European Commission

EU Ecolabel criteria for hard covering products

Final Technical Report
Criteria and supporting rationale

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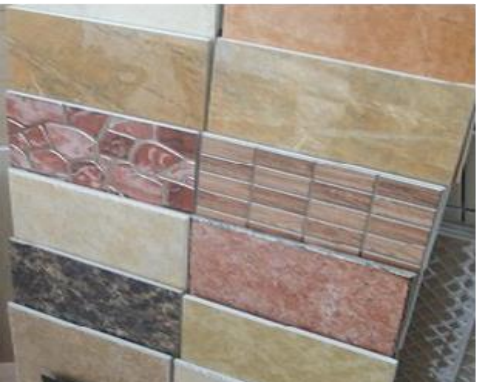

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Contents

Abstract

This report presents criteria for *EU Ecolabel hard covering products*, as adopted in Commission Decision (EU) 2021/76 of 16 March 2021. The criteria are presented together with supporting rationale, which was derived from a combination of scientific research and stakeholder consultation.

The final criteria are the culmination of 3+ year process, which started with a scoping questionnaire released in October 2017. This was followed by the publication of a draft preliminary report and initial criteria proposals in November 2018 and subsequent revisions following two stakeholder meetings (in December 2018 and October 2019) and a final round of modifications made in July 2020. The draft documents can be consulted at the JRC project website: https://susproc.jrc.ec.europa.eu/product-bureau//product-groups/413/documents

The product group applies to four main types of product sectors: natural stone, agglomerated stone, ceramics and precast concrete. A number of horizontally applicable criteria have been defined as well as sector specific criteria.

Since a significant portion of environmental impacts are associated with some of the intermediate products (quarry blocks for natural stone products and cement for precast concrete products), the possibility for awarding the EU Ecolabel to these business-to-business products has been enabled.

The criteria presented include mandatory requirements as well as optional requirements which can result in the awarding of points. If enough points are gained and all mandatory requirements are met, the product can be awarded the EU Ecolabel. The scoring approach allows for greater weighting to be applied to criteria associated with larger environmental impacts and also encourages continuous environmental improvement for license holders.

Broadly speaking for all four product sectors, the criteria predominantly focus on:

- Improving energy efficiency (setting benchmarks where possible and requiring specific energy consumption reduction plans in other cases).
- Reducing emissions that contribute to Global Warming Potential (via CO2 emission limits for combustion-dominated or the incentivisation of renewables for electricity-dominated processes).
- Reducing emissions from combustion processes that contribute to acidification (SOx and NOx).
- Reducing dust emissions, both to the wider environment and in production facilities.
- Improving water efficiency via recycling of process water and reducing contamination of local watercourses via requirements on wastewater treatment.
- Improving material efficiency via the incentivisation of recycled content, the reuse/resale of by-products and improved extraction efficiencies.

The importance of choosing the correct performance class and dimensions of hard covering products for a given use is addressed by setting requirements on fitness for use. The importance of correct installation and maintenance of hard covering products on life cycle impacts is also addressed by setting requirements on user information.

Acknowledgements

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The authors would like to thank the corresponding policy officer in DG Environment (Sylvie Ludain) for the continued support throughout the project. Furthermore, the authors would also like to thank all the stakeholders for their time and valuable input. Special mention is made to Isabella Bianco, Marco Mazzoni and Juan José Tejado (for facilitating site visits and for inputs regarding natural stone production), to Irina Celades Lopez, Victoria Zaera, Beatriz Fatas, Roberta Alani, Maria Cruz Gomez, Jens Fellhauer and Andrea Contri (for facilitating site visits and for inputs regarding ceramic tile criteria), to Beatrice Barbiero, Carmen Sanchis, Maria Ferrer and Niki Poppeliers (for inputs regarding agglomerated stone production) and to Alessio Rimoldi, Vagner Maringolo and Eric Carleton (for inputs regarding cement and precast concrete production).

It has been a challenge to fit environmental criteria for four related-yet-very-different product sectors into a single piece of voluntary policy legislation. Although different views were received and not all comments could be accommodated, they have served to increase the authors' awareness of the different perspectives and preferences for environmental criteria by the different actors in these sectors. This can only be a good thing for future policy interactions and developments.

Executive summary

The previous criteria for EU Ecolabel hard covering products were published in 2009 and were in need of updating due to developments in both production technologies and product policy. The stakeholder engagement process formally began following a review of relevant legislation, technical standards, policies, market data, production technologies and life cycle assessment (LCA) literature to identify the main environmental impacts of hard covering products.

Stakeholder comments, desk research, site visits, discussions with Commission services and criteria from other ISO 14024 Type I ecolabels all served to influence the criteria revision process. The final result is a set of 36 criteria, 7 of which apply to all products horizontally, 11 of which are specific to the natural stone sector, 5 of which are specific to the agglomerated stone sector, 7 of which are specific to the ceramic sector and the remaining 6, being specific to the production of cement and precast concrete.

Policy context

This report contributes to the ongoing implementation of Regulation (EC) No 66/2010 on the EU Ecolabel. The EU Ecolabel is a voluntary policy tool at the cutting edge of the broader sustainable consumption and production policy in Europe. By means of assessable and verifiable criteria, it targets those products (within defined product groups) that have a high level of environmental performance. As of September 2020, valid EU Ecolabel criteria are available for 24 different product groups or services, which have a total of 1757 licenses between them, and which cover almost 76 000 different goods or services.

Key conclusions

The revised criteria allow for licensing of intermediate products with important environmental impacts (e.g. cement and natural stone quarry blocks). This offers suppliers the chance to distinguish their intermediate products and greatly simplifies the EU Ecolabel application process for applicants that produce end products from already licensed intermediate products.

In order to help improve the uptake of EU Ecolabel criteria in this product group, the scope has been expanded to also include kitchen worktops, table tops, vanity tops, roof tiles, kerb stones and compressed earth blocks. Scope has also been made for lime-based precast products (in addition to cement-based ones). The expanded scope, together with the licensing possibility for intermediate products, has more than doubled the size of the market (in terms of sold production value in the EU) that is covered by this product group.

A scoring approach has been introduced to the criteria, which allows a greater weighting to be applied to the criteria that are associated with the biggest environmental impacts. The new criteria present a mix of mandatory and optional criteria that allow applicants different ways to obtain the EU Ecoabel without compromising on the most important sources of environmental impacts.

Related and future JRC work

As part of the broader implementation of the EU Ecolabel Regulation (EC) No 66/2010, this report is therefore related to another 23 reports that are behind 23 currently valid Commission Decisions, each of which define voluntary EU Ecolabel criteria for the respective product groups or services. The EU Ecolabel criteria may also have an impact on public procurement activities in terms of providing a basis for a number of potential green criteria. Public procurement is considered as a highly important part of the market for 'hard covering products'. The development of a Green Public Procurement manual for hard covering products is foreseen, which will provide simple information to procurers about green criteria that can be used in procurement exercises that can already be considered as verified by products carrying the EU Ecolabel. There is also a close relationship between a number of the EU Ecolabel criteria for 'hard covering products' (e.g. energy consumption reduction plans, waste inventories etc.) that link well to the Eco-Management and Audit Scheme (EMAS).

1 Introduction

Policy context

The EU Ecolabel is a voluntary labelling policy that promotes the production and consumption of products with a reduced environmental impact over their life cycle, and is aimed at the products with a high level of environmental performance. Established in 1992, it has become a key policy instrument within the European Commission's Sustainable Consumption and Production and Sustainable Industrial Policy (SCP/SIP) Action Plan (see COM(2008) 397) and the Roadmap for a Resource-Efficient Europe (see COM/2011/0571). The Roadmap was designed to move the economy of Europe onto a more resource-efficient path by 2020 in order to become more competitive and to create growth and employment.

The EU Ecolabel also has links with other policy instruments, such as Green Public Procurement (GPP, see COM(2008) 400), the Eco-Management and Audit Scheme (EMAS) (see Regulation (EC) No 1221/2009 and Regulation (EU) No 2018/2026) and the Ecodesign Directive (see Directive 2009/125/EC).

Looking ahead, the EU Ecolabel is expected by the European Parliament[1] to play an important role in the new Circular Economy Action Plan (CEAP)[2], and will undoubtedly form an important part of the upcoming Green Claims Initiative. Both the CEAP and the Green Claims Initiative are considered as important blocks of the EU Green Deal.

The previous criteria

The revision of EU Ecolabel criteria for 'hard covering products' represents the updating of the last, still-valid set of criteria that were adopted before the current EU Ecolabel Regulation (Regulation (EC) No 66/2010).

The previous criteria established in Commission Decision 2009/607/EC already grouped together four different types of product (natural stone, agglomerated stone, ceramic and precast concrete) which had the common purpose of providing hard surfaces for floors or walls. The EU Ecolabel fitness check in 2017[3] confirmed that such a bundling of different product types with a common final purpose was to be continued, and expanded further if relevant. The criteria in Decision 2009/607/EC were presented in sequence of life cycle stages, with some criteria being relevant to some product types and other criteria being relevant to only one product type. All of the criteria were pass or fail, with the exception of a matrix of 6 criteria that applied only to natural stone quarries.

By 2018, the criteria had only achieved a limited uptake, with around 10-15 valid licenses at any given point in time, almost exclusively awarded to companies based in Italy or Spain. All of the licenses were associated with ceramic tile production, except one for natural stone, which turned out to be part of a research initiative rather than a commercial marketing effort. However, due to the large number of ceramic tile formats possible, the modest number of EU Ecolabel licenses translated into a significant, but highly volatile number of licensed products. Numbers generally varied between 6 000 and 14 000 EU Ecolabel hard covering products.

The revised criteria

Overall, the revision process looked at potential expansion of the scope by considering the inclusion of kitchen worktops, table-tops vanity tops, roof tiles, kerb-stones, bricks and other masonry units made of the same materials already in the scope (i.e. natural stone, agglomerated stone, ceramics and precast concrete). Furthermore, the potential inclusion of criteria for plasterboard, lime, alternative cements, compressed earth blocks, calcium silicate and autoclaved aerated concrete was also considered. However, in the end, only a partial expansion of the scope was accepted.

The criteria were restructured to make it easy for a reader only interested in one sub-product to not need to read through the criteria applicable to other sub-products. The new criteria were also structured in such a way that it was possible to clearly define those that apply to intermediate products and those that apply to end products. This was an important step forward since it was agreed to allow for the award of the EU Ecolabel to

[1] See adopted text P9_TA-PROV(2021)0040, accessed online: https://www.europarl.europa.eu/doceo/document/TA-9-2021-0040_EN.pdf

[2] See Commission Staff Working Document SWD(2020) 100, available online: https://ec.europa.eu/environment/circular-economy/pdf/leading_way_global_circular_economy.pdf

[3] Report from the Commission to the European Parliament and the Council on the review of implementation of Regulation (EC) No 122/2009 of the European Parliament and of the Council on 25 November 2009 on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS) and the Regulation (EC) No 66/2010 of the Parliament and of the Council of 25 November 2009 on the EU Ecolabel (COM(2017) 355).

intermediate products with significant environmental impacts (e.g. natural stone quarry blocks and cement or lime binders).

Another notable novelty in the revised criteria is the introduction of a scoring approach for the criteria. This is based on a combination of mandatory requirements, where no points are awarded, and optional requirements, where points can be awarded up to a defined maximum. To obtain the EU Ecolabel, the applicant must acquire more than a defined minimum number of points, in addition to meeting the mandatory requirements. This approach allows greater weighting to those criteria that are associated with the bigger environmental impacts and provides some flexibility to applicants.

Both the final and the draft intermediate project documents can be consulted at the JRC project website: https://susproc.jrc.ec.europa.eu/product-bureau//product-groups/413/documents

1.1 Methodology and sources of information

The entire life cycle of the product is considered, from the extraction of raw material through to production, packaging, distribution, use and disposal. The EU Ecolabel may define criteria that target environmental impacts from any of these life cycle phases, with the aim being to encompass the areas of greatest impact. Because the life cycle of each product and service is different, the criteria are tailored to address the unique characteristics of each product or service type. They are typically revised every 4-6 years to reflect technical innovation such as alternative materials or production processes, emission control and market developments.

The criteria development and revision processes are carried out in accordance with the EU Ecolabel Regulation (EC) No 66/2010. An important part of the process for developing or revising EU Ecolabel criteria is the involvement of stakeholders through publication of draft technical reports and subsequent consultation exercises. Stakeholders will involve technical experts, non-governmental organisations (NGOs), Member State representatives and industry stakeholders. The main consultation exercise takes the form of ad-hoc working group (AHWG) meetings, supported by other stakeholder interactions such as conference calls, email exchanges, site visits and forum discussions and written comments submitted via an online platform.

Articles 7(2) and 11(2) of Regulation (EC) No 66/2010 make provisions to encourage alignment between criteria for the EU Ecolabel and other suitable ISO 14024 Type I ecolabels for similar products. However, care must be taken to ensure that any such alignments are based on a scientifically sound rationale, do not create geographical distortions for potential applicants and, ultimately, that the proposed criteria are acceptable to the majority of EU Ecolabelling Board (EUEB) members who vote on final proposals prior to their adoption.

The final criteria are the culmination of a 3+ year process, which started with a scoping questionnaire released in October 2017. This was followed by the publication of a draft preliminary report in November 2018, which contained a review of legislation, technical standards and policy (the so-called Task 1); a review of market data (the so-called Task 2) and a review of production processes and LCA literature, with a view to identifying the main life cycle impacts and hotspots (the so-called Task 3).

