance with the Environmental Protection Act (86/2000) will be needed for use in earth construction from waste referred to in this Decree.

[234] C&D expert from the Ministry of the Environment

Legislation	Year of implementation	Legal requirements
Environmental Tax Act (495/1996)	1996	Sets a tax on waste taken to landfills. From 01/01/2005 this tax reaches €30 per tonne of waste.

The Finnish Waste Act from 1993 is the main waste legislation with its latest amendment in June 2007. It has evolved as the main instrument for the transposition of the Waste Framework Directive. There are a number of other decrees that specify aspects of the Waste Act, such as the Government Decision on Construction Waste (294/1997) and the Government Decree on the Recovery of certain waste in earth construction (591/2006).

Even if recycling or re-use does not require an environmental permit, it does require a declaration, using forms available on the website of environmental authorities, which are then submitted to the regional environment centre. The intention of the database is to ensure that activities such as backfilling would not be hidden as recycling or re-use.

16.4.4. Standards

Table 64 - Standards in place for the waste management and buildings

Standard	Legally binding	Requirements	Source
Government Decree on the Recovery of certain waste in earth construction (591/2006) Lists several standard	Mandatory	Sets several standards for the analysis and testing of waste, determining when an environmental permit is or is not required.	Government Decree on the Recovery of certain waste in earth construction (591/2006)
Promise, environmental classification system	Voluntary	The environmental classification system for buildings is a tool based on environmental criteria jointly agreed by the authorities and the operators of the sector. It is used to assess the environmental qualities of buildings.	Ministry of the Environment (2009), *Towards a Recycling Society, The National Waste Plan for 2016,* The Finnish Environment, 14/2009.

16.5. Quantitative data

16.5.1. Total C&D Waste arising and characterisation

Table 65 - Waste arising in 2005 and 2006

C&D waste fractions	2005 (ktonnes)	2006 (ktonnes)
Total C&D Waste arising	**21,870.4**	23,145.7
Bricks, tiles and ceramics	N/A	N/A
Concrete	N/A	N/A
Other mineral waste (stone, sand, gravel and other aggregates)	**20,700.2**	21,866.6
Asphalt	N/A	N/A
Wood	631.0	737.4
Plastics	N/A	0.0
Metal	212,8	251.8
Glass	35.0	37.8
Gypsum	N/A	N/A
Excavation material	N/A	N/A
Other (please precise) miscellaneous	290.2	251.9
Electric waste	0.1	0.0
Other (please precise)sludge	N/A	0.1
“Vegetation” waste	1.0	0.0
Total hazardous C&D waste	**343.6**	**409.1 (not specified)**
Chemicals	**0.1**	**0.1**
Asbestos containing waste	N/A	N/A
PCB containing waste	N/A	N/A
ODS containing waste	N/A	N/A
Phenol containing waste	N/A	N/A
Lead containing waste	N/A	N/A
PAH containing waste	N/A	N/A
Contaminated excavation material	N/A	N/A

In 2005, 343.6 ktonnes of hazardous waste were generated in addition to 21,870.4 ktonnes of C&D waste. In 2006, this amounts reached respectively 409.1 and 23,145.7 ktonnes.

Data gathered in the previous table was adapted from Statistics Finland, where the amounts of waste have been summarised for all types (including cars etc.). The previous table only includes relevant fractions that can be encountered in the C&D stream (among which “vegetation” waste).

Excavated soil accounts for the largest part of C&D waste reported in Finland. When no use is found due to its composition, location, or the stumps and other building waste it contains, it is regarded as waste soil. Most construction waste is made of this fraction, i.e. soil mass of mineral origin.

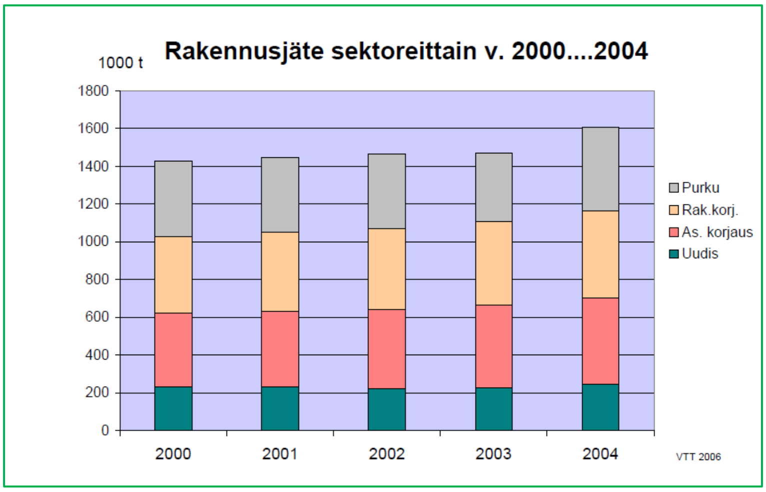
House C&D sites generated 1.6 million tonnes waste in 2007. Wood waste represented 40%, mineral waste 31% and metal waste 14% of the total construction waste.

Renovation building accounts for the largest proportion, i.e. 57% or 1.0 million tonnes, and demolitions sites for 27% of the total amount of waste. The remaining 16% came from new building sites.

Anna-Leena Perala from the Technical Research Centre of Finland was allowed by Statistics Finland to submit to us the unpublished report[235] on the most recent expert analysis on the building waste statistics based on year 2004 but prepared in 2006. Most of the below findings are based on this.

The amount of building waste is classified into three categories: new construction, renovation (residential and other) and demolished buildings. Figure 21 shows the proportion of waste arising from demolition (gray), renovation (divided into residential (orange) and other (red)) and new construction (green).

Figure 21 - Building waste per type of category



Note that the analysis and calculations by Technical Research Centre of Finland do not include excavated soil.

The estimates of building waste are developed in different ways for demolition, renovation and new construction. These estimates have been developed for the following materials: stone, wood, metal and other wastes.

235 Perala, A, Rinatnen, R. Nuuttila, H. and Maensivu, S.(2006), *Vuoden 2004 rakennusjatetilastoa tukeva VTT;n asiantuntijatyo,* VTT, Luottamuksellinen

■ **New Constructions**

Waste arising from new constructions are categorised based on house types. The analysis looked at 197 building sites. Waste leaving the building site was estimated as kg per building cubic metre. It was also possible to estimate the waste to be recovered from the sorted stream leaving the building sites. However, some building sites pointed out that mixed waste could be later recovered in waste treatment facilities.

About 70 % of the waste was composed of mixed fractions: wood waste representing 25%, stone waste 10 %, metals 1 % and other wastes 7 %. The amount of hazardous waste represents approximately 0.002 kg per building cubic metre.

■ **Renovation**

In the estimation of renovation waste, estimates from 2000 were used. The amount of waste was defined based on waste from demolished and from new building materials. Hence the changes in renovation waste amounts were only based on the increased numbers of renovations.

Renovation waste was made up of 80% of mixed waste, 16% of wood based waste, 1% metal and the rest of waste classified as "other". The amount of hazardous substances represented around 1 %.

■ **Demolition**

In 2004, 4,000 sites representing a total surface of 590 000 m^2 were demolished. These were categorised based on the structure material (concrete, brick, steel, wood and others) of the demolished buildings: about 48 % are stone based, 20 % wood based, 10 % bricks, 2 % metal and other materials about 10 %. The amount of waste from demolished buildings was 10 % higher in 2004 than in 2000.

16.5.2. Recycling and recovery of C&D Waste

The system to estimate re-use and recovery rates for C&D waste in Finland is based on a specific categorisation of buildings' types (detached, apartment blocks etc.) and if they are newly built or buildings to be renovated. These estimates are based on coefficients developed through analysis and surveys by the Technical Research Centre. The coefficients have been created based on actual cases (field data). As this system is difficult to put in place, coefficients are only updated every 3 to 4 years. The most recent study was conducted in 2004, based on the categorisation of new constructions, renovations and demolitions, as described earlier. The recovery rates for these are described below.

■ **New Construction**

The recovery rate of residential building sites was 34 % (in mass) but a huge variation exists from a construction site to another.

Of the wastes from new construction sites 26 % were wood based, 63 % stone waste, 9 % metal waste and 2 % other wastes. The recovery rate of building waste arising from all new constructions was approximately 44%, while it was only 30% in 2000. The most significant aspect of this increase is the better recovery of stone waste. However, according to Anna-Leena Perälä (Technical Research Centre of Finland) this is not based on any new technologies but on an increase of the number of waste treatment facilities.

- **Renovation**

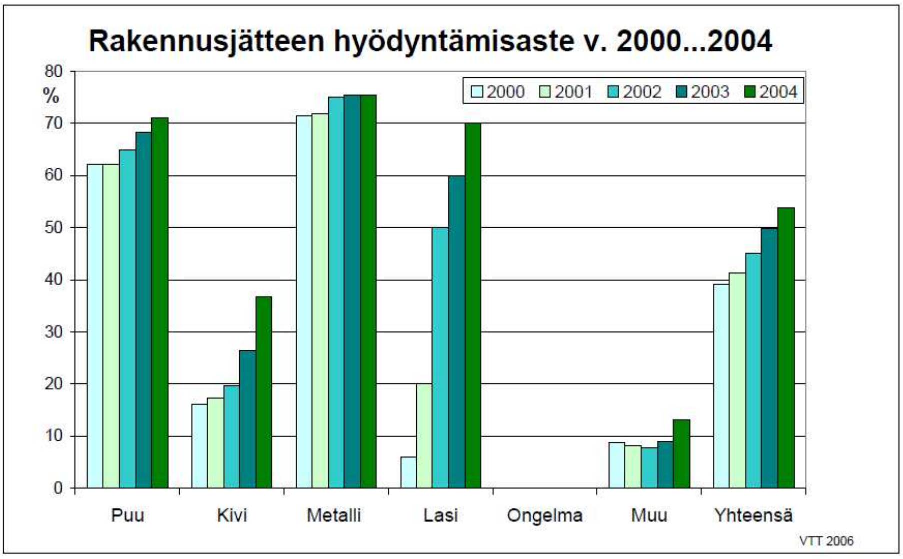
The recovered material from renovations was mostly concrete. As no building site assessment was done, it is not possible to illustrate with any field data the amounts that are recovered.

