



INFORMATION DOCUMENT ON THE EFFECTS OF C&DW RECYCLING

Prepared for DGEnvironment by the F.I.R. as input to the Thematic Strategy on Prevention and Recycling of Waste

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Introduction

DGEnvironment has launched a stakeholder consultation process as part of the development of the Thematic Strategy on Prevention and Recycling of Waste. The F.I.R. has responded to questions that have been posed during the consultation. On the basis of recent meetings it has become clear, that DGEnvironment would still like to receive additional information on Construction & Demolition Waste (C&DW). Most notably, DGEnvironment wishes to be informed about the economic, environmental and social effects of recycling and of possible measures concerning C&DW.

The F.I.R. is the sole representative of the recycling industry of C&DW in Europe. Its members have over twenty years of experience and are well aware of “what works” and “what doesn’t work”. The F.I.R. is highly interested in the developments concerning the Thematic Strategy. As a partner to the European Commission, it feels responsible for providing DGEnvironment with as much information as possible. This document has been drafted in a relatively short time and reflects primary information which we think may help DGEnvironment. We need to emphasize that it has been difficult to arrive at sound, well underpinned conclusions in such a short period of time. We therefore see this as a further step in the process of continuous exchange of knowledge and this document demonstrates F.I.R. commitment to this process.

Main environmental contributions

As a general rule it may be stated, that the environmental benefits of recycling have been recognized in many countries. Without having been quantified, these benefits were the main drivers to begin recycling. In some cases, recycling even resulted from measures after serious environmental incidents had occurred (soil contamination due to improper landfilling). The benefits of recycling are obvious:

- using recycled aggregates conserves natural resources
- prior to or during the recycling process hazardous substances are removed
- recycling of C&DW prevents scarce space to be used for landfilling

Using recycled aggregates conserves natural resources

The most relevant benefit of recycling is the conservation of natural resources. While the positive effects are rather obvious and may be considered self-evident, the problem arises as how to assess these effects. To date, it has not been possible to compare the saving of resources with for instance the reduction of greenhouse gases. This should not however result in a failure to recognize the contribution to sustainable development that recycling makes.

While many effects are hard to quantify, the main effect is rather well quantifiable: each ton of recycled aggregates saves approximately one ton of natural resources.

Prior to or during the recycling process hazardous substances are removed

C&DW contains hazardous substances such as asbestos and tar. These substances are removed during demolition and recycling. Asbestos as an example is nowadays removed before demolition. New recycling techniques are being developed to remove remaining asbestos particles from C&DW.

Recycling of C&DW prevents scarce space to be used for landfilling

Another obvious positive effect of C&DW recycling is the fact that it saves landfilling space. Just as in the case of conservation of natural resources, the effects are only quantifiable by stating that one ton of recycled aggregates saves approximately 0.6 m³ of landfill space. Within the F.I.R. countries this amounts to a saving of some approx. 60 million m³ per year.

Basic information recycling industry

Table 1 summarizes some basic data of the recycling industry in the Member States which are represented in the F.I.R. These countries are: Austria, Belgium, Czech Republic, Germany, Italy (South Tyrol), The Netherlands, Spain and Switzerland. Again it must be emphasized that the data are quite rough.

Table 1. Estimated data C&DW in F.I.R. countries

	Total F.I.R. countries
Number of employees	Estimated: 25,000
Turnover	Estimated: 800 m EUR
Profit	Estimated: 5% - 10%
C&DW arisings	Approx. 170 m ton
Production of recycled aggregates	Approx. 100 m ton
% of recycled aggregates versus primary materials	10%, in some countries up to 20% or more
Number of treatment plants	Approx. 3,000

Some of the data were not immediately available within Member States and had to be estimated. As for the employment figures it has been pointed out, that the recycling industry has meant increased employment within the supplying industries, such as equipment producing industries and laboratories. A study in the USA [1] showed that for each 100 jobs in C&DW recycling, 168 additional jobs are created.

The principles of C&DW management

As has been stated in the F.I.R. document to the Stakeholder Consultation, the main mechanism to achieve recycling is putting taxes on landfilling and prohibiting recyclable materials being sent to a landfill. The way it works out in the Member States is described below.