Also in November 2018, initial scope and criteria proposals (the so-called Task 4) were made in the first draft of the Technical Report (TR v1.0) together with supporting rationale. These criteria were discussed in a series of web-based stakeholder meetings in December 2018 and feedback received. A second version of the criteria proposals were made in September 2019 and discussed with stakeholders in a physical meeting in Brussels in October 2019. A third revision of part of the draft criteria was prepared following new data being provided by ceramic tile industry stakeholders in June 2020. The final draft of the criteria were positively voted by the EU Ecolabelling Board in November 2020. An illustration of the main project process is illustrated in Figure 1.

The final version of the Technical Report provides the rationale and background research for the adopted criteria. For the full history of the project, the final Technical Report should be read in conjunction with the information contained in the Preliminary Report and the intermediate Technical Reports (v.1.0, v.2.0, and v.3.0) that are available on the project website.

A particularly relevant source of information for the natural stone criteria were the criteria defined by the US-based Natural Stone Council ANSI/NSC 373 and German/Europe-based Fairstone standards. For the agglomerated stone criteria, due to a lack of published information, specific inputs from industry stakeholders was essential. For the ceramic criteria, data reported from the 2007 BREF document for ceramics, the criteria defined in ISO 17889-1 standard for sustainable ceramic tiles, data submitted as part of the ongoing BREF

revision process for ceramics and data compiled from current operating permits were used. For criteria relating to cement, lime and concrete production, particularly valuable data sources were the BAT conclusions for cement and lime production, industry emission data published by CEMBUREAU, the Concrete Sustainability Council criteria and inputs from DG CLIMA regarding CO2 emissions and the Emissions Trading Scheme.

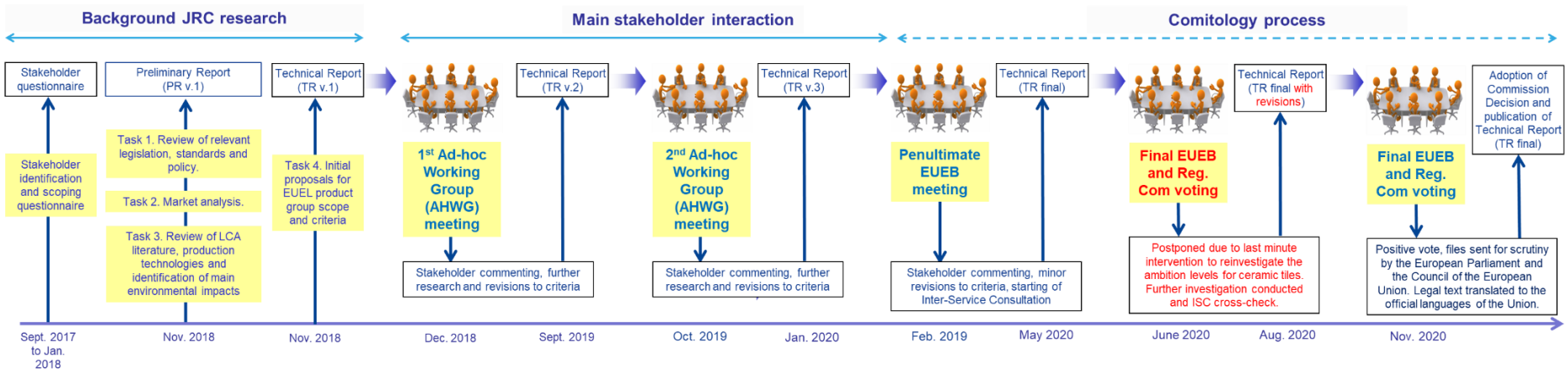

Figure 1. Illustration of the main project process and milestones plotted against time.

1.2 Summary of background report and links to the EU Ecolabel criteria

The background report forms the initial stage of the revision of the criteria for the product group 'hard coverings'. Using the scope and definitions of the original criteria as a starting point, it includes a review of relevant legislation, technical standards and policies for the existing scope, an analysis of the market for hard covering products and a review of the scientific evidence to identify the main environmental impacts of these products. The sections below provide a summary of the findings from the background research.

1.2.1 Product group name, scope, definitions and uptake

Scope

The product group name set out in Commission Decision 2009/607/EC was 'hard coverings', (altered to 'hard covering products' during the revision process).

The scope in the 2009 criteria extended to natural stone, agglomerated stone, concrete paving units, terrazzo tiles, ceramic tiles and clay tiles. The new scope text is provided below.

Scope		
1.	The product group 'hard covering products' shall comprise floor tile, wall tile, roof tile, block, slab, panel, paver, kerb, table-top, vanity top and kitchen-worktop products for internal or external use.	
2.	The product group 'hard covering products' shall not include:	
	(a)	refractory ceramics, technical ceramics, clay pipes, ceramic tableware, ceramic ornamental ware or ceramic sanitary ware;
	(b)	masonry units defined in the EN 771 series of standards;
	(c)	clay roof tiles and fittings defined in EN 1304;
	(d)	reinforced precast concrete products;
	(e)	ancillary products associated with the installation and fitting of hard covering products such as grouts, adhesives, mechanical fastenings and underlay materials.
3.	Hard covering products shall be made of one of the following materials:	
	(a)	natural stone (also known as dimension stone);
	(b)	agglomerated stone based on resin binders;
	(c)	ceramic or fired clay;
	(d)	precast concrete or compressed earth based on hydraulic binders or alternative cements.

Rationale for scope text:

There was a general misconception amongst many stakeholders that the previous scope of this product group only applied to floor coverings, when in fact it also applied to wall coverings. For this reason, the terms 'floor tile' and 'wall tile' have been explicitly mentioned, together with common names of other formats that are explicitly intended to be included in the scope.

It was also deemed necessary to explicitly mention a number of product types that are excluded from the criteria. For example, to avoid confusion over the general term 'ceramic', the main groups of ceramic products that are not intended to be included in the scope are mentioned. Masonry units covered by EN 771 are explicitly excluded, due to objections from the industry. This was the same reason for the very specific exclusion of clay roof tiles. A common basis for these objections was that they were more in favour of the use of Environmental Product Declarations (EPDs). The exclusion of reinforced precast concrete clearly excludes a number of products that, while being made of precast concrete, are used in loadbearing applications for constructed buildings and infrastructure. There are a large variety of different grouts, mortars, adhesives,

fasteners and underlay materials that may be used in the installation of hard covering products. It was not possible to comprehensively review all of these materials, let alone identify which options were most advantageous from an environmental perspective. Furthermore, it is highly likely that the producer of the hard covering product will have no relationship with the producers of the ancillary products. For these reasons, these ancillary products are excluded from the scope.

Finally, the scope text specifies which materials the hard covering products must be made of. For clarity, agglomerated stone only refers to those products with 'resin binders'. Should the same product be made by the same company, but with a cement binder, then it would need to be treated as if it were a 'precast concrete' product, because that is where the criteria for cement are.

Definitions

Definitions
For the purposes of this Decision, the following definitions shall apply: (1) '**agglomerated stone**', means an industrial product manufactured from a mixture of aggregates of various sizes and natures (generally coming from natural stones), sometimes mixed with other compatible materials, additions and resin binder. (2) '**alternative cement**' means any cement not meeting the compositional requirements for common cements defined in EN 197-1[4], including cements with very low Portland cement clinker contents as well as alkali-activated cements and geopolymers, which may contain no Portland cement clinker at all. (3) '**ceramic**' means a material based on clay materials or other non-metallic inorganic materials whose characteristic properties of high strength, wear resistance, long service life, chemical inertness, non-toxicity and resistance to heat and fire are a consequence of a carefully optimised time-temperature transformation occurring during firing operation in a kiln. (4) '**compressed earth blocks**' means products, which have regular and verified characteristics obtained by the static or dynamic compression of earth in a humid state followed by immediate demoulding and whose cohesion, both in the humid and dry state, is due to the clay fraction within the earth material and which may be enhanced by the use of additives. (5) '**fired clay**' means a material produced predominantly from clay or other argillaceous materials by shaping (extrusion and/or pressing), drying and firing of the prepared clay, with or without additives. (6) '**floor tile**' means a flat, usually square or rectangular shaped tile within standardised dimensional ranges, which may be shaped by extrusion, by direct moulding or be cut to size from slabs and that, when laid together, form the facing layer of internal or external floor structures that is normally intended to be visible to or come into contact with users of the floor area. (7) '**hydraulic binder**' means a common cement or a hydraulic lime, i.e. a finely ground inorganic material which, when mixed with water, forms a paste which sets and hardens by means of hydration reactions and processes and which, after hardening, retains its strength and stability even under water. Common cements must fall within one of the 27 cement classes defined in EN 197-1 and hydraulic limes must meet the requirements defined in EN 459-1[5] for natural hydraulic limes, formulated limes or hydraulic limes. (8) '**kerb**' means straight or curved units within standardised dimensional ranges, which may be chamfered or sloped on the facing edge and whose primary purpose is to separate surfaces of the same or different levels, for example as edging to a road or footpath. (9) '**kitchen-worktop**' means a work surface, directly moulded or cut to size from slabs and fixed to a structure either mechanically or by means of specific adhesives that is primarily intended to be used for preparing food. (10) '**natural stone product**' and 'dimension stone' mean pieces of naturally occurring rock, where the natural stone products have been cut and finished to specified sizes, shapes and surface properties in a

[4] EN 197-1:2011. Cement-Part 1: Composition, specifications and conformity criteria for common cements.
[5] EN 459-1:2015. Building lime – Part 1: Definitions, specifications and conformity criteria.

transformation plant, whereas dimension stone is the intermediate input material to the transformation plant, consisting of large blocks or slabs of naturally occurring rock obtained from quarrying operations.

(11) '**paver**' means a unit within standardised dimensional ranges that is rectangular or any other shape that allows it to be laid in a repeating pattern in the surface course of a flexible pavement or rigid pavement and that may be joined using mortar, adhesives or interlocking mechanisms.

(12) '**precast concrete**', means products made of concrete and manufactured in accordance with specific product standards in a place different from the final destination of use, protected from adverse weather conditions during production and which is the result of an industrial process under a factory production control system and with the possibility of sorting before delivery, including single and dual-layered 'terrazzo tiles', as per EN 13748-1:2004 and 13748-2:2004[6].

(13) '**roof tile**' means a product for discontinuous laying on pitched roofs.

(14) '**table-top**' means the top part of a piece of table furniture, directly moulded or cut to size from slabs, and fixed to a table structure either mechanically or by means of specific adhesives that is primarily intended to provide a surface where users can rest, sit, eat, study or work, indoors or outdoors, and in domestic or non-domestic environments.

(15) '**vanity top**' means a surface, directly moulded or cut to size from slabs, and fixed to a structure either mechanically or by means of specific adhesives, that is primarily intended to be used in domestic and non-domestic bathrooms or similar facilities where personal hygiene practices are regularly carried out (e.g. splash zone).

(16) '**wall tile**' means a thin, usually square or rectangular shaped tile within standardised dimensional ranges, which may be shaped by extrusion, by direct moulding or be cut to size from slabs, and that, when laid together, form the facing layer of interior or exterior facing wall structures that is normally intended to be visible to or come into contact with passers-by.

Rationale for definitions text:

A number of technical and generic terms were inserted into the legal text that limits the scope of the hard covering products for the EU Ecolabel. To minimise the possibility of any misunderstanding of these terms, both before and after translation to different languages, a number of these terms were defined in article 2 of the legal act. Where possible, definitions are based on those in relevant EN or EN ISO standards. In many cases, there was no direct definition available, but a definition could be inferred from text used to describe formats that are the same, but made of a specific material. In other cases, definitions became apparent from consulting terminology used in industry workshops and fairs.

Uptake

The results of the scoping questionnaire showed that 80% of respondents felt that recognition of the EU Ecolabel by Green Building Assessment (GBA) schemes would definitely be important and 65% felt that recognition of the EU Ecolabel in Green Public Procurement would be very important. Almost all of the remainder of the responses stated they were "unsure", rather than thinking that these aspects were "unimportant". Respondents to the scoping questionnaire almost unanimously agreed that the 2009 criteria covered the main environmental impacts, but at the same time they felt that there were too many criteria and/or they were too complex. When asked if criteria relating to energy consumption, which is a hot-spot for all the products, should focus only on energy efficiency or also on renewables and CO2 emissions, there was a prevailing preference to focus only on energy efficiency.

In terms of uptake, the product group was considered to be of limited to moderate uptake. Although only a limited number of licenses were awarded, these were associated with relatively high numbers of products. Trends in license numbers and associated license product numbers are plotted below.

[6] EN 13748-1:2004: Terrazzo tiles – Part 1: Terrazzo tiles – Part 1: Terrazzo tiles for internal use. And EN 13748-2:2004: Terrazzo tiles – Part 2: Terrazzo tiles for external use.