- **Demolitions**

It is estimated that the recovery of waste from demolished buildings has increased from 25 % to 50 %.

Coefficients were developed based on the most recent analysis of the Technical Centre of Finland while the recovery rates were estimated by the Statistics Finland. The changes in the recovery rates for wood (puu), stone (kivi), metal (metalli), glass (lasi), other (muu), hazardous (ongelma) and combined (yhteensa), are shown in the following figure[236].

Figure 22 - Recovery rates for specific building waste materials

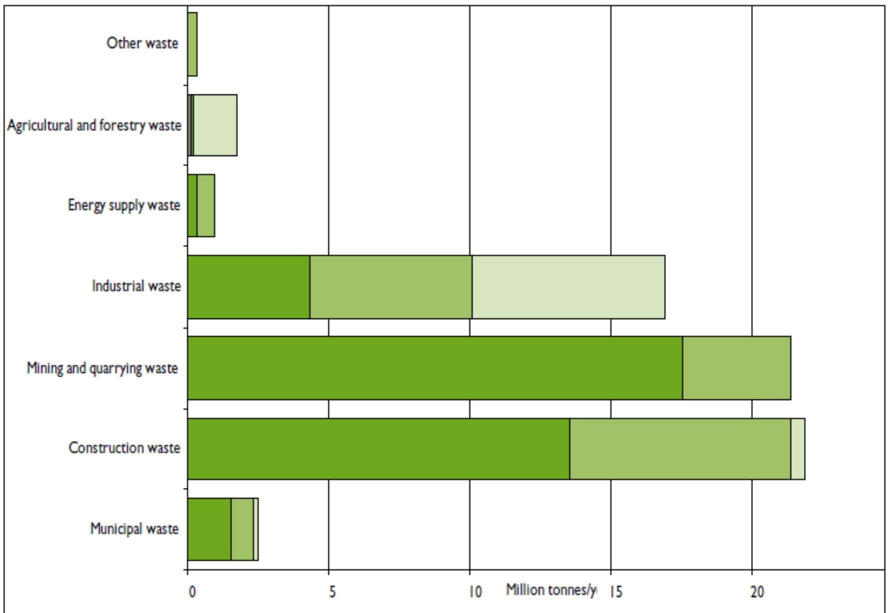


Excavated soil accounts for almost 95 % of the construction waste. In 2005, about 38 % of all construction waste was recovered. Of the waste generated during housing construction (about 1.7 million tonnes, excluding excavated soil) about 33 % was recovered as a material. At the same time, about 27 % was used through energy recovery, while the remaining 40 % ended up at landfills. The accumulation of waste (including construction waste), its recovery and

[236] Perala, A, Rinatnen, R. Nuuttila, H. and Maensivu, S.(2006), *Vuoden 2004 rakennusjatetilastoa tukeva VTT;n asiantuntijatyo,* VTT, Luottamuksellinen

treatment in Finland is shown in the following figure**Erreur ! Source du renvoi introuvable.**[237].

Figure 23 - Accumulation of waste, its recovery and treatment in Finland 2005



	Municipal waste	Construction waste	Mining and quarrying waste	Industrial waste	Energy supply waste	Agricultural and forestry waste	Other waste
Use as energy	0,18	0,49	0	6,83	0	1,6	0
Use as material	0,78	7,82	3,81	5,74	0,65	0,08	0,3
Disposal	1,52	13,56	17,55	4,35	0,31	0,09	0,01

16.6. PRACTICES IN C&D MANAGEMENT

16.6.1. CURRENT PRACTICES IN C&D WASTE MANAGEMENT

In general the distances between treatment facilities and building wastes are one of the main issues in determining the level to which building waste is sorted. Consequently it is not financially viable to sort building wastes in Northern Finland as all the main treatment facilities are in Southern Finland.

Below are some examples of treatment options for building waste.

- Concrete: Concrete structures are normally used as such or after their shape being re-adapted. Concrete can also be crushed for other uses, such as in road construction[238]. The use of crushed concrete for new concrete is limited because small particles need to be sieved away and this is technically difficult to achieve[239].

[237] Ministry of the Environment (2009), *Towards a Recycling Society, The National Waste Plan for 2016,* The Finnish Environment 14/2009
[238] Kiertokapula {2009}, *Raknetamisen jatteet,* 2009.
[239] Juntunen, A {2007}, Rakennusjatteiden lajittelu ja sen kehitystoimenpiteet rkl Halonen OY:ssa, Kajaanin Ammattikokrakoulu, Spring 2007

- Bricks: Undamaged bricks are re-used and damaged ones are crushed for recycling.
- Plasterboard: Clean plasterboard is used as a raw material for the production of new plasterboards. Contaminated plasterboards are sent to landfills[240]. Many treatment facilities do not accept any nails or any contaminant. Therefore, plasterboard manufacturers tend to use plasterboard waste from the production line rather than from building sites[241].
- Wood: Large amounts of wood waste are generated during the demolition process of old buildings. Treated woods cannot be classified as hazardous waste. The most common way of recycling wood waste is composting or burning.

According to Jorma Kaloinen, the recovery and re-use of construction wood waste is extremely difficult, as it is easily contaminated with other material. Indeed, this is one of the main barriers to achieving the 70% target. However, the treatment of wood has increased as a consequence of landfill taxes. This has increased the viability of longer transportation distances for wood fuel, which were not financially profitable in the past. Of course one can argue that the reduction in this type of waste from landfills, from a life cycle analysis point of view, will increase the negative environmental impact as a consequence of longer transport routes.

16.6.2. Emerging management practices

Eko-Expert KH Oy has developed a method to re-use insulation materials with the help of a high power suction machine. Then they can be crushed and used again as part of other insulation materials after a treatment that removes all contaminants.

In the future, the delivering and renewal of environmental permits for industries will be more efficient, paying attention to the recycling of large waste flows ending up traditionally in landfills. If necessary, examination obligations will also be imposed. When permits are renewed, the interpretations concerning the classification of secondary industrial flows as by-products or waste will be harmonised[242].

16.7. Past and future trends of C&D waste, drivers and barriers

16.7.1. Trends in C&D waste generation and composition

Based on the statistics from 2005 to 2006 the amounts of C&D waste were increasing. However, according to Jorma Kaloinen there has been, during the last years, as a

[240] Kiertokapula {2009}, Raknetamisen jatteet, 2009.
[241] Juntunen, A {2007}, Rakennusjatteiden lajittelu ja sen kehitystoimenpiteet rkl Halonen OY:ssa, Kajaanin Ammattikokrakoulu, Spring 2007
[242] Ministry of the Environment (2009), *Towards a Recycling Society, The National Waste Plan for 2016,* The Finnish Environment, 14/2009.

consequence of the recession, a move from new constructions to renovation activities. This resulted in considerably reduced amounts of C&D waste, especially when bearing in mind the way re-use and recovery rates of C&D waste are calculated.

Both Jorma Kaloinen and Juha Espo pointed out that several studies are now carried out to develop measures on how to decrease the amount of construction waste and how to increase recycling and re-use of this waste stream.

16.7.2. Trends in C&D waste management techniques

The Waste Act is to be reviewed in 2010 and it aims to review the definition of waste and product. This is especially important, as it has been in some cases easier to use virgin materials instead of secondary materials which might require the application of an environmental permit and be time-consuming.

In addition, the Waste Management Plan for 2016 suggests that municipalities should undertake the supervision of building demolition more efficiently so that the amount of recyclable waste ending up at landfills could be reduced.

16.7.3. Towards 70% re-use, recycling and recovery

The aim is that in 2016, at least 70 % of all construction waste will be recovered as material or energy. By 2016, the focus of construction will probably shift from new construction to renovation, which would also mean that most of the construction waste would be generated in connection with renovation. However, based on the available evidence it is difficult to see anything that would support these aspirations, especially as the statistics on re-use and recovery of C&D waste are difficult to calculate and the changes are slowly identified due to the way coefficients are estimated.

According to Jorma Kaloinen there will be a greater shift towards proactive material efficiency as the main driver for reducing C&D waste.

17. APPENDIX VI: CASE STUDY HUNGARY

17.1. Sources of information

- Reports and articles

  Fiknerné Sulcz Ágnes, 2nd February 2010. Akad még teendő az építési-bontási hulladékok hasznosítása területé Available at:

  http://www.muszakiforum.hu/cikk/71391/akad-meg-teendo-az-epitesi-bontasi-hulladekok-hasznositasa-teruleten...?area=160

  Standard-Team Kft., www.standard-team.com/cikkek/inert.php

- Websites

  Ministry of Environment and Water Management, Waste Information System (HIR), http://okir.kvvm.hu/hir/

  Baurec Construction Waste Treatment Coordination Non Profit Ltd. http://baurec.hu/site/

17.2. Contacts

Table 66 – Identified contacts for the case study on Hungary

Full name	Name of organisation	Type of organisation
Katalin Fekete	Ministry of Environment and Water/ Department of Waste Management/ Waste Treatment Unit	Ministry
Tibor Laszlo	Ministry of Environment and Water/ Department of Waste Management/ Waste Treatment Unit	Ministry
Istvan Varkonyi	Baurec Construction Waste Treatment Coordination Non Profit Ltd.	Non Profit Ltd.
Judit Ratz	HuMuSz (Hulladék Munkaszövetség) Waste Reduction Alliance	Association of Environmental NGOs

17.3. CONTEXT

The territory of Hungary covers 93,000 km^2 with a population of approximately 10 million people. One fifth of the population is concentrated around the capital of Hungary, Budapest, in the central region of the territory.

Figure 24 - Map of Hungary in the European Union

More than 240 million tons of solid waste is produced per year in Hungary. 33% of the solid waste is produced in rural areas and 67% in urban areas.

The domestic construction industry is still primarily using primary raw materials, rather than prioritising secondary materials. In order to boost the utilisation of waste the willingness of investors and constructors towards the use of these materials has to be enhanced in addition to updating relevant legislation.