C&DW is generally separated at source. C&DW is divided into inert waste, mixed waste and specific components (separated per component). These specific components generally include glass, wood, plastic, paper and hazardous substances. Non-hazardous specific components are also included in the mixed waste in certain instances, e.g. small scale projects.

Inert waste can be brought to inert waste landfills (though not in every country). Costs for landfilling vary between EUR 5 – 40 per ton. It is not always clear if the costs for aftercare are included. The inert waste can also be brought to a recycling (crushing) plant. The costs for treatment vary between EUR 1 – 6 per ton.

As this may seem really beneficial for recycled aggregates, one has to bear in mind that the success of recycling also depends on the sales of products. Sale prices of recycled aggregates are approximately 1 – 6 EUR/ton. In many countries, prices of aggregates are higher than the prices of primary materials. This results in reduced recycling rates in many Member States. In the Czech Republic for instance, but also in several non-F.I.R. countries, recycled aggregates are used to fill up gaps, which is erroneously referred to as “land cultivation”. Proper resource management would provide for an integrated approach with full regard for the environmental effects of all products. The prices of primary materials would have to include the environmental costs (IPP, Integrated Product Policy), which would make the primary and secondary materials more comparable.

Economic and social effects

The economic and social effects of recycling can already be concluded from Table 1. It should be noted though, that these figures only relate to the recycling of C&DW in eight Member States. Also, in most of these Member States, recycling is limited to the recycling of the inert part of C&DW. One may estimate the economic and social effects of C&DW recycling by extrapolation, using indicators. In Table 2 some indicators are presented based on the data of Table 1. In order to calculate the number of employees in the F.I.R. countries per million capita, the figure for Germany has been left out. The reason for this is that the number of employees in Germany is much higher than the number of employees in other countries (due to a much higher number of plants) and is therefore not considered representative.

Table 2. Economic and social indicators of C&DW recycling

Indicator	Value
Turnover per million capita F.I.R. countries	4.5
Employees per million capita F.I.R. countries	46

The data for Italy are not considered, as only the northern part of Italy (South-Tyrol) is a member of the F.I.R. The indicated values are based on a situation in which some Member States have high recycling rates (Netherlands, Belgium, Germany, Austria and Switzerland) and some have a significantly lower rate of recycling (Spain and Czech Republic). In the future, this overall picture (countries with high rates of recycling rates versus countries with low recycling rates) may well be the situation in the whole of the EU. One could therefore extrapolate these findings to the 25 Member States, using the respective number of inhabitants (F.I.R. countries: 179 million, EU 25: 460 million). The estimated effects of recycling of inert C&DW are presented in Table 3.

Table 3. Estimated effects of inert C&DW recycling for the EU

Effect of recycling	Estimated effect EU 25
Total turnover EU	2.1 billion Eur
Total number of employees	> 21,000

Again, one has to stress that these figures only reflect the direct effects of recycling. In addition, other industries will also benefit. For instance equipment suppliers and environmental laboratories will significantly develop when recycling starts growing.

Also it should be mentioned that the figures only reflect the recycling of inert C&DW. In several countries recycling of mixed C&DW has also been well developed. In the Netherlands, for instance, the sorting of waste (C&DW and mixed non-hazardous industrial waste) produced an estimated turnover of 400 million Euro.

Administrative costs for aggregates

The fact that recycled aggregates are regarded as waste results in extra costs for the recycling industry. These costs are mostly related to the fact that extra administrative work has to be performed. In countries such as the Netherlands, Belgium and Germany a significant amount of forms has to be filled in. It is estimated that at one production site at least one employee spends four hours per week doing this job. Per site, this means about 160 hours per year, for 3,000 sites (Table 1) this amounts to 480,000 man-hours. At (for instance) EUR20/h labor cost, the costs for the industry related to the fact that aggregates are considered as waste amount to (at least) 9.6 million Eur in the F.I.R. countries.

Environmental effects

Life cycle analysis (LCA)

A well reported source of information is an article from the INFA Institute [2]. It is interesting to note that the researchers set out limits of the study, realizing that a full LCA study would be too ambitious. In order to keep the calculations workable, issues such as leaching and the harm to ecosystems have not been addressed. The main topic in this study was the production of greenhouse gases. The authors state that the study must be regarded a first step into the development of a full life cycle analysis. They compared the chain of “transport-production-transport-application-demolition-transport” for primary materials and secondary aggregates. The study has proved that recycled aggregates were more environmentally friendly than most primary materials. Only sand and gravel turned out to result in slightly lower productions of greenhouse gases. The outcome of the study is summarized in Table 4.