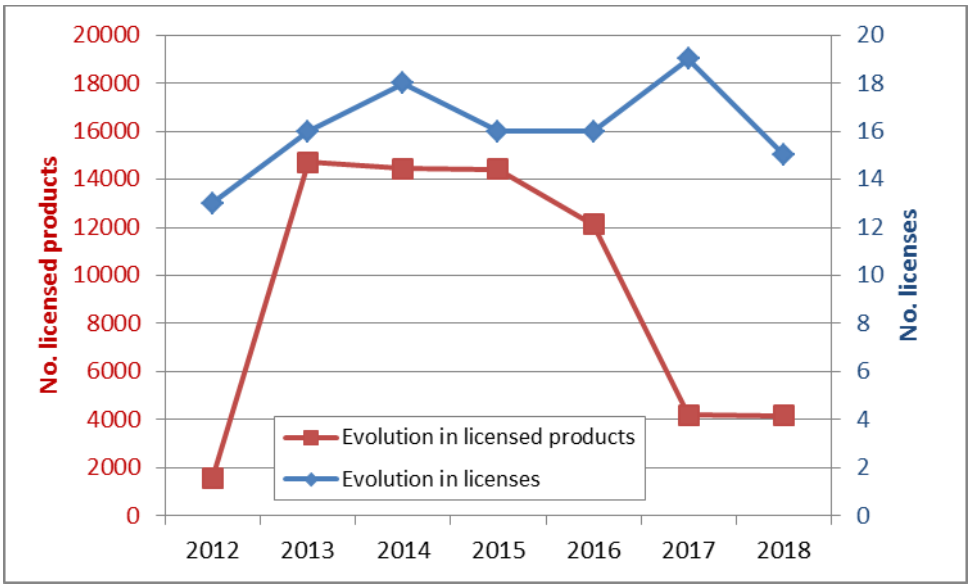

Figure 2. Trends is EU Ecolabel licenses and licensed products for hard coverings

A closer examination of the EU Ecolabel catalogue and the EU Ecolabel statistics compiled by DG Environment revealed that almost all the licenses and licensed products were associated with ceramic tiles produced in Italy or Spain. The data show a significant increase in both licenses and/or licensed products between 2012 and 2014, before it stabilised and began to decline in 2015-2018. Interviews with license holder representatives revealed that the decline was partly due to competition from EPDs and that these had some advantages of the EU Ecolabel in the sense that they were already beginning to be recognised by GBA schemes and that they could be more economical in cases where a sector wide EPD is produced at national level (as has been done for Italy, Spain and Germany for ceramic tile production).

1.2.2 Relevant policy, legislation and technical standards

The product group scope includes two energy intensive production sectors, namely ceramic and cement, which are subject to Directive 2010/75/EU on industrial emissions. This Directive sets upper allowable emission limits for a number of pollutants (e.g. dust, SOx and NOx emissions to air) and may set requirements on minimum energy efficiency for different process technologies.

Another high-profile policy that applies to the ceramic and cement sectors is Directive 2003/87/EC establishing the greenhouse gas Emissions Trading Scheme (ETS). The Directive was recently revised (Directive (EU) 2018/410) to prepare for Phase 4 of the ETS, which will run from 2021 to 2030. The ETS is a key part of the EUs contribution to the Paris Climate Agreement and, more recently, a key policy for achieving a climate neutral EU by 2050 and the European Green Deal.

The Circular Economy Action Plan (CEAP) and the Waste Framework Directive (2008/98/EC) are considered relevant to the product group in terms of material efficiency aspects that can be incorporated into the production process, be this via the minimisation of process waste, the reuse of process waste onsite, recycling or material recovery of process waste offsite or the incorporation of recycled content from other sources into hard covering products.

All of the products in the 2009 scope for 'hard coverings' are associated with large scale quarrying operations for the extraction of raw materials. The potential impacts of quarrying activities associated with land use change make the Birds Directive (2009/147/EC) and the Habitats Directive (92/43/EEC) relevant. Both of these Directives form the basis of the Natura 2000 network. The potential for quarrying activities to contaminate nearby watercourses, including groundwater, make the Groundwater Directive (2006/118/EC) and the Water Framework Directive (2000/60/EC) relevant. The opening of new quarries, or the reopening of old quarries may also be subject to an environmental impact assessment as part of the permitting process, and so the Environmental Impact Assessment Directive (2011/92/EU) is relevant.

Considering that the revised criteria will need to account for Articles 6.6 and 6.7 of the EU Ecolabel Regulation (EC) 66/2010, the REACH Regulation (EC) No 1907/2006 and the Classification, Packaging and Labelling (CLP)

Regulation will need to be referred to when setting restrictions on hazardous substances. This links especially to Articles 57 and 59 of REACH and to the outcomes of the EU Ecolabel chemical task force working groups.

As all of the products within the scope of 'hard coverings' in 2009 could be described as construction products, the Construction Products Regulation (EU) No 305/2011 is especially relevant. This Regulation lays down harmonised rules for the marketing of construction products in the EU. It serves to provide a common technical language for assessing the performance of construction products and helps ensure that reliable information on this products can be made available across the entire single market.

A significant number of technical standards were identified for the product group scope defined in the 2009 EU Ecolabel criteria. For brevity, reference is only made here about the relevant standardisation committees responsible for overseeing the development and revision of relevant standards. The committees are as follows:

- Natural stone: CEN TC 246
- Agglomerated stone: JWG 229/246
- Concrete paving units: CEN TC 178
- Terrazzo tiles: CEN TC 229
- Ceramic tiles: CEN TC 67
- Clay tiles: CEN TC 178

Most of the technical standards are related to performance specifications and performance classes, which link directly to the requirements of the Construction Products Regulation mentioned above. Other relevant technical standards refer solely to terminology and definitions.

1.2.3 Market analysis

The market analysis consisted of reviewing the main relevant 'green' marketing strategies, with a focus on other ISO 14024 Type I ecolabels, ISO 14021 Type III environmental declarations and Green Building Assessment schemes. Furthermore, relevant product codes were identified in the Eurostat's PRODCOM database to demonstrate the typical values and volumes of the different products included in the scope. Where available, other relevant sources of market data were also consulted.

ISO 14024 Type I ecolabels and similar schemes

There was no ecolabel scheme in Europe that had a similar scope for products as that for EU Ecolabel 'hard coverings'. This was in contrast to the situation with criteria for floor and wall coverings that were wood- or textile-based.

Looking beyond Europe, the GECA (Good Environmental Choice Australia), it was clear to see that they had taken some inspiration from the 2009 EU Ecolabel criteria and were licensing all of the same products (i.e. natural stone, agglomerated stone, concrete paving units, ceramic tiles and clay tiles). Furthermore, they also defined criteria for glass tiles and, a separate approach, for cement and for ready mix concrete, which were not covered by the 2009 EU Ecolabel criteria. A similar approach to Australia was taken in New Zealand, as per the ECNZ (Environmental Choice New Zealand) criteria.

The Korean Ecolabel (KEITI) overlaps with part of the scope for EU Ecolabel 'hard coverings' by setting criteria for blocks, tiles, panels, recycled construction materials, aggregates and fine powders (presumably fillers that could be used as fine aggregate in concrete mixes).

More sector specific approaches that were identified in the market included:

- the Concrete Sustainability Council (CSC) criteria for cement, aggregates and concrete products
- the ISO 17789-1 standard for sustainable ceramic tiles
- The US-based Green Squared criteria for ceramic tiles
- the US-based Natural Stone Council (NSC) criteria
- the Greenguard certification for low VOC emission products (used with agglomerated stone products)

Most of the schemes listed above take a more holistic approach to the product, including also management, economic and social criteria, in addition to environmental ones.

ISO 14021 Type III environmental declarations

In the European construction sector, EN 15804 defines how companies should create/update Environmental Product Declarations for their products. This standard has been updated in 2019 to better align with the Product Environmental Footprint (PEF) methodology of the European Commission. One of the big changes will be the requirement to report under Module C (End of Life) and Module D (End of Life recycling), in addition to the already required Module A1-A3 (cradle to gate).

At the time of research into this project, these new style of EPDs where not found in the public domain. One trend that was apparent was the bundling of EPDs into sector wide average declarations, at the national or even the European level. While this information is very useful in terms of setting an average sector performance, it is not at the core of the purpose of an EPD, which is to provide the purchaser with quantitative information about the life cycle impacts of the product(s) they have purchased.

National sector wide EPDs were found for ceramic tile production for Germany, Italy and for Spain. A Europe-wide EPD was found for natural stone and three Europe-wide EPDs were found for three major categories of Portland cement (CEMI, CEM II and CEM III).

Unfortunately, there was not enough EPD data present in the public domain about individual products to make informed conclusions about significant differences in environmental impacts of, for example, precast concrete pavers of difference performance classes (e.g. compressive strength, tensile strength, freeze-thaw resistance etc.). There was literally no EPD type information for agglomerated stone products in Europe.

Green Building Assessment (GBA) schemes

The main GBA schemes operating in Europe (i.e. LEED, BREEAM, HQE, DGNB and VERDE) were cross-checked for relevant criteria that could potentially apply to hard covering products. A summary of potentially relevant areas for the two most internationally applied schemes is provided below.

With LEED, the main areas of potential relevance for hard covering products were:

- use as part of a design for sustainable drainage and/or rainwater harvesting
- use as part of a design to reduce the urban heat island effect
- provision of quantitative information on environmental impacts (i.e. an EPD)
- inclusion of recycled content
- local/regional sourcing, relative to the construction site
- declaration of material/chemical ingredients
- low VOC emissions
- proof of environmental innovation (quite open, but could include low CO2 footprint)

With BREEAM, the main areas of potential relevance for hard covering products were:

- low VOC emissions
- tenuous link to light coloured coverings improving daylighting and reducing outdoor lighting needs
- tenuous link to high thermal mass hard coverings contributing to 'free cooling' in building design
- detailed recognition of EPD information for individual construction products/elements and underlying data
- responsible sourcing of construction products
- durable and resistance designs (hard coverings surely would have an advantage here over, e.g. wood)
- incorporation of locally sourced, recycled aggregates (only possible for agglomerated stone and precast concrete)
- use as part of a design for sustainable drainage and/or rainwater harvesting
- proof of environmental innovation (quite open, as with LEED)

It is also worth noting that VERDE has begun to recognise construction products with an ISO Type I ecolabel, which is a welcome development that can complement the recognition of products with an ISO Type III environmental declaration.

Market data

A brief summary of the value and volume of the EU market for 'hard coverings' is provided here. Unless otherwise specified, the data are from the Eurostat's PRODCOM database. The main PRODCOM codes and categories were analysed for the 'hard covering' product categories as follows:

Table 1. Main sources of market data reviewed from PRODCOM

Sub-product of hard coverings	PRODCOM codes for sold production values
Natural stone	08.11.11.33: Marble and travertine, crude or roughly trimmed 08.11.11.36: Marble or travertine merely cut into rectangular or square blocks or slabs 08.11.11.50: Ecaussine and other calcareous monumental or building stone of an apparent specific gravity ≥ 2.5 08.11.12.33: Granite, crude or roughly trimmed 08.11.12.36: Granite merely cut into rectangular (including square) blocks or slabs 08.11.12.50: Sandstone 08.11.12.90: Porphyry, basalt, quartzites and other monumental or building stone, crude, roughly trimmed or merely cut (excluding [...]) 08.11.30.30: Dolomite, crude, roughly trimmed or merely cut into rectangular or square blocks or slabs (excluding [...]) 08.11.40.00: Slate, crude, roughly trimmed or merely cut into rectangular or square blocks or slabs 23.70.12.10: Natural stone setts, kerbstones and flagstones (exc. slate) 23.70.12.30: Tiles, cubes and similar articles of natural stone
Ceramic tile	23.31.10.00: Ceramic tiles and flags 23.32.11.30: Non-refractory clay flooring blocks, support or filler tiles and the like
Precast concrete	23.61.11.50: Tiles, flagstones and similar articles of cement, concrete or artificial stone (exc. building bricks and blocks)

Sales value data was not available for the agglomerated stone products and no standalone PRODCOM code could be identified. Some sales volume data was reported for 2014, which showed that the EU was responsible for around 18% of global agglomerated stone consumption and around 36% of global production. Both of these shares will have dropped in recent years with the emergence of the Asian markets and producers, especially in China and India.

A comparison of the PRODCOM sold production value of the sectors that the 2009 EU Ecolabel criteria scope were considered to cover, together with the sold production value of all the proposed scope extensions, and the finally agreed scope extension, are presented in the Figure below.

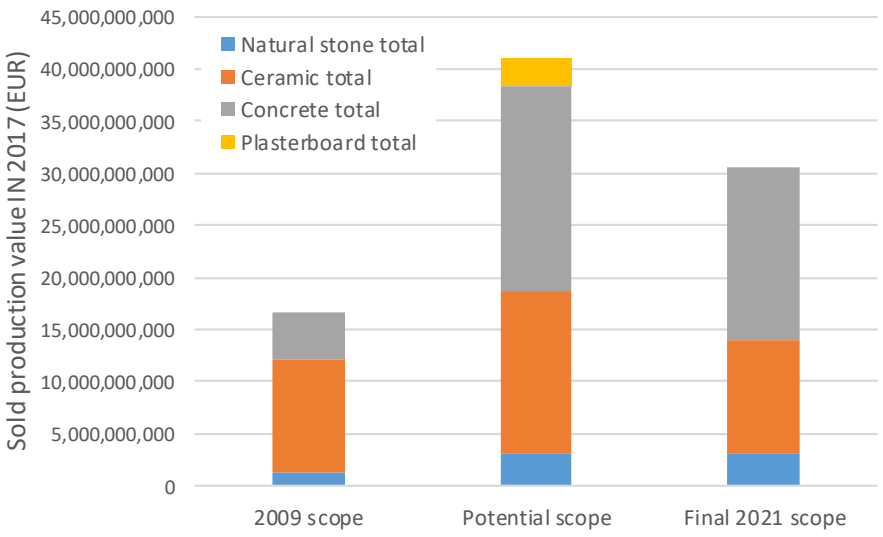

Figure 3. Sold production value for PRODCOM sectors related to the scope for EU Ecolabel hard covering products

The data above show that the maximum scope of products that could potentially be included in the scope for this product group would have resulted in an increase from around 16 to 40 billion EUR of sold production value. The increase for natural stone was due to the inclusion of intermediate stone blocks from quarries for the EU Ecolabel license. The increase in the ceramic sector was proposed to increase due to the inclusion of bricks, roof tiles and masonry units. The increase in the concrete sector was due to the inclusion of cement and lime binders and the inclusion of roof tiles and masonry. Furthermore, it was proposed to include plasterboard.