17.4. POLICY AND STANDARDS OVERVIEW

Hungary faces the challenge of transposing the new EU waste framework directive (2008/98/EC) into national law. The relevant legislation shall be put in place before December 12th 2010. To that end, Hungary has started to prepare amendments to legislation. In order to achieve the 70% reuse, recycling and recovery rate, the regulation 45/2004. (VII.26.) BM[243]-KvVM[244], currently in force, is being fundamentally changed under the authority of the Waste Management Act. By the end of 2010, the ministerial regulation will be raised to the level of a governmental order.

[243] BM: Belügyminisztérium (Ministry of the Interior, now Ministry of Local Government)
[244] KvVM: Kôrnyezetvédelmi és Vízügyi Minisztérium (Ministry of Environment and Water)

17.4.1. KEY NATIONAL AND REGIONAL POLICY DRIVERS

According to the National Waste Management Plan the Regional Environmental Inspectorates have prepared the Regional Waste Management Plans for the 7 statistical planning regions. The deadline was 270 days after the National Plan came into force.

The Regional Plans were published by ministerial order of the Minister of the Environment and Water.

The certification system and the guide documents for C&D wastes are under construction and will be put in place by the end of 2010 together with the regulation relevant to C&D waste management.

The following priority areas have been identified where action is necessary to achieve the recovery rate.

- Creation of new regulation,
- Development of a system of economic incentives,
- Creation of a guide describing possible uses of C&D waste
- Adoption of dual rating system
- Adoption of the procedure of selective dismantling
- Assessment and optimization of the spatial distribution of available inert waste landfills, taking into account the major sites where C&D waste is generated and possibilities of salvage,
- Development and regular update of an accurate information system on data concerning C&D waste

Wide ranging professional discussions have been going on with the participation of processing sector, and certification institutes to ensure the achievement of the recovery rate with realistic applicability of the new regulation in practice.

The development of the new version of the Waste Management Act backing up the regulation on C&D waste management is also under way, and will be finalized by the end of 2010.

The first step towards the production of good quality secondary raw materials is selective demolition which allows for on-site separation of materials as opposed to the previously generally practiced demolition techniques which resulted in mixed debris.

As a prerequisite to selective demolition, a standardized regulatory framework, based on the specificities of the Hungarian construction and waste sector, should be set up in order to allow the classification and thus the presence of the secondary raw materials on the market.

The preference towards material separation, re-use and recovery, as well as the detailed regulation of usage are to be incorporated in construction related legislation. In addition, the construction, road construction standards, technical guidelines, testing and certification methodologies, are being reviewed. Further, a uniform system is to be set up to regulate the conditions of use of secondary raw materials.

Along with the modification of the current regulation 45/2004-es BM KvVM on the scope of C&D wastes some further related legislations will also be updated as well by the end of 2010. The 20/2006. (IV. 5) KvVM regulation regarding "certain rules and conditions of landfilling and landfills" will as well be updated with the incorporation of restrictions of disposal on landfills.

17.4.2. Legal documents

Tableau 67 - Legal documents dealing with waste management

Legislation	Year of implementation	Legal requirements
BM-KvVM decree 45/2004. (VII. 26.)	2004	The purpose of the decree is the detailed regulation of C&D waste management: • Registration of wastes as for source and treatment, • Mandating waste quantity planning as part of the official construction permission procedure • Mandating the reporting of generated construction waste quantity Certain requirements of the regulation are often not respected in practice, and the way of some waste remains undetectable.
Waste Management Act 2000/ XLIII.	2000	
National Waste Management Plan 2003-2008	2002	Targeted 50 % recovery rate by 2008 for C&D Wastes.
National Waste Management Plan	2010	Basic rules on C&D waste management.
Government decree 290/2007. (X. 31.)	2007	On documentation of construction activity, content of the building and the construction diary.

17.4.3. Standards

Tableau 68 - Standards in place in the construction sector (Source: KvVM)

Standard	Requirements
MSZ EN 196-1:1996	Cement testing methods. Determination of strength
MSZ EN 196-3:1996	Cement testing methods. Determination of the setting time and the constancy of volume.
MSZ EN 197-1:2000	Cement. Composition of cements of general use.
MSZ EN 206-1:2002	Concrete. Part I: criteria, performance, and preparation and conformity
MSZ EN 771-3:2003	Specification for masonry Part III: Aggregate concrete masonry units (Dense and light-weight aggregates)

Standard	Requirements
MSZ EN 772-1:2000	Methods of test for masonry units Part I: definition of strength
MSZ EN 932-1:1998	General properties of aggregates. Part I: Sampling methods
MSZ EN 933-1:1998	Geometric properties of aggregates. Part I: Determination of particle distribution. Sieve test.
MSZ EN 933-4:2000	Geometric properties of aggregates. Part IV: definition of granule shape. Granule shape factor.
MSZ EN 933-6:2003	Geometric properties of aggregates. Part VI: Determination of surface characteristics. The stone sets, discharge coefficient
MSZ EN 934-2:2002	Admixtures for concrete, mortar and grout. Part II: Concrete. Definitions, requirements, conformity, marking and labelling
MSZ EN 934-6:2002	Admixtures for concrete, mortar and grout. Part IV: Sampling, conformity control and compliance reviews
MSZ EN 998-1:2003	Specification for mortar. Part I: Rendering and plastering mortar
MSZ EN 998-2:2003	Specification for mortar. Part II:. Masonry
MSZ EN 1097-3:2001	Examination of aggregates for mechanical and physical properties. Part III: determination of density and gap volume
MSZ EN 1097-5:2001	Examination of mechanical and physical properties of aggregates. Part IV: Determination of water content
MSZ EN 1097-6:2001	Examination of mechanical and physical properties of aggregates. Part VI: Determination of density and water absorption.
MSZ EN 1338:2003	Concrete paving blocks. Requirements and test methods
MSZ EN 1339:2003	Concrete paving flags. Requirements and test methods
MSZ EN 1340:2003	Concrete berms requirements and test methods
MSZ EN 1367-1:2000	Test methods of stone sets' resistance and thermal properties. Part I: Determination of frost resistance.
MSZ EN 1367-2:1999	Test methods of stone sets' resistance and thermal properties. Part II: Magnesium sulphate process
MSZ EN 1744-1:2001	Chemical properties of stone clusters. Part I: Chemical analysis
MSZ EN 1992-1-1:2005	Eurocode 2: Design of concrete structures. Part I-I: General rules and rules for buildings
MSZ 4719:1982	Concretes

Standard	Requirements
MSZ EN 45014:2000	General criteria for manufacturers certificate of conformity
MSZ 4737-1:2002	Special cements. Part I: sulphate resistant cement
MSZ 4755-1:1990	Concrete pavement slab. Quality control
MSZ 4755-2:1990	Concrete pavement slab. Standard slabs.
MSZ 11405-1:1992	Leier-building elements. General specifications
MSZ 11405-4:1992	Leier-building elements. Examination of cellar masonry Items, granule distribution calculation.
MSZ EN 12350-1:2000	Examination of the fresh concrete. Part I:Sampling
MSZ EN 12350-2:2000	Examination of the fresh concrete. Part II: Examination of collapsing
MSZ EN 12350-4:2000	Examination of the fresh concrete. Part IV: Compaction factor (read compression rate)
MSZ EN 12350-5:2000	Examination of the fresh concrete. Part V: Flow table test
MSZ EN 12350-6:2000	Examination of the fresh concrete. Part VI: II: Density
MSZ EN 12350-7:2000	Examination of the fresh concrete. Part VII: Air content. Pressing methods.
MSZ EN 12390-1:2001	Examination of hardened concrete. Part I: shape, size and other requirements of the specimens
MSZ EN 12390-2:2001	Examination of hardened concrete. Part II: Strength test specimens preparation and storage
MSZ EN 12390-3:2002	Examination of hardened concrete. Part III: of the specimens compressive strength
MSZ EN 12390-4:2002	Examination of hardened concrete. Part IV: II: Compressive strength. Standards for test
MSZ EN 12390-7:2001	Examination of hardened concrete. 7th Part II: A well-established bulk density of concrete
MSZ EN 12620:2003	Aggregates (additives) for concrete
MSZ EN 13043:2003	Aggregates (additives), roads, airports and mixtures and other trafficked areas Surface
MSZ EN 13055-1:2003	Lightweight aggregates. Part I: Easy aggregates (additives) for concrete, mortar and grout
MSZ EN 13139:2003	Aggregates (additives) mortar
MSZ EN 13369:2004	Precast concrete products of general rules
MSZ ENV 13670-1:2000	1st design of concrete structures Part. General specifications
MSZ 18288-2:1984	Granule structure building stone and impurity examination. Granule structure sedimentation analysis
MSZ 18288-3:1978	Granule structure building stone and impurity examination. Granule structure Examination

Standard	Requirements
MSZ 18288-4:1984	Granule structure building stone and impurity examination. The chemical analysis of contamination
MSZ 18288-5:1981	Granule structure building stone and impurity examination. Granule structure characteristics calculation
MSZ 18293:1979	Sand, sandy gravel and gravel
MSZ CR 13902:2000	Methods of test for fresh concrete water / cement factor in the determination. CEN Report

17.5. QUANTITATIVE DATA

Every year about ten million tons of C&D waste is produced in Hungary. It includes seven million tons of earth, which - when pollution free - can be used without any problem, while the quantity of other C&D wastes is approximately three million tonnes. Although mandated by legislation, these quantities are only estimations as the precise quantity of C&D wastes generated within Hungary cannot be calculated with the current practice of market actors who often do not comply with these obligations.