Table 4. Environmental effects of primary and recycled materials – greenhouse gases from production [2]¹⁾.

Product	Greenhouse potential (kg/m ³)
Recycled aggregates	22,5
Limestone	45
Gravel and Sand	22
Basalt	70
Diabas	65
Dolomite	60

¹⁾. Data taken from diagrams.

Another analysis performed by Forschungszentrum Karlsruhe [3] looked at the impact of concrete and the substitution of gravel by recycled aggregates. The following data relate to the production of 1 m³ of concrete (Table 5).

Table 5. Environmental effects of substitution of gravel by recycled aggregates in concrete [3].

	Concrete with recycled aggregates (RA)			Concrete only gravel
	#1 35% RA	# 2 35% RA	#3 50% RA	#4 0 % RA
Saving of primary gravel	581 kg.	528 kg.	840 kg.	-
Cumulated energy input	1,774.8 MJ	2,105.0 MJ	1,604 MJ	1,418.1 MJ
CO ₂ equivalence	269.6 kg.	326.5 kg.	232.3 kg.	229.8 kg.

Product #3 (50% recycled aggregates) showed almost the same CO₂ production as product #4 (primary materials). However, in the first case, 840 kg. of primary materials were saved.

A third LCA was performed in Austria [4]. This LCA is very well documented and describes in detail all processes involved as well as all process charts of these processes. It does so in much more detail than the LCA by Forschungszentrum Karlsruhe. The LCA takes as the functional unit the production of 1 m³ of concrete. It distinguishes between two scenarios. Both scenarios take a whole life cycle into account. This means that they start looking at the demolition of a construction, followed by the production of concrete. In the first scenario concrete from demolition (first step) is not being recycled but transported to a landfill. In the second step (concrete production), primary materials have to be used and transported to the concrete production site. In the second scenario though, the concrete from demolition is recycled and then transported to the concrete production site. In this case, less primary material is to be extracted and transported. Recycling takes place on-site in a mobile crusher.

The LCA shows interesting results which are summarized in Table 6. The data reflect the emissions to the air.

Table 6. Environmental effects (air emissions) of producing 1 m³ of concrete with and without recycling [4].

Item	Recycling scenario	Landfill scenario
Energy input (MJ)	1318	1495
Use of primary resources (kg)	758	1.894
Landfill use (m ³)	-	1.26
Emissions (in g.)		
SO ₂	55.76	79.36
Pb	1.85 E-03	2.32 E-03
CO ₂	228860	254794
CH ₄	0.91	1.76
Benzene	4.57 E-03	8.78 E-03
Benzo(a)pyrene	2.28 E-03	4.39 E-03
N ₂ O	0.37	0.70
Particles	5.48	10.53
CO	576.53	803.91
Carbonhydrates	109.64	211.34
NO _x	930.42	1296.51
Dust	62.46	63.62

Another life-cycle based study was found in [5]. In this report a comparison has been made between virgin aggregate for concrete production and recycled aggregate which may be used as a substitute. The data in this report are not as well documented as the data in the other references. Still, the outcome of the analysis show the same result, namely that less energy is required when use is made of recycled aggregates. Tabel 7 shows the energy demand for virgin and recycled aggregates. It is assumed that recycling takes place on site, hence transportation does not take place.

Tabel 7. Raw material acquisition and manufacturing energy for primary and recycled aggregates [5].

Process energy (million BTU/ton)		Transportation energy (million BTU/ton)		Total energy (million BTU/ton)	
Virgin	Recycled	Virgin	Recycled	Virgin	Recycled
0.040	0.032	0.054	0	0.094	0.032

Reduction of landfill gas emissions

It is a well known fact that landfill gases are emitted from all landfills, even if they are provided with landfill gas extraction systems. It is estimated that more than 50% of the landfill gas produced is emitted to the open air [6]. Mixed C&DW is landfilled in most Member States.