In the end, masonry units for all material types, clay roof tiles and plasterboard were not included in the expanded scope. Nonetheless, the scope of the new 2021 criteria will represent a doubling of sold production value (based on 2017 data anyway).

This doubling is even without counting on the specific inclusion of kitchen-worktops, table tops and vanity tops, which could not be quantified by PRODCOM data. These newly included products are especially important for the agglomerated stone sector in Europe.

1.2.4 Key environmental aspects and relation to the criteria

Each of the four main sub-products included in this product group (natural stone, agglomerated stone, ceramics and precast concrete) have their own unique combinations of raw materials and production processes. Consequently, it was necessary to review each of these sub-products separately in order to identify the main environmental impacts.

Thanks to the general trend towards producing sectorial-level EPDs for ceramic tile, (e.g. Confindustria Ceramica, 2016) precast concrete (e.g. British Precast 2017a, 2017b, 2018) and natural stone (e.g. EURO-ROC, 2014), it was possible to reach a general conclusion that the production stage (A1-A3) and installation stage (A4-A5) were the dominant aspects for overall life cycle impacts of the products.

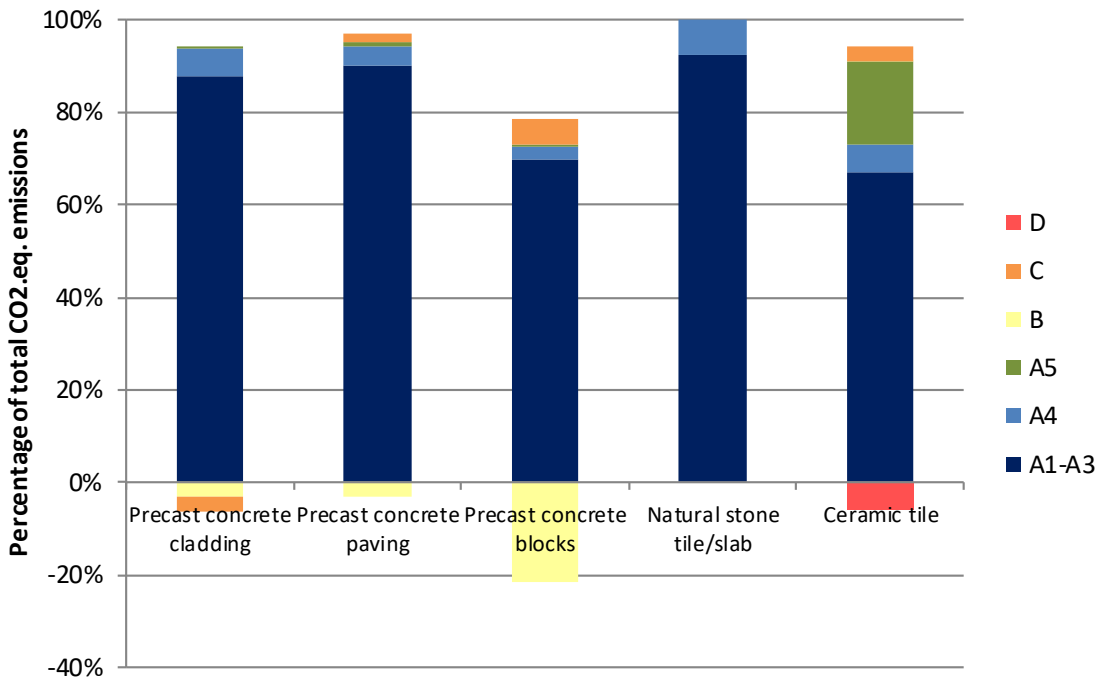

Figure 4. Comparison of the relative distributions of Global Warming Potential (GWP) impacts for different hard covering product types

The life cycle stages shown above are split into life cycle modules as per the system defined in EN 15804 and EN 15978, which are as follows:

- A1-A3: The "Product Stage". This includes impacts associated with raw material supply, raw material transport to factory gate and manufacturing processes.
- A4-A5: The "Construction Stage". This includes impacts associated with transport to site of use and construction/installation processes.
- B: The "Use Stage". This includes impacts or benefits associated with use, maintenance, repair, replacement, refurbishment and any operational energy or water use.
- C: The "End of Life Stage". This includes impacts or benefits associated with deconstruction, demolition, transport, waste processing and disposal.
- D: The "Benefits and Loads Beyond the System Boundary". This refers exclusively to impacts and benefits, especially benefits, associated with the reuse, recycling or recovery of the product or constituent components/materials.

From the data in Figure 4, all of the concrete products show some module B benefits (i.e. negative GWP) which was considered due to carbonation, whose rate was assumed to be higher in the lower density wall blocks than the denser (and thus less porous) cladding and paving products. Comparing the module C impacts, this was different for all three precast concrete products (slightly negative, slightly positive and more positive) despite the fact that all had the same assumption of 90% recycling and 10% landfilling at end of life.

Some module A5 impacts are evident with the ceramic tile EPD, this can be expected due to material losses from cutting tiles to size or tile breakage. The ceramic tile EPD also includes the use of grouts and adhesives in the A5 installation stage. The combination of material loss and grouts/adhesives/mortars does not appear to be significant for precast concrete or natural stone product installation.

A brief consideration of other life cycle impacts beyond GWP is provided below.

Raw material and production stage impacts (A1-A3)

Raw material production (A1) impacts are especially significant for natural stone products and precast concrete products due to the impacts associated with natural stone quarrying and cement production respectively. Land use impacts and biodiversity impacts are dominated by quarrying of raw materials for all

hard covering products. Criterion 1.1 sets common requirements for raw material extraction and criterion 2.6 goes further by optionally rewarding natural stone quarries with lower land use impacts.

The impact of transportation (A2) is highly variable depending on the sub-product and raw material in question. Due to the bulk nature of transport and the fact that a fraction of the transported material may be damaged, an optional rewarding of regionally integrated natural stone production is provided in criterion 2.11, where the quarry is within a distance of 260km of the transformation plant.

The production stage (A3) is the dominant source of environmental impacts and this is where the EU Ecolabel criteria are predominantly focussed. This is also the stage that is most controlled by the license holder and where maximum steerability can be achieved. All sub-products have common elements in the EU Ecolabel criteria for the A3 life cycle stage, relating to: (i) energy consumption; (ii) material efficiency and (iii) emissions to air and water. Specific requirements have been nuanced based on the nature of the production process and available data for each sub-product in the literature. For example, where sufficient data is available to define specific energy consumption benchmarks, such benchmarks are defined. Otherwise, it is required for an energy inventory to be kept and an energy consumption reduction plan (to optimum levels) to be implemented. Material efficiency concepts always relate to the reuse of process waste but, where plausible (based on the nature of the product) and justifiable (based on relative distance of sourcing compared to virgin materials), will also reward any incorporation of recycled or secondary materials. Where the production process is combustion based, emissions to air focus on dust, NOx, SOx and CO2, whereas if they are not, emissions to air only focus on dust. Emissions of NOx and SOx to air are dominant factors in acidification impacts.

Installation stage impacts

The installation of a hard covering product is generally carried out by a different company or individual with no direct relationship to the producer of the product. The main action a producer can take to minimise impacts during the installation stage is therefore limited to providing clear instructions and guidelines on the correct installation (see criterion 1.5 on user information). The other action that a producer can take is to provide information on the standard performance class of the product, at least in cases when such classes exist, so that a lack of information about the specification of the product is not an excuse for improper performance and premature end of life (see criterion 1.4 on fitness for use).

Table 2. Link between life cycle impacts identified and the revised EU Ecolabel criteria

Life cycle impact	Criteria	Link
1. Land use impacts (A1-A3)	Criterion 1.1 – Industrial and construction mineral extraction	Criterion 1.1 ensures that all extraction activities have at least been subject to an environmental impact screening procedure, approved by relevant authorities and respect legislation on biodiversity.
	Criterion 2.2 – Material efficiency at the quarry (natural stone)	Criterion 2.2 has an indirect influence on land use impacts by ensuring that less natural stone material needs to be extracted per unit of product sold, and rewards the sale of by-products.
	Criterion 2.6 –Quarry landscape impact ratios (natural stone)	Criterion 2.6 rewards natural stone quarry sites that use less land to store by-products and waste (i.e. by producing less in the first place, storing it efficiently, reusing it onsite, storing it underground or by selling it offsite). It rewards sites that establish biodiverse areas or do not disturb them in the first place and/or that are able to use the site for the generation of renewable energy.
2. Energy consumption (mainly A3)	Criterion 2.1 – Energy consumption at the quarry (natural stone) Criterion 2.7 – Energy consumption at the transformation plant (natural stone) Criterion 5.5 – Energy consumption (at the precast concrete plant)	Common approach taken for these three criteria where, due to the difficulty in setting a benchmark, applicants need to establish an energy inventory and a specific energy consumption reduction plan. Points are awarded for the use of renewable energy and furthermore for more beneficial ways of contracting renewable electricity. Both lower energy consumption and higher renewable energy shares are reflected in an optional carbon footprint approach as well.
	Criterion 3.1 – Energy consumption (agglomerated stone)	A maximum limit set on specific electricity consumption (1.1 MJ/kg) and maximum points available to reach a threshold of environmental excellence (0.7 MJ-kg).
	Criterion 4.1 – Fuel consumption for drying and firing (ceramics)	Maximum limits are set on specific fuel consumption as a function of the specific ceramic product in question and maximum points available for reaching a threshold of environmental excellence.
3. Global warming potential (mainly A3)	Criterion 2.1 – Energy consumption at the quarry (natural stone) Criterion 2.7 – Energy consumption at the transformation plant (natural stone) Criterion 5.5 – Energy consumption (at the precast concrete plant)	A plan to reduce CO2 emissions to optimum levels is to be implemented. Both lower energy consumption and higher renewable energy shares are reflected in an optional carbon footprint approach as well. Points are available in proportion to how much of the energy consumed is from renewable sources, the manner in which any renewable energy is purchased and where carbon footprint analysis has been carried out.
	Criterion 3.1 – Energy consumption (agglomerated stone)	Points are available relating to the share of renewable electricity used and the way the renewables are contracted.
	Criterion 4.2 – CO2 emissions (ceramics)	Maximum limits are set on specific CO2 emissions as a function of the specific ceramic product in question and maximum points available for reaching a threshold of environmental excellence.
	Criterion 5.2 – CO2 emissions (precast concrete)	Maximum limits are set on specific CO2 emissions for grey Portland cement clinker, for white Portland cement clinker and alternative cements and maximum points available for reaching a threshold of environmental excellence.

Life cycle impact	Criteria	Link
4. Acidification potential	Criterion 4.4 – Emission of dust, HF, NOx and SOx to air (ceramics)	Maximum limits are set on specific NOx and SOx emissions, with maximum points available for reaching a threshold of environmental excellence.
	Criterion 5.3 – Emission of dust, NOx and SOx to air (from cement kiln)	

2 Assessment and verification

The text applying to general aspects of assessment and verification, which appears in the preamble of the Annex to Decision (EU) 2021/476, is presented below.

Assessment and verification
The specific assessment and verification requirements are indicated within each criterion. Where the applicant is required to provide declarations, documentation, analyses, test reports or other evidence to show compliance with the criteria, these may originate from the applicant and/or his supplier(s) and/or their supplier(s), etc. as appropriate. Competent bodies shall preferentially recognise attestations and verifications that are issued by bodies accredited according to the relevant harmonised standard for testing and calibration laboratories, and verifications issued by bodies that are accredited according to the relevant harmonised standard for bodies certifying products, processes and services. Where appropriate, test methods other than those indicated for each criterion may be used if the competent body assessing the application accepts their equivalence. Where appropriate, competent bodies may require supporting documentation and may carry out independent verifications or on-site inspections to check compliance with these criteria. Changes in suppliers and production sites pertaining to products to which the EU Ecolabel has been granted shall be notified to competent bodies, together with supporting information to enable verification of continued compliance with the criteria. As a prerequisite, the hard covering product(s) shall meet all applicable legal requirements of the country or countries in which the product is placed on the market. The applicant shall declare the product's compliance with this requirement.

Rationale for general assessment and verification text:

The assessment and verification text appearing at the beginning of the Annex generally refers to the different types of evidence (e.g. declarations, test reports, etc.) that are considered relevant proofs of compliance for criteria. This text is necessary in order to establish the framework and general rules for verification procedures so that they do not need to be repeated in every individual assessment and verification text.

Each EU Ecolabel criterion text is followed by specific assessment and verification requirements stating which type of evidence should be provided to the Competent Body that is assessing the application. It is important to clarify here that when evidence is required from the supply chain, it is possible for the evidence to be submitted directly from the supplier to the Competent Body (this may be important when the proof requires information that may be commercially sensitive).

When evidence is required from tests or analyses, these should preferentially be carried out by laboratories that are accredited in accordance with relevant harmonised (ISO or EN) standards. However, this may not always be possible and in some cases it may be to accept evidence from in-house testing or testing by third parties that are in only accredited with relevant national standards. The same situation applies to test reports.

When a test method is specified in the assessment and verification text for a particular EU Ecolabel criterion, this method should be followed unless the applicant can demonstrate to the Competent Body that they have used another method that produces equivalent results. In such cases, the justification for equivalence must be clearly demonstrated and Competent Bodies should share this knowledge with other Competent Bodies.

Even in cases where evidence is provided exactly in accordance with the specific assessment and verification text for a particular EU Ecolabel criterion, it must be understood that the Competent Body

reserves the right to request further information, to visit the site and even consider independent means of testing and verification. If the applicant objects to such actions, this could potentially jeopardise the award of the EU Ecolabel.