17.5.1. TOTAL C&D WASTE ARISING AND CHARACTERISATION

Table 69 – Waste amounts arising for 2005 and 2008[245]

C&D waste fractions	2005 (tonnes)	2008 (tonnes)
Total C&D Waste arising	**4,987,084**	**6,788,241**
Total non-hazardous C&D waste	**4,129,992**	**6,569,932**
Bricks, tiles and ceramics	570,777	1,025,627
Concrete	514,902	751,842
Other mineral waste (stone, sand, gravel and other aggregates)	1,274,261	1,216,290
Bituminous mixtures, without coal tar	229,783	131,513
Wood	13,679	4,009
Plastics	1,796	4,974
Metal	865,117	418,135
Glass	1,609	4,450
Gypsum	1,080	3,574
Excavation material	654,261	3,005,396
Insulation materials	2,728	4,121

[245] Waste Information System (HIR – Hulladék Informàciòs Rendszer) http://okir.kvvm.hu/hir/

C&D waste fractions	2005 (tonnes)	2008 (tonnes)
Total hazardous C&D waste	**857,091**	**218,309**
Asbestos containing waste	3,455	2,153
PCB containing waste	9	1
ODS containing waste	N/A	N/A
Phenol containing waste	N/A	N/A
Lead containing waste	122	155
PAH containing waste	N/A	N/A
Contaminated excavation material	817,923	103,868
Mixtures of, or separate fractions of concrete, bricks, tiles and ceramics containing dangerous substances	1,025	17,902
Glass, plastic and wood containing or contaminated with dangerous substances	1,326	2,649
Coal tar and tarred products	1,270	308
Cables containing oil, coal tar and other dangerous substances	14	59
Metal waste contaminated with dangerous substances	7,618	3,525
Gypsum-based construction materials contaminated with dangerous substances	N/A	5
Hg containing waste	8,678	71,523

17.5.2. Recycling and recovery of C&D Waste

Table 70 - Waste production and amounts that are treated through the different options (Source: Ministry of Environment and Water)

C&D waste fractions	%	Recycling & other material recovery	Energy recovery by incineration	Disposal	Overall recovered
Total C&D Waste arising	N/A	N/A	N/A	N/A	N/A
Total non-hazardous C&D waste	**44,17%**	**2 156 186**	**284**	**2 725 220**	**2901939**
Concrete, bricks, tiles and ceramics	36,79%	N/A	N/A	N/A	377328
Bituminous mixtures, without coal tar	3,54%	N/A	N/A	N/A	4656
Wood, glass and plastic	0,65%	N/A	N/A	N/A	87
Metal	19,40%	N/A	N/A	N/A	81118
Gypsum	0,01%	N/A	N/A	N/A	0,36
Insulation materials	0,01%	N/A	N/A	N/A	0,41
Other	16,94%	N/A	N/A	N/A	N/A

17.6. Practices in C&D waste management

17.6.1. Current practices in C&D waste management

As a general observation we can state that the majority of generated C&D waste ends up in landfills or in many cases illegally dumped although there are more and more possibilities to their use. Some of the major characteristics of Hungarian C&D waste management practices are listed below.

- A part of the construction firms are not aware of the construction-demolition waste obligations.
- The investor's acceptance to use demolition waste is relatively low
- Construction permission procedures are not stringent enough, and authorities rarely have the capacity to check for the way of C&D waste, thus the relevant sanctions are rarely taken
- Selective demolition is not frequently practiced, thus the currently practiced demolition methods result in mixed debris
- The processing costs are higher than the dumping charges and in lack of appropriate incentives and controls will remain so. (Fiknerné, 2010)
- Secondary raw materials are kept in an unattractive position on the market as mining is taxed at a significantly lower level in Hungary as in other European countries. (2% in Hungary vs >10% in Europe in average) (Varkonyi)

17.6.2. Emerging management practices

No emerging treatment and management techniques have been identified through the interviews.

17.7. Towards 70% re-use, recycling and recovery

It is estimated that the construction-demolition waste recovery rate is currently only around 30-35% (in addition to the quantity of excavated soil), thus, by 2020 the current rate should be at least doubled. The main needs in the field of C&D waste management where actions can serve the achievement of the 70% recovery rate by 2020 are listed below:

- Legislation has to be created to encourage the re-use and recovery of separated materials, to regulate treatment modalities and to set up a harmonised system of classification of secondary materials
- Construction, road construction standards, technical guidelines, testing and rating methodologies have to be reviewed, and a uniform system has to be set up to regulate the conditions of use of secondary materials. These will have to be

continuously developed in the future as new building practices and new types of building materials keep appearing which will require more complex techniques than current building materials.

- An efficient awareness raising campaign has to be launched for the construction sector (Varkonyi)
- Precise definitions have to be accepted for the "end of waste aspect" (Fiknerné, 2010)

Considering the relatively low current recycling rates, the high amounts of C&D waste illegally disposed of (and therefore not accounted for in the statistics reported), and the recent policy development specifically targeting C&D waste, Hungary is representative of MS for which the targets set by the WFD represents an important driver. However, one of the main challenges is still the better enforcement of existing legislation, particularly through diverting C&D waste from illegal landfill. Combined implementation and enforcement of landfill regulations and C&D waste targeted actions listed above will lead, at first, to better reporting and monitoring, and is likely to drive significant increases in recycling rates.

18. APPENDIX VII: WORSHOP MINUTES

18.1. PREAMBLE

These minutes describe the discussion arising from the workshop presentations given by BIO IS, the experts interviewed for the purpose of the material study (concrete, ceramics, asphalt and gypsum) and other stakeholders.

All the speakers' presentations are available online: http://www.eu-smr.eu/cdw/meetings.php

Gunther Wolff welcomed participants to the workshop in his opening remarks and gave some background information on the Waste Framework Directive (WFD) and especially the 70% target for re-use, recycling and other material recovery of construction and demolition waste by 2020.

C&D waste had not been specifically regulated until recently, though it represents an important waste stream. The EU aims at becoming a recycling society, therefore prevention, reuse and recycling have the priority, whereas incineration and landfilling are the last options to consider for waste management. Currently, huge differences exist between Member States (MS) regarding the recycling and re-use rates, going from 10 to 90% where data is available.

The study carried out by BIO IS for the DG ENV aims at describing the current situation, and identifying and promoting best practices regarding the management of C&D waste.

18.2. .GENERAL PRESENTATION OF THE PROJECT

18.2.1. BIO IS PRESENTATION

Mathieu Hestin of BIO Intelligence Service launched the day's proceedings with an introduction to the project and a description of the day's agenda as shown in the following table.

Table 25 – C&D waste workshop, June 21st, 2010, Brussels

Time	Topic	Speaker / Moderator
13:30 – 14:00	Registration	
14:00 – 14:15	Opening and welcome remarks	Gunther Wolff, *European Commission, DG ENV*
14:15 – 14:45	Findings of the study on Construction and Demolition Waste	Mathieu Hestin, *BIO Intelligence Service*
14:45 – 16:30	Construction materials and recycling options • Concrete • Masonry • Asphalt • Gypsum	Mathieu Hestin, *BIO Intelligence Service* Alessio Rimoldi, *European Precast Concrete Manufacturers* Christophe Sykes, *Tiles and Bricks Europe* Christine Marlet, *Eurogypsum* Egbert Beuving, *European Asphalt Pavement Association*
16:30 – 16:45	Coffee Break	
16:45 – 17:15	Construction Waste and Resources Roadmap	Gillian Hobbs, *BRE*
17:15 – 17:30	Concluding remarks	Gunther Wolff, *European Commission, DG ENV*
17:30	**End of the workshop**	

The objectives of the study on C&D waste were first to define the framework for the calculation of the re-use and recycling target and secondly to describe the current situation within the EU and identifying potential drivers and barriers for the further improvement of the rates.

Mathieu Hestin described the C&D waste generation and recycling rates estimations made by BIO IS based on available data. He outlined the high uncertainty of the data and the important geographic variations due to different practices and differences in the definitions and reporting. He further described the two main policy drivers at the EU level (the WFD and the Directive on landfill), some national policies and standards identified at the national level. Mathieu Hestin furthermore developed on the barriers and drivers for the improvement of the re-use and recycling rates and the content of the final report (material focuses and country case studies).

Eventually, he delineated the next steps of the project: the finalisation of the report thanks to the stakeholders' comments that are to be sent by mid-August.

18.2.2. Stakeholders' discussion

- **Christophe Sykes, TBE aisbl**

Mr Sykes outlined the issue of excavated soil: is it considered as a potential resource or as a waste? Mr Hestin explained that excavated soil had not been included within the scope of this study, as it was excluded from the recycling target.

Mr Sykes further underlined the lack of analysis of the chemical composition of the waste stream. Indeed, if the largest volume is made of the inert fraction, the remaining part is considered as toxic and the environmental impacts are not clearly tackled in the report.

Mr Wolff answered that the Directive requires the sorting out of the C&D waste stream; hazardous waste is not included in the 70 % target, however, it has to be separated at source and treated specifically and under proper management options.

- **Peter Jones**

Mr Jones outlined the high uncertainty of certain figures on ODS presented in the report, which requires a clear warning and analysis. He stressed that if insulation panels do not represent an important stream in weight, they do in volume as they are light weight materials.

- **UEPG**

The European Aggregates Association insisted on the fact that standards on the quality of secondary raw aggregates already exist. Therefore, some of the recommendations defined in the report do not bring anything new. This should be further described in the report.

- **FIR**

The Fédération Internationale du Recyclage asked for a clear definition of backfilling since the difference with landfilling seems very small in some cases. For example, in Sweden, a limited fraction of waste is landfilled.

The FIR confirmed the existence of standards for aggregates.

Mathieu Hestin confirmed the need for clarification of certain definitions, especially on backfilling operations.

Mr Wolff added that the EC has been working on the definitions for the calculation of the targets since the TAC meeting that took place on April 3rd, 2010 and that a Commission Decision was being prepared.

- **The European Aluminium Association**

The association outlined the fact that the final report does not tackle the aluminium fraction at all.

Mr Wolff underlined the fact that most of the metal construction and demolition waste is already recycled. Therefore, the EC is not worried by metals that can be found in the C&D waste stream.

18.3. THE CONCRETE FRACTION

18.3.1. BIBM PRESENTATION

Alessio Rimoldi, Secretary General of the European Federation of Precast Concrete, described the use that are made of concrete in the construction sector and the properties that make it the most consumed material worldwide with 25 billion tonnes and 2.5 billion tonnes at the EU level. It is estimated that between 40 to 60% of the C&D waste arising at the European level is made of concrete. Mr Rimoldi outlined the difficulties to have reliable data as the risks related to concrete are low because of its inert properties; close monitoring and reporting is therefore not always encouraged. The objective set by the Industry is zero landfilling, through the promotion of prevention of waste on the one hand and re-use and recycling on the other hand, in accordance with the Waste hierarchy. When considering the re-use and recycling definitions in place in the concrete sector, it appears that recycling is not feasible as concrete cannot be recycled back into its original constituents. However, material recovery is an option, crushed concrete being used as aggregates for road sub-base or as a secondary raw material. As the availability of raw materials is not an issue and that the environmental impacts of crushing concrete and of extracting raw materials are almost the same, the potential drivers towards recycling depend strongly on the local market conditions. Finally, Mr Rimoldi insisted on the fact that the Industry is calling for long term strategies to develop re-use and recovery of concrete and is ready to bear the investments that will be needed.