The C&DW arisings in the F.I.R. countries are about 170 Mton/a, that is approx. 1 ton per capita. For the whole of the EU this would mean a production of 460 Mton/a. Of course, extrapolation should be done with care. Most of the non-F.I.R. countries are less well developed and therefore consumption and waste-production figures will differ. However, in a "final state" the calculation may stand.

C&DW is made up of approx. 15% of mixed waste, i.e. 70 Mton per year in the EU "final state". About 50% of the waste is biogenic, hence 35Mton/a. Sorting of mixed waste results in a reduction of appr. 75% of the waste going to a landfill. Producing Solid Recovered Fuel of the remaining sorting residue may further increase the reduction to 95%. Recycling of C&DW may therefore result in the reduction of approx. 33 Mton/a going to landfills. The production of landfill gas from biogenic material is roughly about 100 kg CH₄/ton and 230 kg CO₂/ton [7]. The possible reduction of landfill gas emissions is stated in Table 8, assuming 50% loss of methane.

Table 8. Estimated landfill gas reduction when mixed C&DW is recycled

Amount of mixed C&DW	Amount of biogenic waste prevented from landfilling	Methane production per ton biomass	Reduction of landfill gas (CH ₄)
70 million ton/a	33 million ton/a	100 kg/ton	3.3 Mton/a

Leaching

The environmental behaviour of aggregates is tested in each of the F.I.R. countries on the basis of national environmental legislation. Data on the actual behaviour in field applications however are rare. The limits for application however are very strict, this can be illustrated by the standards used in the Netherlands. Secondary building materials may only be applied if the leaching of heavy metals does not lead to more than 1% increase of the background concentrations in the first meter of soil in a hundred years. This in effect means that the environmental impact is negligible.

Transport reduction

In most of the F.I.R. countries the transport distance from a recycling plant to a construction site is always shorter than the distance between a quarry (primary materials) and the construction site. Also, the distance between a demolition site and a recycling plant is mostly shorter than the distance between a demolition site and a landfill site. This can be explained by the fact that there are more recycling plants available than landfill sites. The advantages of recycling become even more evident when mobile plants are used. In this case the distance between demolition site and

construction site (where recycled aggregates from the demolition site can be applied) results in even more savings in transport.

One may distinguish between two situations:

- A: - transport of primary material from a quarry to construction site
- transport of waste from demolition site to landfill during end-of-life deconstruction
- B: - transport of recycled aggregates from recycling plant to construction site
- transport of waste from demolition site to recycling plant during end-of-life deconstruction.

The distances between construction/demolition sites and supply or disposal can vary significantly between Member States. The current infrastructure of recycling sites in such countries as Germany, Switzerland and the Netherlands do however strongly facilitate transport reduction. In most cases, recycling sites are closer than landfill sites. This is of course even truer when mobile crushers are applied. Quarries also appear to be further away in general. The difference between case A and B varies between countries. In general though, the total distance in case “A” is definitely larger than in case “B”. When recycling is applied, the difference ranges from 15 – 60 km. The transport savings result in positive effects on the environment. In Table 9 an estimation of these effects is given. In order to give an indicative idea of the effects, a “flow” of materials to and from all construction/demolition sites per year in the F.I.R. countries of 100 Mton (total production recycled aggregates) is considered. This means 2.5 million freight rides are required (40 ton per truck, return rides are not considered). The impacts of transport are given at the Eclipse website [8]. These data are also presented in Table 9. Data are presented for a selection of components, the reduction in distance due to recycling is assumed to be 35 km.

Table 9. Environmental effects from transport savings due to recycling (air emissions)

Component	Emission 1 km 40 ton truck	Emission savings resulting from recycling (F.I.R. countries)
CO (g)	0.414	36 ton
CO ₂ (g)	60.1	5,259 ton
C _x H _y (mg)	130	11 ton
Dust (PM10, mg)	4.01	0.4 ton
N ₂ O (mg)	0.269	23.5 kg
NO _x (g)	0.99	87 ton
Pb (ug)	4.78	418 g
SO ₂ (mg)	44.2	3.9 ton

Production of Solid Recovered Fuel

Mixed C&DW and other similar wastes can be upgraded to Solid Recovered Fuel (SRF). It is estimated in the Netherlands alone, that SRF may replace coal and gas to produce 12 PJ energy annually and even 25 PJ in the long term.

References

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