For any criteria that relate to supplied chemicals or materials, it is understood that suppliers can change over time, that one supplier can supply multiple different types and grades of chemical/material and that even for a given supplier and given chemical/material, variations in time are possible depending on upstream supply chain and other factors. Consequently, any significant changes in the supplied chemicals/materials must be communicated to the Competent Body and supported by any relevant evidence (e.g. supplier declarations) to demonstrate ongoing compliance with EU Ecolabel criteria.

The final paragraph in the general assessment and verification text has been inserted in order to make it clear that non-compliance of the EU Ecolabel product with all applicable legal requirements of the country or countries in which the product is placed on the market may result in the full or partial revocation of the EU Ecolabel license.

3 Criteria structure

Since this product group is effectively a grouping of 4 different sub-products, it is first necessary to explain how the criteria are structured into horizontally applicable criteria and sub-product specific criteria.

Table 3. Overview of EU Ecolabel criteria structure, according to the specific sub-product (note that some of the longer criteria titles have been abbreviated)

1. Criteria common to all hard covering products			
1.1. Industrial and construction mineral extraction			
1.2. Restricted substances			
1.3. VOC emissions			
1.4. Fitness for use			
1.5. User information			
1.6. Information appearing on the EU Ecolabel			
1.7. Environmental Management System (optional)			
Material and technology specific criteria			
2. Natural stone	3. Agglomerated stone based on resin binders	4. Ceramic and fired clay	5. Precast concrete or compressed earth blocks with hydraulic binders or alternative cements
2.1. Energy consumption at the quarry*	3.1. Energy consumption	4.1. Fuel consumption for drying and firing	5.1. Clinker factor**
2.2. Material efficiency at the quarry*	3.2. Dust control and air quality	4.2. CO2 emissions	5.2. CO2 emissions**
2.3. Water/wastewater management at quarry*	3.3. Recycled / secondary material content	4.3. Process water consumption	5.3. Emissions of dust, NOx and SOx to air**
2.4. Dust control at the quarry*	3.4. Resin binder content	4.4. Emissions of dust, HF, NOx and SOx to air	5.4. Recovery and responsible sourcing of raw materials
2.5. Personnel safety and working conditions at the quarry*	3.5. Reuse of process waste	4.5. Wastewater management	5.5. Energy consumption
2.6. Quarry landscape impact ratios* (optional)		4.6. Reuse of process waste	5.6. Environmentally innovative product designs (optional)
2.7. Energy consumption at the trans. plant		4.7. Glazes and inks	
2.8. Water/wastewater management at the transformation plant			
2.9. Dust control at the transformation plant			
2.10. Reuse of process waste from the transformation plant			
2.11. Regionally integrated production at the transformation plant (optional)			

**criteria applicable for awarding the EU Ecolabel to intermediate blocks of dimension stone from natural stone quarries. **criteria applicable for awarding the EU Ecolabel to intermediate hydraulic binders or alternative cement products.*

Rationale for criteria structure

In Decision 2009/607/EC, the criteria were generally structured in the same sequence as a product life cycle, starting with raw material extraction, the processing, then the use phase. Sub-products were either natural or processed and the latter were either fired or hardened. From the perspective of a potential reader who is only interested in one set of criteria e.g. ceramics, the document was not reader-friendly. Consequently, the criteria have been restructured as follows:

- Horizontal criteria for all sub-products (1.1 to 1.7);
- Specific criteria for natural stone products (2.1 to 2.11);
- Specific criteria for agglomerated stone products based on resin binders (3.1 to 3.5);
- Specific criteria for ceramic and fired clay products (4.1 to 4.7), and
- Specific criteria for precast concrete products based on hydraulic binders or alternative cements (5.1 to 5.6).

In cases where intermediate products can be certified (i.e. blocks of natural stone from the quarry or cement for precast concrete), it was decided to make sure that the criteria are ordered with those relating to the intermediate product coming first. Specifically for natural stone, this means that criteria 2.1 to 2.6 refer to blocks from the natural stone quarry and criteria 2.7 to 2.11 to the transformation plant where the final product is made. For precast concrete, criteria 5.1 to 5.3 refer to cement production and 5.4 to 5.6 to precast concrete production.

Horizontal criteria common to all hard covering products

Criterion 1.1. Industrial and construction mineral extraction

Criterion 1.1. Industrial and construction mineral extraction
The extraction of industrial and construction minerals (e.g. limestone, clay, aggregates, dimension stone etc.) for the manufacture of an EU Ecolabel hard covering product shall only take place on sites which are covered by the following documentation: - an environmental impact assessment and, where relevant, a report in accordance with Directive 2014/52/EU of the European Parliament and of the Council[7] - a valid authorisation for the extraction activity issued by the relevant regional or national authority; - a rehabilitation management plan associated with the authorisation for the extraction activity; - a map indicating the location of the quarry; - a declaration of conformity with Regulation (EU) No 1143/2014 of the European Parliament and of the Council[8] on the prevention and management of the introduction and spread of invasive alien species; - a declaration of conformity with Council Directive 92/43/EEC[9] (habitats) and Directive 2009/147/EC of the European Parliament and of the Council[10] (birds). With regards to the last point above, in cases where extraction sites are located in Natura 2000 network areas, composed of Special Areas of Conservation under Directive 92/43/EEC and Special Protection Areas under Directive 2009/147/EC, extraction activities shall have been assessed and authorised in accordance with the provisions laid down in Article 6 of Directive 92/43/EEC and have taken into account the relevant EC Guidance document[11]. Also with regards to the last point above, in cases where extraction sites are located outside the EU, if materials are extracted from areas officially nominated as candidates for or adopted as Areas of Special Conservation Interest; part of the Emerald network pursuant to Recommendation No 16 (1989) and Resolution No 3 (1996) of the Bern Convention[12] or protected areas designated as such under the national legislation of the sourcing / exporting countries, the extraction activities shall have been assessed and authorised in accordance with provisions that provide assurances equivalent to Directives 92/43/EEC and 2009/147/EC. **Assessment and verification**: The applicant shall provide a declaration of compliance with this requirement issued by the competent authorities, or a copy of the authorisations issued by the competent authorities and any other required declarations and documentation. The rehabilitation management plan shall include the objectives for the rehabilitation of the quarry, the conceptual final landform design, including the proposed post quarry land use, details on the implementation of an effective revegetation program and details of an effective monitoring programme to assess performance of the rehabilitated areas. In case industrial or construction mineral extraction activities have been carried out in Natura 2000

7 Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (OJ L 124, 25.4.2014, p.1).

8 Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species (OJ L 317, 4.11.2014, p. 35).

9 Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206, 22.7.1992, p. 7).

10 Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (OJ L 20, 26.1.2010, p. 7).

11 Guidance document on non-energy mineral extraction and Natura 2000. A summary. ISBN: 978-92-79-99542-2.

12 Convention on the Conservation of European Wildlife and Natural Habitats. Council of Europe. European Treaty Series – No. 104.

network areas (in the Union), the Emerald network or protected areas designated as such under the national legislation of the sourcing/exporting countries (outside the Union), the applicant shall provide a declaration of compliance with this requirement issued by the competent authorities or a copy of their authorisation issued by the competent authorities.

Rationale:

The criterion title "*industrial and construction mineral extraction*" is preferred instead of the former title "*raw materials*", since the former is in line with the terminology used in the BAT Reference Document for the management of waste from extractive industries published by the Commission in 2018 (BAT, 2018).

Environmental Impact Assessment (EIA)

Some quarries are hundreds of years old and most pre-date the 2011/92/EU EIA Directive and even the 2001/42/EC Directive on Strategic Environmental Assessments. Consequently, not all quarries will have an EIA, and it is possible that the result of an EIA screening procedure will be that an EIA is not needed. In such cases, the results of the screening procedure should be provided.

Rehabilitation management plans

Raw material extraction is the largest contributor to land-use impacts for hard covering products. It should be ensured that appropriate measures are taken to minimise biodiversity losses and ensure appropriate recovery of the areas where extraction activities take place. These can only be verified by providing full documentation of the extraction activity, including the environmental recovery plan and the environmental impact assessment report. It was considered that the term "*rehabilitation management plan*" would be a better term than "*environmental recovery plan*".

The rehabilitation management plan must state the objectives for the rehabilitation of the quarry. A conceptual final landform design, including the proposed post-quarry land use should be included and specific details on the implementation of an effective revegetation program should be provided. Rehabilitation may be progressive or only at the end of the quarry life. In all quarries, some degree of progressive rehabilitation should be possible. An effective monitoring programme is essential for assessing the performance of the rehabilitated areas. The rehabilitation management plan should be designed to reach the following main objectives:

- Achievement of acceptable land use suitability (post quarrying) – Rehabilitation will aim to create a stable landform with land capability and/or agricultural suitability similar to that prior to quarry activities, unless other beneficial land uses are pre-determined and agreed. This will be achieved by setting clear rehabilitation criteria and outlining the monitoring requirements that assess whether or not these criteria are being accomplished.
- Creation of stable landform – Disturbed land will be rehabilitated to a condition that is self-sustaining, or one where maintenance requirements are consistent with the agreed post-quarry land use.
- Preservation of downstream water quality – Current and future water quality will be maintained at levels that are acceptable for users downstream of the site.

In order to achieve this, it is necessary to coordinate a practical approach that could include among others:

- Conducting proven and resilient revegetation techniques that acknowledge altered landform and soil conditions;
- Undertaking effective soil management techniques including stripping, stockpiling, respreading and appropriate weed control; and
- Establishing a monitoring program that can determined whether the rehabilitated areas are moving towards a successful outcome.

Alien and invasive species

The rehabilitation and revegetation programmes should take into account the Regulation (EU) No 1143/2014 on the prevention and management of the introduction and spread of invasive alien species. Therefore a requirement to declare compliance with the regulation has been included.

According to the European Commission, Invasive Alien Species (IAS) "are animals and plants that are introduced accidently or deliberately into a natural environment where they are not normally found, whose introduction or spread has been found to threaten or adversely impact upon biodiversity and related ecosystem services."

IASs are considered the second largest threat to global biodiversity and quarrying can lead to their spreading. Quarry sites run the risk of becoming colonised by IAS. The ability of an IAS to easily adapt to its surroundings, grow and spread rapidly and, in some instances, prevent the development of native species, meaning that they can easily colonise quarry environments and have a negative impact on native biodiversity. Many invasive species that grow in aggregate quarries produce a lot of seeds that are exported via the aggregate material. Once dispersed on construction sites IAS can easily spread further into natural ecosystems and damage them. Alongside ecological damages, IAS are a potential hazard for infrastructure, and can cause economic damages to roads, pipes, etc.

Compliance with the Birds and Habitats Directives

The Habitats Directive (92/43/EEC) aims to promote the maintenance of biodiversity, taking account of economic, social, cultural and regional requirements. Together with the Birds Directive (2009/147/EC), it forms the cornerstone of Europe's nature conservation policy and establishes the EU wide Natura 2000 ecological network of protected areas, safeguarded against potentially damaging developments.

Extraction and quarrying activities in Natura 2000 sites

Natura 2000 sites cover around 18% of the EU's land area and almost 6% of its marine territory. These sites stretch across all EU 27 countries and form the largest coordinated network of protected areas in the world.

Natura 2000 is a network of core breeding and resting sites for rare and threatened species, and some rare natural habitat types which are protected in their own right. The aim of the network is to ensure the long-term survival of Europe's most valuable and threatened species and habitats, listed under both the Birds Directive (2009/147/EC) and the Habitats Directive (92/43/EEC).

Natura 2000 is not a system of strict nature reserves from which all human activities would be excluded. While it includes strictly protected nature reserves, most of the land remains privately owned. The approach to conservation and sustainable use of the Natura 2000 areas is much wider, largely centered on people working with nature rather than against it. However, Member States must ensure that the sites are managed in a sustainable manner, both ecologically and economically.

To this end, the extraction of raw materials from Natura 2000 sites to make EU Ecolabel products is not expressly forbidden. The precedent set by Commission Decision (EU) 2015/2099 for EU Ecolabel Soil Improvers and Growing Media is followed.

Raw materials can be supplied from outside of the EU as well. Consequently, some form of equivalence is needed to ensure that raw material extraction for the production of EU Ecolabel products is not disturbing protected areas outside of the EU. Specific reference is made to Emerald sites and general reference is made to nationally protected areas.

Criterion 1.2. Restricted substances

Criterion 1.2. Restricted substances
The basis for demonstrating compliance with each of the sub-criteria under criterion 1.2 shall be the applicant providing a list of all the relevant chemicals used together with appropriate documentation (safety data sheet and/or a declaration from the chemical supplier). As a minimum, all process chemicals used by the applicant in relevant production processes must be screened. 1.2 (a) Restrictions on Substances of Very High Concern (SVHCs) All ingoing chemicals used in the production process by the applicant and any supplied materials that form part of the final product shall be covered by declarations from suppliers stating that they do not contain, in concentrations greater than 0,10 % (weight by weight), substances meeting the criteria referred to in Article 57 of Regulation (EC) No 1907/2006 of the European Parliament and of the Council[13] that have been identified according to the procedure described in Article 59 of that Regulation and included in the candidate list for substances of very high concern for authorisation. No derogation from this requirement shall be granted. ***Assessment and verification:*** *The applicant shall provide a declaration that the product has been produced using supplied chemicals or materials that do not contain any SVHC in concentrations greater than 0,10 % (weight by weight). The declaration shall be supported by safety data sheets of process chemicals used or appropriate declarations from chemical or material suppliers.* *The list of substances identified as SVHCs and included in the candidate list in accordance with Article 59 of Regulation (EC) No 1907/2006 can be found here:* *http://echa.europa.eu/chem_data/authorisation_process/candidate_list_table_en.asp.* *Reference to the list shall be made on the submission date of the EU Ecolabel application.*
1.2 (b) Restrictions on substances classified under Regulation (EC) No 1272/2008 of the European Parliament and of the Council[14] Unless derogated in Table 2, the product shall not contain substances or mixtures in concentrations greater than 0,10 % (weight by weight) that are assigned any of the following hazard classes, categories and associated hazard statement codes, in accordance with Regulation (EC) No 1272/2008: - Group 1 hazards: Category 1A or 1B carcinogenic, mutagenic and/or toxic for reproduction (CMR): H340, H350, H350i, H360, H360F, H360D, H360FD, H360Fd, H360Df. - Group 2 hazards: Category 2 CMR: H341, H351, H361, H361f, H361d, H361fd, H362; Category 1 aquatic toxicity: H400, H410; Category 1 and 2 acute toxicity: H300, H310, H330; Category 1 aspiration toxicity: H304; Category 1 specific target organ toxicity (STOT): H370, H372. - Group 3 hazards: Category 2, 3 and 4 aquatic toxicity: H411, H412, H413; Category 3 acute toxicity: H301, H311, H331; Category 2 STOT: H371, H373. The use of substances or mixtures that are chemically modified during the production process, so that any relevant hazard for which the substance or mixture has been classified under Regulation (EC) No 1272/2008 no longer applies, shall be exempted from the above requirement. Table 2. Derogations to restrictions on substances classified under Regulation (EC) No 1272/2008 and applicable conditions

[13] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC (OJ L 396, 30.12.2006, p. 1).