18.3.2. STAKEHOLDERS' DISCUSSION

Mathieu Hestin added to Mr Rimoldi presentation that the re-use of concrete blocks prevents the production and use of cement, which represents the main environmental impacts of this material, particularly in terms of greenhouse gases emissions.

18.4. THE CERAMIC FRACTION

18.4.1. TBE AISBL PRESENTATION

Christophe Sykes, Secretary General of the Tiles and Bricks of Europe Association, described the Industry profile that has been greatly impacted by the economic crisis and the characteristics of the product that make it an extremely durable material. Numerous options exist for the re-use and recovery of bricks and tiles, among which the use as filling and stabilising material and re-use in the products original form. The Netherlands and Denmark achieve high recycling rates of this fraction with more than 95% but still are calling for more attractive recycling options. Finally, for the minimisation of the waste stream and the improvement of recycling practices, TBE promotes longer life-span building, economical attractiveness of secondary raw material and technical value of secondary aggregates.

18.4.2. STAKEHOLDERS' DISCUSSION

The representative of the Netherlands Ministry of the Environment mentioned a study on the environmental benefits of adding waste ceramics powder into virgin clay that proved this option to be very beneficial: the energy consumption and emissions of the process are lower than the production of virgin clay, and the quality of the brick is higher.

It was stressed that the composition of the mortar was essential to allow the reuse of bricks; in Georgia, for example, mortar is made of material originating from seashells and allows an easy removal and reuse of bricks. Mr Sykes answered that the choice of materials, including mortar, was mostly driven by aesthetical and architectural considerations, which have to be taken into account.

18.5. THE ASPHALT FRACTION

18.5.1. EAPA PRESENTATION

Egbert Beuving, Director of the European Asphalt Pavement Association, described the missions of the EAPA among which calling for an effective and sustainable use of asphalt and the promotion of higher levels of asphalt recycling. Mr Beuving drew the emphasis on the recycling options which consist in adding reclaimed asphalt pavement (RAP) to new asphalt mixes by presenting the different methods (cold or warm RAP method) and the respective incorporation rates achieved. These options can be put in place in a central plant or directly in situ.

The presentation consisted of different pictures showing asphalt plants, how reclaimed asphalt is removed from the road and the machinery that are used for this purpose. Mr Beuving states that reclaimed asphalt can obtain the non waste status when it meets the specific European quality criteria, according to the European Standard EN 13108-8. At the European level, almost 52 million tons of reclaimed asphalt is available and 86% is estimated to be re-used and recycled.

Mr Beuving mentioned the issue related to old pavement containing tar that can only be recycled through the cold RAP method. Finally, the asphalt Industry strongly supports the re-use of RAP at the highest possible level and encourages considering it as a product and not a waste. Indeed, asphalt is 100% recyclable material and recycling should be encouraged by the product (road) owner.

18.5.2. STAKEHOLDERS' DISCUSSION

The representative of the Netherlands Ministry of Environment asked Mr Beuving whether bitumen was expected to become scarce and the near future, and what consequences this scarcity would have on prices. Mr Beuving answered that he had no specific information on the evolution of prices, but that scarcity was not to be expected in the near future. Research on artificial binders (e.g. bio binders) is currently undergone. A second question was raised on the use of rubber or plastic modified asphalt and the possible barrier it can represent for the future recycling of reclaimed asphalt. Mr Beuving answered that plastic modified asphalt had been used for a long time and that it can be recycled in any process described during the presentation.

- **Christophe Sykes, TBE aisbl**

Mr Sykes outlined the fact that the banning and the taxing of some waste management options such as landfilling without the parallel development of alternatives is not a solution, and can represent a risk that waste streams are diverted to illegal treatment operations.

- **Swedish EPA**

Nanna Spett from the Swedish EPA asked whether high levels of tar in asphalt could prevent its recycling, and what the acceptable levels were. Mr Beuving answered that tar levels were usually low enough to allow recycling, but that the acceptable levels depended on the country.

- **Gunther Wolff, EC, DG ENV**

Mr Wolff asked for the reasons explaining such high recycling rates: is it because it is economically beneficial or the reduction of the environmental impacts? According to Mr Beuving, it depends on several factors among which the local availability of raw materials.

- **Peter Jones**

Mr Jones mentioned that a thin layer of bitumen is used for roofs; Mr Beuving confirmed that this bitumen could also be recycled into asphalt pavement.

18.6. THE GYPSUM FRACTION

18.6.1. EUROGYPSUM PRESENTATION

Christine Marlet, Secretary General of the European Federation of national associations of gypsum products, described the gypsum industry in Europe.

The focus of this presentation is laid on plasterboards since they are the only products that can be taken back to the plant at the construction stage (cut-off, damages plasterboards, etc.). Gypsum from plasterboard is considered to be 100% recyclable into new plasterboard in a closed loop system as the properties remain unchanged when integrating recycled gypsum.

Since decision 2003/33/EC establishing criteria and procedures for the acceptance of waste at landfills, gypsum is classified as a non-inert waste, leading to increasing landfill costs and the development of recycling options, also encouraged by the promotion of resource efficiency. Mrs Marlet insisted on the need to have access to gypsum products that can be found in demolition waste. For this purpose, works must be dismantled instead of being demolished in order to avoid any contamination (wood, steel, plastic, etc.). Finally, Mrs

Marlet outlined the part that the actors of the gypsum industry can play in the development of the C&D gypsum waste recycling.

18.6.2. Stakeholders' discussion

The representative of the Netherlands Ministry of the Environment mentioned that the management of gypsum waste in his country suffered from exports to Germany, where no landfill taxes are applied.

The discussion then moved towards producer responsibility for gypsum waste. Christine Marlet indicated that this was an industry-wide (and not a company specific) issue, as the products are very similar. While recognising the responsibility of the gypsum industry, she stressed that the responsibility was shared along the supply chain, and that C&D site managers for instance had a high responsibility; high recycling rates will not be achieved if building are not correctly dismantled.

Mr Sykes also mentioned the responsibility of the distributors (in the case of B2C business), and that consumers needed the possibility to take back construction and demolition waste materials to public sorting facilities; this is well developed in France and in the Netherlands for example, and should be extended.

18.7. The UK example: the construction resources and waste roadmap

18.7.1. BRE presentation

Mrs Gillian Hobbs, from the Building Research Establishment, described the concept of C&D resource efficiency. It is related to building efficiency (BREEAM rating system, etc.), to low impact elements and products and to resource efficient products (recycled and hazardous content, recyclability, etc.). England promotes the best environmental options for the management of C&D waste and especially the reduction, the re-use and the recycling of this waste stream. The target set for 2012 by the Waste Strategy (2007) and the Sustainable Construction Strategy (2008) requires halving the amount of construction, demolition and excavated waste sent to landfill (compared to the 2008 baseline).

The construction resources and waste roadmap was launched in 2008 and promotes waste reduction through a voluntary commitment of the Industry and a strategy defined in common with the Government.

The Industry committed to develop resource efficiency plans (packaging, flooring and joinery), product roadmaps (plasterboard, windows) and site waste management planning.

In parallel, the Government is increasing landfill tax and packaging recovery targets. Moreover, the Government could establish landfill restriction and protocols for quality control and for the end of the waste status, as well as financially support businesses.

The priority areas being identified by the Industry are the landfill bans on recyclable and biodegradable waste and the design for deconstruction and recycling.

Finally, Mrs Hobbs presented the main recommendations of the roadmap.

18.8. CONCLUSION

Mr Wolff concluded the day by outlining the fact that this workshop was part of the first study carried out on this subject since 1999 and come up with new conclusions and very interesting findings thanks to the examples set by the federations. Several limiting factors affecting recycling have been identified such as the cross-border movement of waste and the possible “diversion” of backfilling operations.

MS that are lagging behind in this area can take advantage of the examples set by countries with a long recycling tradition and high recycling and recovery rates.

In the case of the front runners, several legal measures have contributed to recycling, e.g. an increase of landfill taxes or landfill bans. Mr Wolff also stressed that a number of “soft” measures, such as R&D, knowledge dissemination, network development, involving actors along the value chain, voluntary schemes at the national level, etc. could also contribute to a more sustainable use of resources. Moreover, the development of recycling is closely linked to the development of standards and certification at the EU and national level. Trust in the recycling products is needed for the increase of recycling practices.

Taking into account the importance of the State in the construction sector, the promotion of the use of recycled products through Green Public Procurement by public administrations can be an additional and promising measure.

19. APPENDIX VIII: Stakeholders comments on the draft final report

Following the workshop held in Brussels, feedback and comments on the draft final report were asked to stakeholders.