[14] Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006 (OJ L 353, 31.12.2008, p. 1).

Substance /mixture type	Applicability	Derogated hazard class, category and hazard statement code	Derogation conditions
Titanium dioxide (TiO2)	All materials within scope	Carcinogenic, category 2, H351 (inhalation)	TiO2 is not intentionally added to the product but is present because it is a naturally occurring impurity in the raw materials used. TiO2 content (expressed as TiO2) in any raw material used to manufacture the final product is less or equal to 2,0% (w/w).
Crystalline silica	All materials within scope	Specific Target Organ Toxicity, (repeated exposure), category 1 and 2, H372, H373	The applicant provides a declaration of compliance with any relevant instructions for safe handling and dosing specified in the safety data sheet or supplier declaration. Factory cutting operations are carried out using wet process tools or dry processes where a vacuum hood is in place to collect dust. Safety instructions regarding exposure to dust during any cutting operations carried out by installers are provided with the product.

Assessment and verification: *The applicant shall provide a list of all relevant chemicals used in their production process, together with the relevant safety data sheet or chemical supplier declaration.*

Any chemicals containing substances or mixtures with restricted CLP classifications under Regulation (EC) No 1272/2008 shall be highlighted. The approximate dosing rate of the chemical, together with the concentration of the restricted substance or mixture in that chemical (as provided in the safety data sheet or supplier declaration) and an assumed retention factor of 100 %, shall be used to estimate the quantity of the restricted substance or mixture remaining in the final product.

Since multiple products or potential products using the same process chemicals may be covered by one license, the calculation for each chemical only needs to be presented for the worst-case product covered by the EU Ecolabel license (e.g. the most heavily surface-treated or pigmented or printed product).

Justifications for any deviation from a retention factor of 100 % or for chemical modification of a restricted hazardous substance or mixture must be provided in writing.

For any restricted substances or mixtures that exceed 0,10 % (weight by weight) of the final hard covering product, a relevant derogation must be in place and proof of compliance with any relevant derogation conditions must be provided.

Rationale:

The structure of the horizontal hazardous substance criteria follows the general recommendations of the EU Ecolabel Chemicals Task Force. The wording of the current proposal is based predominantly on the most recently voted product group which is a (non-complex) article (Graphic paper, Tissue paper and Tissue paper products, voted in June 2018).

Legal background

The existing EU Ecolabel criteria for the product group "Hard Coverings" were published in 2009, specifically in Commission Decision 2009/607/EC. This was prior to the publication of the revised EU Ecolabel Regulation in 2010.

Article 6(6) of EU Ecolabel Regulation (EC) No 66/2010 makes specific provision for a horizontal approach to hazardous substance restrictions for all product groups.

Article 6(6): "The EU Ecolabel may not be awarded to goods containing substances or preparations/mixtures meeting the criteria for classification as toxic, hazardous to the environment, carcinogenic, mutagenic or toxic for reproduction (CMR), in accordance with Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures nor to goods containing substances referred to in Article 57 of Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH)".

Nevertheless, the EU Ecolabel Regulation also recognizes also that in certain circumstances, the restriction of some substances may not be technically or environmentally justifiable. Therefore, Article 6(7) of the Regulation states that:

Article 6(7): "For specific categories of goods containing substances referred to in paragraph 6, and only in the event that it is not technically feasible to substitute them as such, or via the use of alternative materials or designs, or in the case of products which have a significantly higher overall environment performance compared with other goods of the same category, the Commission may adopt measures to grant derogations from paragraph 6. No derogation shall be given concerning substances that meet the criteria of Article 57 of Regulation (EC) No 1907/2006 and that are identified according to the procedure described in Article 59(1) of that Regulation, present in mixtures, in an article or in any homogeneous part of a complex article in concentrations higher than 0,1% (weight by weight).".

The term "*containing*" is highlighted above because legal clarity was needed regarding what particular content can be considered as relevant. In principle, contained could be considered as the presence of just one molecule of a particular restricted hazardous substance. An EU Ecolabel Chemicals Task Force was convened and it was agreed that for the purposes of interpreting Articles 6(6) and 6(7), the term "*containing*" should be considered as equating to a content exceeding 0.10% (weight by weight) of the entire product or its homogenous part. The concentration 0.10% was used instead of the 0.1% mentioned in REACH because it reduces the potential for convenient rounding down of concentrations.

As a general rule for applying the 0.10% rule, it is proposed to consider all the products covered by this product group as simple articles. Even though some products may not be homogenous (e.g. dual layered concrete pavers, dual layer terrazzo tiles or glazed ceramics) such a proposal is considered reasonable since these heterogeneous areas are bonded in such a way that they cannot be mechanically separated by simple means.

SVHC restrictions

Since Article 6(7) prevents any derogation of SVHCs above 0.1% and the Chemicals Task Force agreed that "contained" means greater than 0.10% by weight, it can be concluded that any products considered to "contain" any SHVC cannot qualify for the EU Ecolabel.

The 0.10% limit is particularly useful for SVHC declarations since it aligns perfectly with communication requirements that are stipulated in the REACH Regulation (specifically in Articles 7(2) and 33 of REACH).

Article 7(2) requires importers or producers to notify ECHA if an SVHC is present in articles they import or produce in concentrations exceeding 0.1% (w/w) and add up in total to more than 1 tonne of a particular SVHC per actor per year.

Article 33 is even more relevant, since any recipient (i.e. a business to business transaction) or consumer (business to consumer transaction) must, upon request, be informed within 45 days of the presence of any SVHC present in the article(s) they have purchased if the concentration of the SVHC exceeds 0.1% (w/w). The weak point of Article 33 is that this communication requirement is only triggered by a specific request and only if the answer is positive (i.e. that there is an SVHC present >0.1%). There is no obligation to respond if no SVHC is present >0.1% w/w, even if it is simply to confirm that there is no issue.

A more pragmatic and ambitious approach has been applied to Hard Coverings where SVHCs are screened at the level of 0.1% in ingoing chemicals rather than 0.1% of the weight of the final product.

CLP restrictions

There is no longer any reference to risk phases (e.g. R45, R50 etc.) when mentioning the classification of substances and mixtures because these were linked to the Dangerous Substances Directive (67/548/EEC) which was repealed by the CLP Regulation as of June 2015. Instead, reference is exclusively made to hazard statements and classes (e.g. H350, H400 etc.).

The term "*toxic, hazardous to the environment, carcinogenic, mutagenic or toxic for reproduction (CMR)*" from Article 6(6) was translated into specific CLP hazard categories by the EU Ecolabel Chemicals Task Force and resulted in the Group 1, Group 2 and Group 3 hazards as listed in the criterion proposal.

Depending on the nature of the product group and its normal use, the potential to also restrict category 1 skin sensitizers (H317) or category 1 respiratory sensitizers (H334) may be considered. These particular hazards were not considered relevant to hard coverings and so H317 and H334 are not listed in the proposed CLP criterion.

Unfortunately REACH does not make any provision for communication requirements about non-SVHC substances in articles like hard coverings and the CLP Regulation is focussed on labelling of substances and mixtures, not articles. Consequently, in order to demonstrate compliance with the CLP restriction criteria, the EU Ecolabel applicant has to be aware of all of the chemical substances or mixtures that have been used during the processing of the hard covering product. The following pieces of information are needed:

- List of chemical substances or mixtures used.
- Safety data sheets or relevant supplier declarations.
- Information about dosing rates and chemistry of any reactions that take place.

Armed with the above information, each chemical product can then be cross-checked against the following flow chart:

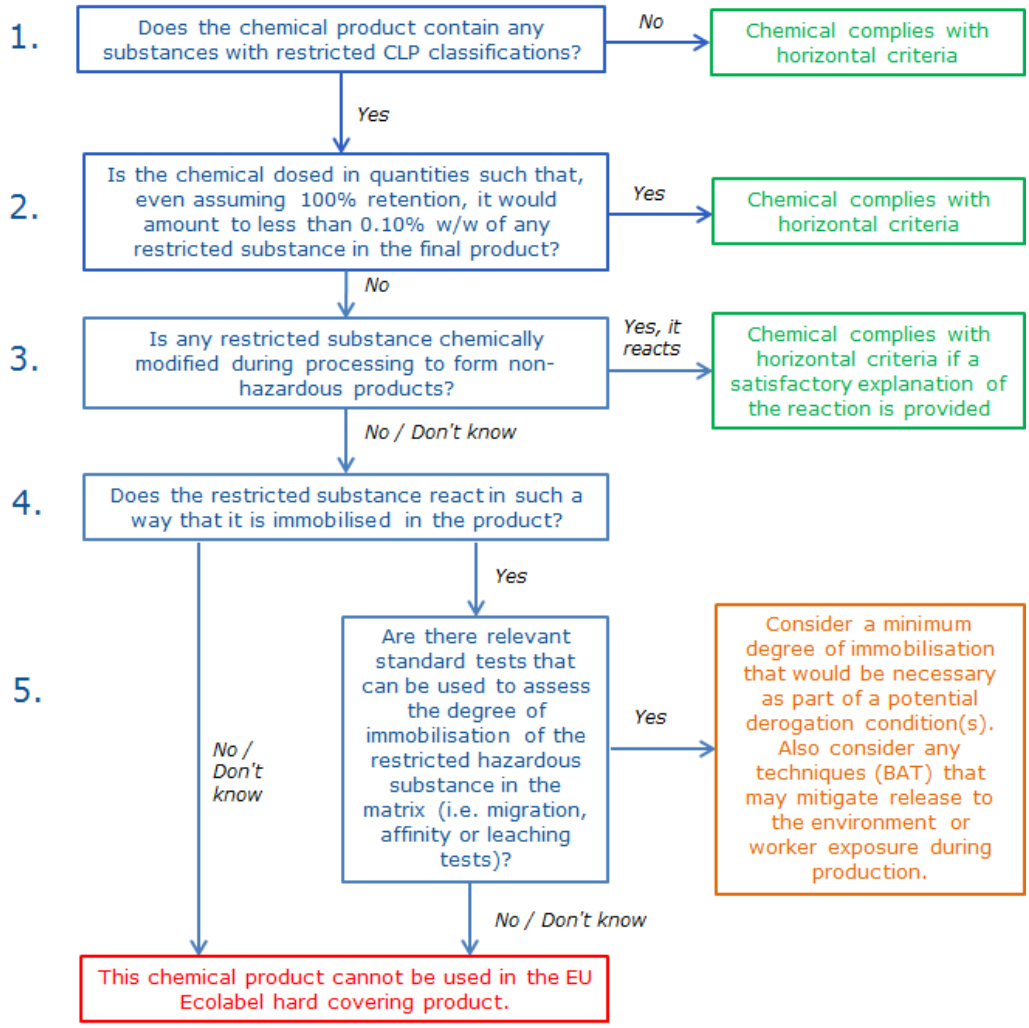

Figure 5. Flow chart for checking compliance with CLP restrictions and potential need for derogations.

According to the flow chart above, the easiest means to demonstrate compliance is simply not to use chemicals containing hazardous substances in the first place.

When considering whether or not it is technically feasible to substitute the chemical or not, consideration has to be given to the functionality that the chemical imparts to the product (e.g. brightness, gloss, scratch resistance etc.). If less hazardous alternatives do exist, then a case has to be made for why the more hazardous chemical is used. Maybe it is more efficient, maybe its performance is better proven or similar reasons.

If the quantities of the restricted hazardous substance(s) involved are small, then applicants should check their dosing rates and calculate if its use can be justified based on the fact that it would account for less than 0.10% of the final product weight.

The last chance for justifying the use of a chemical containing restricted hazardous substances without any specific derogation is to assess whether or not the substance reacts in such a way as to no longer be hazardous. Reactivity should be considered in terms of chemical reaction instead of physical immobilisation. For example, a monomer reacting to form a polymer is a clear example of a relevant chemical reaction but the depositing of a pigment in a coloured matrix is simply immobilisation, and thus not a relevant reaction.

Finally, if a restricted hazardous substance cannot comply with the previous four steps, but its use is considered essential for the specific products or for desirable product functionalities, then a derogation request should be made.

Any derogation request should explain clearly what substance(s) are involved, their CLP classification(s), why they should be derogated and suggested conditions that could be attached to any such derogation (e.g. worker exposure control, maximum dosing rate, minimum functionality or minimum immobilisation achieved etc.).

Derogation for Titanium Dioxide (TiO2)

As of February 2020, TiO2 has been reclassified as H351 (inhalation). Even though TiO2 is expected to be well immobilised in all hard covering products, it is not expected to be chemically modified, which would otherwise exempt it from the requirements of the horizontal CLP restrictions for EU Ecolabel products.

TiO2 is the 9th most common element in the earth's crust and the entire crust could have average contents of around 1% as TiO2. Feedback from the Italian Ceramics association (Confindustria Ceramica) confirmed that raw material contents of TiO2 in Italian clays ranged from 0.16 to 0.38% w/w, i.e. always above the 0.1% threshold for the horizontal hazardous substance criteria. Consequently, the presence of TiO2 in hard covering products above 0.1% is permitted in cases where the content is a consequence of natural impurities in the raw materials used and not via any intentional addition of TiO2 to the manufacturing process.

Derogation for crystalline silica

Crystalline silica is the main material used in quartz-based agglomerated stone products, may be added to precast concrete as a filler, could be added to ceramic raw material blends and is potentially relevant to siliceous natural stone products.

There is no REACH registration duty for crystalline silica due to the fact that there is an exemption for registration of any "*minerals which occur in nature, if they are not chemically modified*".

A review and hazard assessment of the health effects of respirable crystalline silica concluded with the recommendation that the fine fractions of crystalline silica and cristobalite should be classified as STOT RE 1 (H372). Such a classification is linked to occupational health experience with workers that have been affected by silicosis.

The RE part of STOT RE 1 stands for Repeated Exposure, meaning that this is an issue that will be specific for factory workers and installers that are potentially exposed to airborne crystalline silica particles during each work day. Consequently, the derogation condition is focused on limited the risk and extent of exposure to workers.

Criterion 1.3. VOC emissions

Criterion 1.3. VOC emissions

No surface treatments using formaldehyde-based resins shall be permitted.

Any natural stone, ceramic, fired clay or precast concrete products based on hydraulic binders or alternative cements that have been surface-treated with VOC-containing compounds shall be tested for VOC emissions and shall comply with the limits defined below.

All agglomerated stone products based on resin binders shall be tested for VOC emissions regardless of the nature of any surface treatments used and shall comply with the limits defined below.

	Limit (after 28 days)	**Method**
Total VOC	300 µg/m3	EN 16516
Formaldehyde	10 µg/m3	
R-value	< 1	
Carcinogenic 1A and 1B VOCs listed in Annex H of EN 16516:2017 (excluding formaldehyde and acetaldehyde)	1 µg/m3 per individual substance	

***Assessment and verification**: The applicant shall declare if the final product surface has been treated with any waxes, adhesives, coatings, resins or similar surface treatment chemicals and provide any related safety data sheets or supplier declarations about the VOC content of the surface treatment chemicals used.*

In cases where VOC emission testing is required, the applicant shall provide a declaration of compliance, supported by a test report carried out according to EN 16516. If compliance with the chamber concentration limits specified at 28 days can be met at any other time between 3 and 28 days, the chamber test may be stopped prematurely.

Rationale:

Impact on indoor air quality

The emission of VOCs is a serious environmental concern, especially in the context of indoor air quality. The products within the scope of EU Ecolabel hard coverings (e.g. natural stone, agglomerated stone, ceramics and concrete) tend to have much lower potential for VOC emissions to indoor air than, for example, wooden floor coverings or carpets.

However, in order to improve certain technical properties of the hard covering products, such as scratch resistance, stain resistance or water repellency, these products may be treated with waxes, resins or other surface treatment chemicals which may (or may not) have a significant VOC content.

Green Building Assessment schemes recognize the importance of VOC emissions from interior building products on indoor air quality. For example, the BREEAM International New Construction (Version sd233 1.0) offers up to 5 credits for flooring and wall materials (amongst others). The LEED v.4 criteria for building design and construction offer up to 3 credits for low emitting materials under its Indoor Environmental Quality criteria.

Level(s), a policy initiative of the Commission to develop a common framework for the assessment of sustainable buildings, has a dedicated indicator (4.1) for indoor air quality and considers design stage factors that influence VOC emission (i.e. ventilation rate and specification of potential VOC-emitting materials in fit out) as well as in-situ monitoring during the post-completion and occupation stages.

The main minimum requirement for the criteria is to basically know and declare any surface treatment chemicals have been used. An EU Ecolabel applicant will already have this information after demonstrating compliance with the horizontal CLP criterion (1.2b). The other minimum requirement is

that any resins used must not be formaldehyde-based. Formaldehyde is now classified as a category 1 carcinogen and even if free-formaldehyde is consumed during the resin polymerization, small but continual amounts of free-formaldehyde can be released during the product use stage when the resin comes into contact with moisture or atmospheric humidity.

Other approaches in the market

The have been many recent developments in the market relating to VOC emissions. At the European level, considerable progress has been made in harmonizing LCI values (standing for Lowest Concentration of Interest)[15].

In Germany, the AgBB have published a new evaluation procedure for VOC emission from building products in 2018. Total VOCs (28 day limit of 1000 µg/m3), Total SVOCs (28 day limit 100 µg/m3), no carcinogenic substance (category 1A and 1B) must exceed 1 µg/m3 after 28 days and requirements are maybe for individual VOCs in different ways depending on whether an EU-LCI has been established or not.

In France, a VOC label is used for construction, decorative and furnishing products placed on the French market as per Décret no. 2011-321. The VOC label has A+, A, B and C classes, based on ISO 16000 chamber testing of the following VOCs.

Table 4. Limit values for the French VOC label in the context of EU-LCI (in µg/m3)

Substance / Emissions class	A+	A	B	C	EU-LCI
Formaldehyde	< 10	< 60	< 120	> 120	100
Acetaldehyde	< 200	< 300	< 400	> 400	1200
Toluene	< 300	< 450	< 600	> 600	2900
Tetrachloroethene	< 250	< 350	< 500	> 500	80
Xylene	< 200	< 300	< 400	> 400	500
1,2,4-Trimethylbenzene	< 1000	< 1500	< 2000	> 2000	450
1,4-Dichlorbenzene	< 60	< 90	< 120	> 120	150
Ethylbenzene	< 750	< 1000	< 1500	> 1500	850
2-Butoxyethanol	< 1000	< 1500	< 2000	> 2000	1600
Styrene	< 250	< 350	< 500	> 500	250
TVOC	< 1000	< 1500	< 2000	> 2000	-

The data in the table above show that there are some important differences between the French values and the EU-LCIs. In some cases, the EU LCI values are actually lower than the "A" requirement for the French VOC label (e.g. tetrachloroethene, 1,2,4-trimethylbenzene, ethylbenzene and styrene).

Choice of requirements for VOC emissions from hard coverings

Total VOC is the simplest measure to evaluate the emissions of VOCs to air and the ambition level is aligned with the AgBB requirement and the A+ requirement in the French VOC label.

A very stringent limit has been placed on formaldehyde emissions because they should not be used in the first place, hence this is a laboratory check on their non-use.

[15] EU-LCI Values - https://ec.europa.eu/growth/sectors/construction/eu-lci/values_en

Styrene emissions are highly relevant for agglomerated stone products due to the common use of polyester resins as binders. A common limit is set for all hard covering products that is in line with the A+ requirement of the French VOC label and the EU-LCI value.

The requirements on carcinogenic VOCs are considered necessary due to the potential impacts on occupier health. This is generally in line with the requirements in force in France and Germany. Since a separate (and higher) limit was specified for formaldehyde, this VOC is excluded from the general rule. It was also requested that acetaldehyde should be excluded from this rule.

Why the separate approach for agglomerated stone?

Unlike hard covering products made of natural stone, ceramics or precast concrete, all agglomerated stone products have a potential source of VOC emissions, the resin binder. Consequently, VOC emission testing must always be carried out, even if VOC-containing surface treatments are not applied.

A review of agglomerated stone products on the market showed that a US testing method for VOC emissions was the established practice (Greenguard). Stakeholders requested that a European approach is maintained for any VOC emissions from EU Ecolabel products. A read-across of the EN 16516 method and the UL 2821 method for Greenguard revealed some significant differences that impede a direct comparison of the limits from each method (the most important being that EN 16516 refers to 28 day values and UL 2821 to 7 day values).

Criterion 1.4. Fitness for use

Criterion 1.4. Fitness for use
This criterion does not apply to intermediate products (i.e. dimension stone blocks, hydraulic binders or alternative cements). The applicant shall have a quality control and quality assessment procedure in place to ensure that products are fit for use. ***Assessment and verification***: *The applicant shall provide a declaration of compliance with this criterion, supported by the following documents:* – *Certification of the production site according to ISO 9001 or a copy of the in-house quality management system and associated quality assurance and quality control procedures.* – *A detailed description of the procedure for handling consumer complaints.* – *CE marking of the product(s) in accordance with Regulation (EU) No 305/2011*[16] *of the European Parliament and of the Council (with the exception of table-top, vanity top and kitchen-worktop products).* *Where relevant, further evidence demonstrating fitness for use shall be provided. Such evidence should be based on appropriate EN or ISO standards, or equivalent methods. An indicative, non-exhaustive list of potentially relevant standards is provided below:* - *Natural stone products: EN 1341, EN 1342, EN 1343, EN 1467, EN 1468, EN 1469, EN 12057, EN 12058 or EN 12059;* - *Agglomerated stone products based on resin binders: EN 15285, EN 15286, EN 15388 or EN 16954;* - *Ceramic and fired clay products: EN 1344, EN 13006 or EN 14411;* - *Precast concrete products based on hydraulic binders or alternative cements: EN 1338, EN 1339, EN 1340 or EN 13748.*

Rationale:

These environmental criteria take the whole product life cycle into account from the extraction of the raw materials, to production, packaging and transport, right through to use and disposal/recycling. Fitness-for-use criteria also guarantee good product performance (of course with the caveats of correct installation and use). The main purpose of the requirement on fitness for use is to make sure that products are sold that are correctly marked with whatever relevant performance class(es) they conform with, which will help ensure the customer about their correct installation and use, which will reduce the risk of wasted materials and premature end-of-life.

The highest environmental impacts caused by hard coverings are due to their raw material extraction and production stages. These impacts, especially those on resource consumption, can be minimized provided that the service life of the product is extended. To guarantee a long durability of the finished products a design for fitness for use is needed. This criterion aims at ensuring these characteristics in the EU Ecolabel products.

Hard coverings are products which are extremely durable, resulting in a long life expectancy. According to a study of Life Expectancy of Home Components prepared by the National Association of Home Builders (NAHB), the average life span of different coverings varies between 75 and more than 100 years. Despite the long life, the use stage causes negligible environmental impacts. This is due to the fact that the maintenance of hard coverings is quite simple and usually is limited to maintenance to

[16] Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC (OJ L 88, 4.4.2011, p.5).

seal the surface for natural stone products and cleaning operations, although it depends on the type of flooring, material and application (domestic, office, etc.).

EN standards and test methods are available for demonstrating appropriate levels of performance. The full titles of the standards are included here for reference.

Natural stone products

- EN 1341, Natural stone — Slabs of natural stone for external paving — Requirements
- EN 1342 Sets of natural stone for external paving - Requirements and test methods
- EN 1343 Kerbs of natural stone for external paving - Requirements and test methods
- EN 1467, Natural stone — Rough blocks — Requirements
- EN 1468, Natural stone — Rough slabs — Requirements
- EN 1469, Natural stone products — Slabs for cladding — Requirements
- EN 12057, Natural stone products — Modular tiles — Requirements
- EN 12058, Natural stone products — Slabs for floors and stairs — Requirements
- EN 12059, Natural stone products — Dimensional stone work — Requirements

Agglomerated stone

- EN15285 — Agglomerated stone — Modular tiles for flooring and stairs (internal and external)
- EN15286 — Agglomerated stone —Slabs and tiles for wall finishes (internal and external)
- EN 15388 — Agglomerated stones — Slabs and cut to size products for vanity and kitchen tops
- EN 16954— Agglomerated stone — Slabs and cut-to-size products for flooring and stairs (internal and external)

Clay and ceramic tiles

- EN 1344 — Clay pavers – Requirements and test methods
- EN13006 – Ceramic tiles – Definitions, classification, characteristics and marking
- EN14411 — Ceramic tiles - Definition, classification, characteristics, assessment and verification of constancy of performance and marking

Concrete blocks, flags and tiles

- EN1338 — Concrete paving blocks - Requirements and test methods
- EN1339 —Concrete paving flags - Requirements and test methods
- EN 1340 – Concrete kerb units – Requirements and test methods
- EN 13748 — Terrazzo tiles - Part 1: Terrazzo tiles for internal use
- EN 13748— Terrazzo tiles - Part 2: Terrazzo tiles for external use

Criterion 1.5. User information

Criterion 1.5. User information
This criterion does not apply to intermediate products (i.e. dimension stone blocks, hydraulic binders or alternative cements). The product shall be sold with relevant user information, which provides advice on the product's proper installation, maintenance and disposal. The product packaging or documentation accompanying the product shall provide contact details (telephone or email) and a reference to online information for consumers that have enquiries or need specific advice regarding installation, maintenance or disposal of the hard covering product. Specific information that should be made available includes: - Details about any relevant technical performance classes that indicate the appropriate use environment for the hard covering product, for example, tensile strength, frost resistance/water absorption, stain resistance and resistance to chemicals. - Details about any necessary preparation of the underlying surface prior to installation, recommended installation techniques as well as specifications for any other relevant materials used during installation such as grouts, sealants, coatings, adhesives, mortars and cleaning agents used by the installer. - For hard covering products with surfaces exposed to interior or exterior environments, instructions on routine cleaning operations and recommended cleaning agents. Where relevant, information on less periodic maintenance operations, such as rejuventation of floor surfaces with high-pressure cleaners or by recoating and polishing shall be provided as well. - Information on the correct recycling or environmentally preferable disposal of packaging provided with the hard covering product, off-cuts of the hard covering product created during installation and the product itself at the end of life. ***Assessment and verification:*** *The applicant shall provide to the competent body a declaration of compliance with this criterion, a high resolution image of the packaging and a link to the online version of the user information.*

Rationale:

Information about correct installation, maintenance and disposal can play an important role in the overall environmental performance of the hard covering product. In this sense, if the supplier, installers and consumers is correctly informed at the appropriate time, the optimal performance of the product can be expected.