Many constructive comments were received and the information provided or the corrections proposed were integrated in the final report. The table below presents the comments sent by the following stakeholders[246]:

- Christian WADEY, DEFRA
- Eva MARAQUE, AFIPEB
- Laurent CHATEAU, ADEME
- Edmar MEUWISSEN; EUMEPS
- Geert CUPERUS, FIR
- Common comments from EPRA, UEPG & ECP
- Oliver Loebel, PU Europe
- Peter Jones, Independent consultant
- Dieter ROSEN, Bundesverband der Deutschen Ziegelindustrie

Stakeholder	Comment
General comments	
Christian Wadey, DEFRA	This report addresses the importance of having consistent and reliable data on C&D waste and identifies potential drivers for improving re-use and recovery of the waste stream in the context of the WFD 70% target. Both these objectives are sound but miss what should be the primary objective of reducing the original arisings of C&D waste. The highest cost to the construction industry is the creation of waste, reducing the creation of waste is the most cost effective and sustainable option and is not addressed sufficiently within this report. Reducing the amount of C&D waste generated also immediately reduces the quantity of waste required to achieve the 70% target of waste re-used or recovered. WRAP have extensive guidance on designing out waste in construction, both for Buildings and in Civil Engineering. This guidance is supported by a Net Waste Tool for assessing the cost benefits of a range of waste reduction and re-use options. The use of Site Waste Management Plans is also an essential part of the measurement and management of C&D waste. *Response: These elements were taken into account when finalising the report*
Christian Wadey, DEFRA	On generation data: Why wasn't the European Waste catalogue used as a more reliable way of gathering evidence? *Response: EUROSTAT data was the main source used in this report; when available, it was completed with national data*

[246] Responses are given to those comments which necessitated revision(s) of the information in the report

Christian Wadey, DEFRA	*On generation data:* The figures used for C&D waste arising in the UK include excavation waste and this has been taken into account in this analysis leading to inaccurate assumptions on the UK performance against th 70% target. *Response: Figures for the UK were corrected in the final report with national data*
Christian Wadey, DEFRA	The data in the report is massively unreliable. For example the practice of adding 1m tonne per capita per y underreporting countries (under the sub-title 'Incomplete Data') is questionable. There is also the proposed exclusion of excavation data from the six countries with the highest per capita generate, to the tune of 75%. *Response: for MS where data was clearly lacking, the EU average generation was applied. The hypothesis of excavated material was replaced in the final report with national estimates when available*
Laurent Château, ADEME	The part of excavated material in French C&D waste is higher than 75%. National data provide a better estim *Response : this information was added to the final report*
E. Maraque, AFIPEB	In page 14, in the "New estimation of total C&D waste arising in EU-27", we feel that a table presenting the r recent and corrected data for each Member State would be necessary (tables 2 and 3 together) in order to counterbalance the false impression given in the table 1 which is the only table listing all Members States in 3.1. *Response: Tables were revised in the final report.*
Christian Wadey, DEFRA	Detailed figures in a WRAP report for C&D arising and recovery in England for 2008[5] show recovery signific ahead of the 70% target. (report produced by Capita Symonds.) The Bio report focuses on concrete, masonry, asphalt, metal, wood, gypsum, plastics and 'miscellaneous'. D analyses on concrete, asphalt, masonry, wood and gypsum are provided later in the report sections 4 to 8. This focus on single waste streams misses the major issue of mixed C&D waste going to both treatment cent and landfills. Figures for England in 2008 highlights this problem: When considered as percentages the scale of mixed wastes arising and then moving to landfill shows that th mixed waste stream merits special consideration and its management is more significant for meeting the 70 target than the single streams in sections 4 to 8. *Response: UK data were replaced in the final report with the national estimated provided*
Laurent Château, ADEME	Recycling rates in France are estimated to be lower than presented in the draft final report. Based on availab national data, it is approximately 45% *Response : data for France was updated in the final report*
Christian Wadey, DEFRA	On Secondary materials regulation and standards : Four member states, Germany, Flanders, Spain and Finlar used as examples in this section but no reference is made to the European Aggregates Standards which appl member states and enable the use of a masonry, concrete and asphalt as resources for the production of aggregates. They have applied to all MS since 2004 *Response : This information was added to the final report*
Christian Wadey, DEFRA	The choice of resources used to produce aggregates is directly related to comparative processing costs, marl price and distance to market. WRAP carried out two detailed assessments of this relationship, one for Englar the other for Scotland. *Response : This information was added to the final report*
Geert Cuperus, FIR	1. FIR welcomes the study of Bio Intelligent Service and its partners on the Management of C&DW. It provide lot of information concerning the current situation in Europe. Specifically we endorse the conclusions in the that confirm the fact that 70% recycling of C&DW is feasible. We think that this is a major outcome of the study that cannot be highlighted enough. 2. We like to add that 70% recycling is very well feasible also in countries with currently low rates of recyclin Experience has shown that if political willingness is there, recycling may well develop in just a few years. 3. The report clearly points out that the main mechanisms for recycling are landfill taxes and landfill bans. Experience has shown that even small increases in landfill taxes create opportunities for recycling. 4. Regarding point 2 and 3, it is a pity that the report does not go into too much detail on the economics of recycling. This would have shown that recycling of C&DW is very well feasible when landfill taxes go up just a Euro/ton. Paragraph 4.4.2 makes a comparison with primary aggregates. It is even more relevant to compare costs of recycling with the costs of other waste management options. The costs of waste management optio determine where the waste goes. We think the report will benefit from a clear analysis of the price mechani that actually manage the waste. 5. The most usual way of processing C&DW is by crushing a mixed inert fraction. This results in Mixed Recycl Aggregates. Unfortunately, due to the approach per material, this main way of working is not reflected in the report. Other methods like crushing for tennis sand etc. are not to be considered as usual approaches. We th the report will benefit from a clear description how management of C&DW in practice actually works. Item 4 above relates to this: if the waste management chain of C&DW is clearly described, the costs per step visuali controlling mechanisms. *Response: it was not the purpose of this report to go into details in the economics and price mechanisms; ho*

	such considerations are taken into account in the analysis, e.g. in the concrete section
Geert Cuperus, FIR	6. In several chapters reference is made to "recycling as a filling material". We need to stress that this is wrong way of presenting the situation. Recycled aggregates are not used as filling material. They are construction products in accordance with European standards from CEN/TC154, CEN/TC227 etc. "Filling" refers to a practice where it does not matter what kind of material is used and where no requirements apply. This is the case when for instance C&DW as such is used. We call upon the authors to change texts wherever a relation is made between "recycling" and "filling". *Response: recycling is understood in a broader sense in this report. However, it is clearly stated that backfilling is not recycling, but a form of material recovery*
Geert Cuperus, FIR	7. We welcome the fact that the issue of "backfilling" as a threat to recycling is mentioned in the report (paragraph 3.4.4). It is also clearly stated that the contribution of backfilling to the target is hard to assess. Here, we think the authors should also explain why this is so. It is important to understand that waste management can only exist when reliable data are in place. Recycling companies have the obligation of registering all incoming waste and make notification to the authorities. Backfilling operations duck out of the control systems. FIR has therefore suggested that any party performing backfilling operations should have the obligation to register and make notification. Experience in Flanders, Germany and the Netherlands has shown that management of C&DW is not that much of a problem. It is possible to develop a structure where almost full control of the C&DW waste stream is achieved. Further works of the Commission should focus on the best practices available in those (and other) Member States. 8. Further to 7, we can imagine that you pay specific attention (specific chapter?!) to the impacts that backfilling might have. With respect to that, we can refer to the situation in the Netherlands some 20-25 years ago, when C&DW was still used as such in road construction. As there were no requirements in place, C&DW was used as such. As a consequence of this, all Dutch roads built before 1990 are suspected to contain asbestos in the foundations. If these roads are de-constructed, it is likely that asbestos containing material is found. The environmental impacts are evident. The economic costs for remediation will be huge. If C&DW is going to be used in backfilling operations throughout Europe, the chances of the diffuse spreading of contaminants will be considerable. If there will be no requirements put on backfilling, this "waste management operation" will be in conflict with article 1 of the Waste Framework Directive, which requests prevention and reduction of the adverse impacts of waste management. *Response: Given the unclear definition of backfilling, it was difficult to assess the extent of this practice in most MS, and the related impacts.*
UEPG - ECP - EPRA	1. The report, at more than 200 pages, is too long and as a consequence will not be fully read and understood by stakeholders. The key points could be summarised in 20-30 pages. *Response: The first section presenting general data included the overarching analysis of the information gathered in the report.*
UEPG - ECP - EPRA	2. It is very important to give clear definitions of the terminology used very early in the report to ensure that the reader can relate, without confusion, to other studies, reports and statistics produced by the Member States. The current draft admits to inconsistent data, which unfortunately reduces the value of the report itself. *Response: Some definitions were clarified, and data gaps filled, in the final version of the report*
UEPG - ECP - EPRA	3. For the purposes of this report the term "recycled" is used in the widest sense and includes all recycling and re-use options for C & D waste – both in-situ and in recycling plant situations. Construction waste includes materials surplus to site requirements, plus surplus or rejects materials arising for example in ready mixed concrete or precast unit production. Demolition materials include all materials arising from the deconstruction of all structures. In the case of roads this includes both the foundation layers and the asphalt layers (including the surface planning). Getting good data on the total quantities of all such categories of recycled materials is most important for this study to be valid.

UEPG - ECP - EPRA	4. It is important that practicable End-of-Waste Criteria are established as soon as possible. The recent ECHA decision stipulating recycled aggregates as "Articles" under REACH was crucial in avoiding a completely unnecessary registration process, which would have seriously damaged the industry. *Response: this driver was added to the final report*
UEPG - ECP - EPRA	5. The report should also refer to the individual CEN Aggregate Product Standards that give particular and pr definitions for "recycled" material in relation to the stated end use, for example as unbound materials for ro bases, or as aggregates for concrete or aggregates for asphalt. These standards set clear quality requiremen these applications to ensure that those end-products are durable and meet their technical specifications. Compliance with technical quality standards is crucial to responsible recycling.
UEPG - ECP - EPRA	6. It must be clearly stated that excavated material should not be included in the reported statistics so as to a common basis for all measurements. Such inclusion may be incorrectly inflating some statistics. *Response : this is clearly stated in the final report*
UEPG - ECP - EPRA	7. It must be made clear that the target of 70% recycled materials relates to the percentage of the C & D wa that is actually available to be recycled. For example, in the UK, which is currently achieving the 70% target, recycling level represents only about 25% of the total aggregate demand. This is also true for Belgium and th Netherlands, which also achieve the 70% target, but again represents only about 20% of their national aggre demands.
UEPG - ECP - EPRA	8. It is also very important to better establish the total current European available C&DW. The report puts th estimate at 535m tonnes. In 2008, UEPG data shows that 216m tonnes were recycled. This corresponds to ju 40% of total available C&DW, but in turn equates to only 6% of the total European aggregates demand of 3.5 billion tonnes for that year.
UEPG - ECP - EPRA	9. EPRA supports higher European recycling rates, though because these rates are so varied between Memb States, the challenges need to be addressed at national level to determine what kind of political and regulat measures would best work in each. Such national initiatives need to address the physical infrastructure need recycling, as well as encouragement in the use of recycled materials, in parallel insisting that these meet the required technical standards.
UEPG - ECP - EPRA	10. Some financial incentives may also be needed, though any taxation in the absence of other measures of aggregate production or landfilling may only have the adverse effects of inducing illegal production or illegal dumping. The economics of recycling depend on several factors that are required to make recycled aggregat competitive with natural aggregates. For instance, the WBCSD/CSI Report on Recycling Concrete, and in part the diagram on page 18, illustrates the economical factors needed to encourage high recycling rates.
UEPG - ECP - EPRA	11. It should also be realised that there are technical limits as to what proportion of recycled materials may incorporated into new products. For example, recycled aggregates may be used to form up to 100% of road foundation layers, in fact the most common application of recycled aggregates. All asphalt is recyclable into asphalt, but must comply with the relevant technical requirements of the new use. Therefore the amount of reclaimed asphalt that can be used in very specific asphalt mixtures is limited. In ready mixed concrete, up to recycled material is possible, but the practical limit in incorporating recycled coarse aggregates is unlikely to exceed 10%, as any further increase requires more cement to ensure sufficient strength, thus offsetting the environmental and cost advantages. In high-strength concrete applications the use of recycled aggregates is appropriate due to the difficulty in meeting the high technical specifications.
UEPG - ECP - EPRA	12. The ultimate aim must arguably be to achieve the most efficient and sustainable use of resources. Accor the waste reduction hierarchy, the first and highest priority is optimal design, reducing the amount of mater needed in the structure, and in cleverly designing buildings so that their use can be later changed without demolition, or with only part-demolition.
UEPG - ECP - EPRA	13. Current design practice is to enhance the lifespan of structures by means of refurbishment rather than demolition. This trend will lead to a progressive reduction in the available C & D material and consequently ability to recycle will be reduced. For example, structural frames that can be re-clad and/or have new intern layouts to suit a change of use. It must also be recognised that more durable materials (such as concrete) ha potentially very long lifetimes (greater than 100 years), and therefore rank high on overall sustainability. An rise in C&DW arising may occur though due to demolition of 60-ties and 70-ties dwellings in Member States.

UEPG - ECP - EPRA	14. Finally, of course, waste generation should be minimised at the production, construction and demolition stages. Such minimisation is in the direct economic interest of producers and contractors. Likewise, optimal sorting of waste streams during the demolition process will lead to the highest rates of recycling and best quality of recycled materials, also in the best commercial interests of the responsible contractors involved.
Concrete	
Christian Wadey, DEFRA	This is a very long section on a waste that is already fully recycled in a large number of member states and does not present a recovery problem of any significance. There are many case studies on the use of recycled aggregates produced with concrete at http://aggregain.wrap.org.uk/applications/aggregain/casestudysearch/index.rm
Geert Cuperus, FIR	11. Page 33. Mixed Recycled Aggregates can also be used for concrete production. 12. Page 40 and on: there are applications of Recycled Aggregates in concrete of 50% and even of up to 100%. Fines can also be used in concrete (page 41). In the Netherlands 100% coarse and fines is used in concrete applications. Page 3, impacts: use of Recycled Aggregates makes that thinner layers of asphalt are necessary. 14. Page 45, impacts: according to measurements storage of Recycled Aggregates does not result in dust problems, even at high wind velocities. 15. Page 50, 4th bullet: clients need to acknowledge the good properties of Recycled Aggregates. They must be regarded as product and not as waste. *Response: This information was added to the final report*
Bricks, tiles and ceramics	
Christian Wadey, DEFRA	The report recommends quality certification for aggregates produced from recycled concrete. Whilst promoting quality recycled aggregates is good practice there should be some caution here because aggregates processed from concrete, brick and asphalt and produced in compliance with the harmonised European Standards for aggregates already have established procedures for factory production control in line with the Construction Products Directive. For aggregates for unbound applications there is no requirement for a third party certification scheme to demonstrate compliance to the standards and the imposition of a third party scheme on recycled aggregates by individual member states would be contrary to the CPD. Good practice in aggregate production and the demonstration of compliance to specifications and standards is essential for adding value to products and providing confidence to purchasers. In the UK this is encouraged through compliance with the 'Quality Protocol for the production of aggregates from inert waste.' There have been over 30,000 copies of the Quality Protocol downloaded from WRAP's web site between Nov 2004 and Dec 2009. *Response: This information was taken into consideration when finalizing the report*
Dieter Rosen, Bundesverband der Deutschen Ziegelindustrie	The sentence „However it is not suitable for heavy roads due to the risk of deformation" should be modified Reason. The main part of demolished brick in Germany is used as aggregate in road construction. Under German regulations, there is no limitation to the application of crushed clay bricks, roofing tiles or other because of the congestion of the road. Because of the quality requirements for frost attack, and impact resistance there is a limitation of 30 Mass-% as the maximum brick content in the recycled building material. The remaining material is concrete or asphalt. *Response : The report was modified accordingly*
Dieter Rosen, Bundesverband der Deutschen Ziegelindustrie	A new architectural trend for high-end buildings for example in Berlin is to rebuild used facing bricks. Reason: Facing bricks from demolished buildings are now used for example by David Chipperfield Architects for new administrative buildings or museums. *Response: This information was added to the report*
Dieter Rosen, Bundesverband der Deutschen Ziegelindustrie	*About designing buildings to use less material*: No one uses more bricks, blocks or roof-tiles than needed. Due to the national regulations the brick wall must have special properties for example for strength or insulation against heat or cold temperatures. The products have been improved a lot to fulfil all these requirements and more so to be produced with as little energy as possible. In our opinion there is no room for using less bricks or roof-tiles, if the current regulations exist. *Response: the corresponding sentence was rephrased; however, we maintain optimal use of material as a potential driver for waste prevention*
Geert Cuperus, FIR	16. Page 55, 1st bullet. Masonry derived aggregates are actually not so much used in building projects. A relation is made to heavy traffic situations. It is important to note that Mixed recycled Aggregates are used in the construction of airports.
Asphalt	

Laurent Château, ADEME	The asphalt section should mention two additional issues: 1. Asbestos can be present in some asphalt materials, at least in asphalt produces before its ban. This makes recycling of this asphalt impossible, with the additional difficulty that asbestos-containing asphalt cannot be identified 2. Cold recycling techniques requires the use of certain chemicals, which environmental impacts are not wel known. *Response : this information was added to the final report*
Christian Wadey, DEFRA	Section contains good information from EAPA and again shows high recovery of recycled asphalt across mem states with limited opportunities for growth. Case studies are available from WRAP for the use of recycled aggregates containing recycled asphalt.
Geert Cuperus, FIR	17. Page 62 and on: Tar containing asphalt is treated thermally to produce clean aggregates. These can be us several new applications, for instance back in asphalt.
	Wood
Laurent Château, ADEME	Energy recovery is possible in municipal waste incinerators, especially for contaminated wood, which can on burnt in an authorised facility. *Response: this recovery option was added to the final report*
	Gypsum
Laurent Château, ADEME	Decision 2003/33/CE bans the landfilling of gypsum waste in inert waste landfills, to avoid the production of Arising of gypsum waste is theoretically important, but hard to collect, due to their production in high densit areas.
Laurent Château, ADEME	5 to 10% of recycling for gypsum construction waste seems overestimated.
Laurent Château, ADEME	Recycling of gypsum waste a soil treatment should not be promoted as a recovery option. Releases of sulpha groundwater and would have important negative impacts
Laurent Château, ADEME	Another driver for higher recycling of gypsum is that producers revise their admission criteria for gypsum wa production plants.
	ODS
Christian Wadey, DEFRA	ODS section-All of the information from this section seems to be centred on the advice of one UK contractor United Kingdom also seems to come in for quite strident criticism, when in comparison to many (perhaps the majority) of member states we are no worse than they are.
Peter Jones	1. High cost of ODS treatment On page 111 the cost is quoted as almost €1,000 per kg of foam. In my view this is dramatically high and bei highlighted on the first page of the chapter acts as a clear call to dismiss treatment options under grounds o To support my argument I will look at actual costs of treatment of sandwich panels in the UK. Panels are currently treated via refrigerator recycling plants run by Europe wide companies such as Sims, EM Viridor. The companies quote between €5 and €10 per m² of panel, depending on location, quantity and wha customer is willing to pay. This cost includes cutting panel, shredding in plant, recovery and separate destruc of ODS, transport and landfill cost of inert polyurethane waste and recovery and sales of scrap steel. Claddin contractors will currently fix new sandwich panels to walls and roofs for €4 to €8 per m². This cost includes a labour and access equipment. Therefore I think it is not unreasonable to estimate that disassembly and rem panels would be €10 per m². A refrigerator plant should not be more than 150km from a demolition site. In of transport costs sandwich panels can be shipped [road and sea] from Finland to the UK for €3 per m². Therefore an average cost would be about €20 per m² to cover all costs. This is in line with the UK National Federation of Demolition Contractors [NFDC] estimates and also research by the BRE. The density of polyurethane foam used in sandwich panels is 40kg/m³ so a 1m² of 100mm thick panel would contain 4kg of foam. Based on the above figures this gives a total treatment cost of ODS foam as €5 per kg. A figure you quote is larger by a factor of 200 you can appreciate my view that the figure is dramatically high. *Response: Costs were indeed overestimated in the draft report, this has been corrected in the final report*

Peter Jones	2. Barriers to reuse and recycling On page 111 you say "medium or low feasibility". I think this is unjustifiably negative, especially as the report states that there is large degree of uncertainty. I suggest it should be rephrased as "high, medium or low feasibility". *Response: these conclusions were provided by the ICF study on ODS, and were updated with the final version of the report*
Peter Jones	3. EOL costs for ODS contained in sandwich panels I am not clear as to what this table refers – is it just the ODS recovered from foam or the foam with ODS. The costs are clearly labelled as "Cost per kg of ODS". In that case: • Transport cost of €5 per kg is amazingly high. Either distance is measured in 10,000kms or costs are on level of transport of highly radioactive material. • What is recovery processing? • What is segregation/processing? • Destruction of ODS at €3/kg is reasonable and in line with TEAP estimates. However if one accepts the €83 per kg total the logical conclusions are: - If this figure is in reference to the foam and ODS it contains 1m² of panel containing 4kg of foam would cost €332 per m² for treatment. This seems unlikely – see point 1 above. - If this figure is in reference to the ODS extracted from the foam one would need to process between 20kg [assume 5% ODS blowing agent] and 10kg [assume 10% blowing agent. This would equate to between 5 and 2.5 m² of typical panel. In this case you estimate cost of treatment as €33 and €16 per m² - both figures seem economically feasible.
Peter Jones	4. Quantities in waste You quote a figure of 0.1% or 0.05% that on its own I think could be misleading, particularly as you accept there are few robust data sets on C&D waste. Including concrete and mineral waste [80%] in the total makes ODS insulation appear a minor issue. Quoting weight and not volume also downplays ODS insulation. For example you quote 250,000 tonnes – that in volume would be 12.5 million m³ - equivalent to a reasonable mountain! *Response: To ensure comparability of results between waste fraction, the quantities of waste are always presented in weight*
Peter Jones	5. Description of waste From page 115 it is reasonable to infer that ODS containing waste is not being identified in consignment notes i.e. complying with legislation. As the Commission must be aware of this it is reasonable to ask: - What are the reasons for the Commission to allow continuing non-compliance? - What actions are being taken to ensure compliance?
Peter Jones	6. Co -combustion with MSW Page 116. Incineration of steel faced sandwich panels is impractical as it would result in major problems with bottom ash and ash extraction
Peter Jones	7. Recycling On page 118 you quote me as saying PS foam recycling is anticipated to be very expensive compared to the value of recycled material. That is not what I said and I was not referring to the cost of recycled PU raw material. This will depend on developing technologies and market demand. My reference was to the likelihood that the embodied energy in recycled PU raw material could be considerably higher than that in 'virgin' raw material. Hence, it could be argued that recycled PU raw material is less sustainable. *Response: this was corrected in the final report*
Peter Jones	8. Main driver On page 121 you quote PU Europe as saying the WFD is not considered as the main driver and it looks to regulation by the ODS regulation. I find it difficult to accept that one sector of the industry can pick and choose which regulations to follow. The WFD is directly concerned with landfill and hazardous waste and is seen by contractors, waste industry and enforcement authorities as the major driver. ODS regulation is indirectly concerned with landfill, contains the technical and commercial feasibility get out phrases and has failed to control the release of ODS from foam insulation and allowed the plastics lobby to avoid addressing their responsibility for the ODS legacy from the products they manufactured. It is no surprise that PU Europe supports the continuing and ineffectual ODS regulations in contrast to the WFD. I think it is unacceptable that the report appears to give support, or at the very least condones this environmentally damaging position that is taken for obvious commercial benefit. I suggest that the actual position and legal res*ponsibilities are made clear and PU Europe choosing which legislation to follow is not an option.* *Response: this section was revised in the final report*

Peter Jones	9. Current rates When it comes to current rates you quote 0%. I think this is not true and as such too negative and pessimisti towards improving the rate of recovery. Material is being recycled and ODS recovered and destroyed – there raft of anecdotal evidence to demonstrate this. Rates vary through the EU and in different construction secto For example contractors involved in cold stores are very aware of ODS and panels recovered from demolitio this sector are recycled. For example the International Association of Cold Store Contractors [IACSC] has had code of practice on this since 2005. The rate may be low but it is certainly not 0%.
Peter Jones	10. Ways to reduce % of ODS going to landfill -Enforcement of current regulations. In particular correct descriptions on waste consignment notes. This wo also support empirical research into waste flows -Guidance to enforcement authorities. -Guidance to construction and waste industry. -Education programme to clients, contractors, designers -Encourage use of building material with high percentage of recycled content -Encourage government and private sector to include requirements for recycling and recovery in contract conditions. -Fund research into demolition methods, recycling materials, ODS recovery methods. -Fund and publicise best practice examples of reducing demolition waste -Fund and co-ordinate work by EU demolition contractor organisations to develop new methods of working will be to commercial advantage of the sector. Demolition contractors to see themselves as material recover treatment and recycling experts.
Oliver Loebel, PU Europe	PU Europe had expected that the report would provide a quantitative and qualitative analysis of different end-of-life options in terms of their environmental impact (ODS destruction rate), technical feasibility and cost implications. At present, the report seems to suggest that ODS destruction with prior recovery should be worked towards although this is neither the best environmental nor economic solution. • The report contains a number of inaccuracies regarding HCFC and HFC use and compliance with existing legislation, which we would ask to be corrected. • Given the significant uncertainty regarding the numbers used, it would be better to work with ranges instead of worst case figures. *Response: available ranges are presented in the final report*
Oliver Loebel, PU Europe	Table (section "Environmental impacts") You should provide a CO2eq savings range instead of a number (18,473,000 t.CO2eq) by explaining the different estimations according to the "top-down" and "bottom-up" methods and include the real ODS average recovery rate from the foam at the end of the product life (58% for fridges). *Response: available ranges are presented in the final report*
Oliver Loebel, PU Europe	Section 9.1 Product description and applications The second paragraph needs substantial corrections. HFC use in PU foam is today a niche application mainly spray foam and discontinuous sandwich panel production. Over 90% of PU foam is blown with pentane and than 10% with HFC. Hence, the phrasing "more and more replaced" is not correct. Wherever possible, HFCs been replaced by pentane. HCFCs have been banned since 2004 and are not used today. The second phrase refer to HFCs and not HCFCs. The last phrase refers to the question why certain producers still use HFCs. We explained that, for reasons relating to the safety at work, spray foam cannot use pentane. Furthermore, som small producers (discontinuous sandwich panel production) still use HFCs as they cannot afford the investme pentane-using equipment. *Response: this section was revised in the final report*
Oliver Loebel, PU Europe	Section 9.2.1 Current and forecast ODS banks PU Europe fully understands the difficulties of the consultant to accurately quantify ODS banks. The number proposed are therefore not contested. However, as the difference between 40% and 90% is so significant, PU Europe suggests that the consultant work with a range or an upper and a lower estimate. *Response: available ranges are presented in the final report*

Oliver Loebel, PU Europe	PU Europe disagrees with the statement in paragraph 2 that, for construction foams, the obligation to remove ODS depends exclusively on its technical and economic feasibility. Article 22.4 of Regulation 1005/2009 states that "Controlled substances contained in products and equipment other than those mentioned in paragraph 1 shall, if technically and economically feasible, be recovered for destruction, recycling or reclamation, or shall be destroyed without prior recovery, applying the technologies referred to in paragraph 2." It is true that hazardous waste facilities have to respect strict environmental standards. It is however incorrect to say that countries which allow the incineration of ODS containing foam in municipal solid waste incinerators (MSWI) do not comply with legislation. Regulation 1005/2009 (art. 22.2) refers to annex VII of that Regulation (approved destruction technologies). For dilute sources (such as foam), the annex offers two options: municipal solid waste incineration or rotary kiln incineration. This is also fully in line with the UNEP TEAP reports of 2005 and 2009. Furthermore, the Waste Incineration Directive (art. 6.1) stipulates the following: "Incineration plants shall be designed, equipped, built and operated in such a way that the gas resulting from the process is raised, after the last injection of combustion air, in a controlled and homogeneous fashion and even under the most unfavourable conditions, to a temperature of 850°C, as measured near the inner wall or at another representative point of the combustion chamber as authorised by the competent authority, for two seconds. If hazardous wastes with a content of more than 1% of halogenated organic substances, expressed as chlorine, are incinerated, the temperature has to be raised to 1.100 °C for at least two seconds." As a worst case scenario, it could be assumed that 3% of the waste fed in the incinerator is ODS containing PU foam. If we estimate the content of ODS in the foam at 6%, the total share of ODS in the waste would amount to 0.18 %. This is well below the 1% limit. For rotary kiln incineration, the share would be as low as 0.01-0.03 %. In practice, the share of ODS (the concentration of halogens) will be lower as ODS containing foam is never delivered in pure form to an MSWI. Depending on the application in the building, the combination with other materials, the way the building was demolished / deconstructed, the storage with other materials and transport and supply conditions, there will always be other materials attached to the PU foam, or the foam will be mixed with other materials. *Response: this section was revised in the final report*
Oliver Loebel, PU Europe	Section 9.3.2 Emerging techniques As outlined above, Regulation 1005/2009 does not require recovery if this is "technically and economically" feasible. Rather it offers two options recovery or destruction without prior recovery.
Oliver Loebel, PU Europe	Section 9.4.1 Environmental impacts Whilst it is true that ODS emissions must be minimised at the end of the product life, PU Europe disagrees with the conclusions of this section. Destruction with prior recovery does not offer the environmentally best solution. The Deutsche Umwelthilfe estimates the ODS recovery rate for household appliance at only 58%. This means that almost half of the ODS is released in the atmosphere in the recovery process. On the other hand, incinerating ODS foam in modern MSWI leads to a 99.9% destruction of the ODS. Comparing these two options is of fundamental importance when the report wants to draw sound conclusions. A complete analysis should also provide a holistic view on all environmental impacts. For example, the small number of ODS recovery facilities would entail higher environmental impacts due to longer transport distances. MSWI are available at relatively short distances in most (but clearly not all) Member States. As regards table 34, it should be specified whether the numbers given assume a 100% recovery rate, although this is not achieved in practice (see example above). If this was the case, the figures would be unrealistic. In any case, they should be compared with the emission savings potential for other end-of-life options, such as incineration in MSWI. *Response: this section was revised in the final report*
Hazardous Substances	
Edmar Meuwissen, EUMEPS	Could you let me know what the criteria were for including those five hazardous substances? *Response: these substances were identified as potential contaminants of the C&D waste stream.*
Laurent Château, ADEME	Lead based paints were banned in France in 1949. Some guidelines on the management of this type of waste suggest that several options are available: http://www.oppbtp.fr/content/download/13475/87842
Laurent Château, ADEME	PAHs can also be found in chimneys or other smoke evacuation conducts, and contaminate the building materials.