At the installation stage, information should include suitable installation techniques, suitable bases or underlays, compatible sealants, how to cut pieces to size correctly and about relevant performance classes. This can help minimise waste rates and broken pieces during installation and prevent premature end of life.

During the use stage, the choice of correct cleaning agents is especially important in cases of acid soluble marble-based products.

A knowledge of maintenance operations can help maintain the hard covering product in optimal conditions and extend useful lifetime (e.g. repolished and rejuvenated).

Criterion 1.6. Information appearing on the EU Ecolabel

Criterion 1.6. Information appearing on the EU Ecolabel
If the optional label with text box is used, it shall contain the following three statements, as appropriate: For natural stone products (intermediate blocks of dimension stone or final products): - material efficient production process; - reduced dust emissions; - production with closed loop wastewater recycling. For agglomerated stone products based on resin binders: - material efficient production process; - energy efficient production process; - reduced dust emissions. For ceramic and fired clay products: - material efficient production process; - energy efficient and low CO2 production process; - reduced emissions of dust and acidifying compounds to air. For hydraulic binders or alternative cements (intermediate products in the manufacture of precast concrete or compressed earth products): - reduced CO2 emissions; - reduced dust emission; - reduced emissions of acidifying compounds to air. For precast concrete products or compressed earth blocks based on hydraulic binders or alternative cements: - material efficient production process; - energy efficient production process; - uses low environmental impact binder. The applicant shall follow the instructions on how to properly use the EU Ecolabel logo provided in the EU Ecolabel Logo Guidelines: http://ec.europa.eu/environment/ecolabel/documents/logo_guidelines.pdf ***Assessment and verification:*** *The applicant shall provide a declaration of compliance with this criterion, supported by a high resolution image of the product packaging that clearly shows the label, the registration/licence number and, where relevant, the statements that can be displayed together with the label.*

Rationale:

Information given to the consumers ensures that end-users are informed of the main environmental benefits of the product. It is important that the sometimes complex criteria can be translated into simple but relevant messages for the consumer, in order to help them make decisions on environmentally conscientious purchases.

The diverse criteria that have been specified for the four main groups of hard covering products have some common themes.

- Material efficiency: this is addressed by mandatory requirements on the reuse of process waste and has been tailored in other criteria specific to the sector in question (e.g. incorporation of recycled content in agglomerated stone and precast concrete).
- Energy efficiency: this is addressed in one of two ways, setting benchmarks where data was available to justify them or requiring an energy consumption reduction plan in cases where benchmarks could not be set.
- Air quality: this is addressed in many different ways, focusing on dust only in processes for natural and agglomerated stone and extending to acidifying gases (NOx and SOx for cement and ceramic production, where major combustion occurs).
- Global warming: Limits are set for CO2 emissions associated with combustion (and any decarbonation of raw materials) for cement and ceramic production processes, where major combustion takes place. For all products, the use of renewable energy is rewarded and for natural stone and precast concrete products, a carbon footprint is also rewarded).

A requirement about the logo and the number certification shall be included as per the "*Guidelines for the use of the EU Ecolabel logo*" on the Commission website.

According to Article 8 (3b) of the EU Ecolabel Regulation 66/2010, for each product group, three key environmental characteristics of the ecolabelled product may be displayed in the optional label with text box. The guidelines for the use of the optional label with text box can also be found in the above "Guidelines".

The information to be displayed is different according to the different hard covering products and provides an accurate reflection of the key issues addressed in the technical criteria.

Criterion 1.7. Environmental Management System (optional)

Criterion 1.7. Environmental Management System (optional)
This criterion applies to the production site of the applicant where the licensed EU Ecolabel product is produced. 3 points shall be awarded for applicants that have a documented environmental management system in place according to ISO 14001 and certified by an accredited organization; or 5 points shall be awarded for applicants that have a documented environmental management system in place according to the EU Eco-Management and Audit Scheme (EMAS)[17] and registered by an accredited organization. ***Assessment and verification**: The applicant shall provide a copy of the valid ISO 14001 certificate or evidence of their EMAS registration, as appropriate, and provide the details of the organization which carried out the accreditation.* *In cases where an applicant has both ISO 14001 and EMAS certification, only the points for the EMAS certification shall be awarded.*

Rationale:

An Environmental Management System (EMS) is considered as a fundamental requirement to ensure that an organization has established environmental goals and is taking measures to assess and reduce the environmental impact of its activities. Such a philosophy fits perfectly well with any company that may be interested in applying for the EU Ecolabel and can provide a framework for how to gather necessary data that would be relevant to certain EU Ecolabel criteria.

EU Ecolabel points are kept for those applicants that can demonstrate to have a documented environmental management system that has been assessed by a suitably accredited third party (3 points for ISO 14001 and 5 points for EMAS).

Although very similar, the reason for providing more points to EMAS is because it has a stricter interpretation of how environmental processes are to be planned and managed. For instance, ISO 14001:2015 requires the identification of environmental aspects and impacts, while EMAS requires the carrying out of a comprehensive initial environmental review of the processes. Likewise, ISO 14001 requires the definition of an external legal reporting system based on the needs of external parties (such as legal agencies), while EMAS requires external reporting through a regularly published environmental statement (EC, 2016b).

The requirement for EMSs was made optional due to concerns about possible issues with Article 43 of the Public Procurement Directive, which says that any label recognized has to be related to the subject matter of the contract (i.e. the hard covering product). Concern was expressed that an EMS could be considered as being linked mainly to the organization producing the hard covering product and not the product itself.

Article 43

Labels

1. Where contracting authorities intend to purchase works, supplies or services with specific environmental, social or other characteristics they may, in the technical specifications, the award criteria or the contract performance conditions, require a specific label as means of proof that the works, services or supplies correspond to the required characteristics, provided that all of the following

[17] Regulation (EC) No 1221/2009 of the European Parliament and of the Council of 25 November 2009 on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS), repealing Regulation (EC) No 761/2001 and Commission Decisions 2001/681/EC and 2006/193/EC (OJ L 342, 22.12.2009, p. 1).

conditions are fulfilled:

*(a) the **label requirements only concern criteria which are linked to the subject-matter of the contract** and are appropriate to define characteristics of the works, supplies or services that are the subject-matter of the contract;*

(b) the label requirements are based on objectively verifiable and non-discriminatory criteria;

(c) the labels are established in an open and transparent procedure in which all relevant stakeholders, including government bodies, consumers, social partners, manufacturers, distributors and non-governmental organisations, may participate;

(d) the labels are accessible to all interested parties;

(e) the label requirements are set by a third party over which the economic operator applying for the label cannot exercise a decisive influence.

Where contracting authorities do not require the works, supplies or services to meet all of the label requirements, they shall indicate which label requirements are referred to.

Contracting authorities requiring a specific label shall accept all labels that confirm that the works, supplies or services meet equivalent label requirements.

Where an economic operator had demonstrably no possibility of obtaining the specific label indicated by the contracting authority or an equivalent label within the relevant time limits for reasons that are not attributable to that economic operator, the contracting authority shall accept other appropriate means of proof, which may include a technical dossier from the manufacturer, provided that the economic operator concerned proves that the works, supplies or services to be provided by it fulfil the requirements of the specific label or the specific requirements indicated by the contracting authority.

2. Where a label fulfils the conditions provided in points (b), (c), (d) and (e) of paragraph 1 but also sets out requirements not linked to the subject-matter of the contract, contracting authorities shall not require the label as such but may define the technical specification by reference to those of the detailed specifications of that label, or, where necessary, parts thereof, that are linked to the subject-matter of the contract and are appropriate to define characteristics of this subject-matter.

Another reason for making the requirement for EMS optional was that some SMEs may not always have a possibility to have an in-house system in place, let alone a third-party verified one.

Criteria for natural stone products

Scoring system

The EU Ecolabel may be awarded both to intermediate quarry products (large blocks or slabs of dimension stone) directly produced by quarry operators and to final natural stone products produced by transformation plants.

In cases where the applicant is not the quarry operator and the quarry operator is not covered by an EU Ecolabel license, the applicant shall declare the quarry from which the material used to produce the EU Ecolabel natural stone product has been sourced, supported by delivery invoices dating no more than 1 year prior to the application date.

In that case, the applicant shall provide all relevant declarations from the quarry operator that are demonstrating compliance with all the quarry-related EU Ecolabel requirements and any other relevant optional requirements that may result in points being granted.

The scoring system and the minimum number of points necessary for EU Ecolabel natural stone products are presented in the table below.

Table 5. EU Ecolabel scoring system for intermediate and final natural stone products

Criteria where points can be awarded	Intermediate blocks or slabs of dimension stone	Final transformed natural stone hard covering products
1.7. Environmental Management System of the quarry (optional)	0,3 or 5 points	n/a
1.7. Environmental Management System of the transformation plant (optional)	n/a	0,3 or 5 points
2.1. Energy consumption at the quarry	Up to 20 points	Up to 20 points
2.2. Material efficiency at the quarry	Up to 25 points	Up to 25 points
2.6. Quarry landscape impact ratios (optional)	Up to 10 points	Up to 10 points
2.7. Energy consumption at the transformation plant	n/a	Up to 20 points
2.8. Water and waste water management at the transformation plant	n/a	Up to 5 points
2.10. Reuse of process waste from the transformation plant	n/a	Up to 10 points
2.11. Regionally integrated production at the transformation plant (optional)	n/a	Up to 5 points
Total maximum points	**60**	**100**
Minimum points required for EU Ecolabel	**30**	**50**

Natural stone quarry requirements

Criterion 2.1. Energy consumption at the quarry

Criterion 2.1. Energy consumption at the quarry
The quarry operator shall have established a program to systematically monitor, record and reduce specific energy consumption and specific CO2 emissions to optimal levels. The applicant shall report energy consumption as a function of energy source (e.g. electricity and diesel) and purpose (e.g. use of onsite buildings, lighting, cutting equipment operation, pumps and vehicle operation). The applicant shall report on energy consumption for the site both on an absolute basis (in units of kWh or MJ) and on a specific production basis (in units of kWh or MJ per m^3 of quarried material and per m^3 or t of material sold/produced and ready for sale) for a given calendar year. A plan to reduce specific energy consumption and CO2 emissions shall describe measures already taken or planned to be taken (e.g. more efficient use of existing equipment, investment in more efficient equipment, improved transportation and logistics etc.). In addition, a total of 20 points may be granted as follows: – Up to 10 points shall be awarded in proportion to how much of the energy consumed (fuel plus electricity) is from renewable sources (from 0 points for 0% renewable energy up to 10 points for 100% renewable energy). – Up to 5 points shall be awarded depending on the manner in which any renewable electricity is purchased as follows: via private energy service agreements for on-site or near-site renewables (5 points); corporate power purchase agreements for on-site or near-site renewables (5 points); long term corporate power purchase agreements for grid-connected or remote grid renewables[18] (4 points); green electricity certifications[19] (3 points); purchase of renewable energy guarantees of origin certificates for the full electricity supply or green tariff from utility supplier[20] (2 points). – 3 points shall be awarded where a carbon footprint analysis has been carried out for the product in accordance with ISO 14067 or 5 points if the Product Environmental Footprint method's elements related to greenhouse gas emissions[21] has been used. ***Assessment and verification:*** *The applicant shall provide an energy inventory for the quarry for a period of at least 12 months prior to the date of award of the EU Ecolabel license and shall commit to maintaining such an inventory during the validity period of the EU Ecolabel license. The energy inventory shall distinguish the different types of fuel consumed, highlighting any renewable fuels or renewable content of mixed fuels. As a minimum, the specific-energy consumption and specific CO2 emission reduction plan must define the baseline situation with energy consumption at the quarry when the plan was established, identify and clearly quantify the different sources of energy consumption at the quarry, identify and justify actions to reduce energy consumption and to report results on a yearly basis.* *The applicant shall provide details of the electricity purchasing agreement in place and highlight the share of renewables that applies to the electricity being purchased. If necessary, a declaration from the electricity provider shall clarify (i) the share of renewables in the electricity supplied, (ii) the nature of the purchasing agreement in place (i.e. private energy service agreement, corporate power purchase agreement, independent green energy certified or green tariff) and (iii) whether the purchased*

[18] According to article 15(8) of Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (OJ L 328, 21.12.2018, p. 82).

[19] Based on guarantees of origin with independent third party verification of additional requirements according to article 19 of Directive (EU) 2018/2001.

[20] Renewable energy sources disclosed according to article 19(8) of Directive (EU) 2018/2001 and point 5 of Annex I to Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (OJ L 158, 14.6.2019 p. 125).

[21] https://eplca.jrc.ec.europa.eu/permalink/PEF_method.pdf

electricity is from on-site or near-site renewables.

In cases where guarantee of origin certificates are purchased by the applicant to increase the renewables share, the applicant shall provide appropriate documentation to ensure that the guarantee of origin certificates have been purchased in accordance with the principles and rules of operation of the European Energy Certificate System.

In cases where points are claimed for a carbon footprint analysis, the applicant shall provide a copy of the analysis, which shall be in accordance with ISO 14067 or the Product Environmental Footprint method and have been verified by an accredited third party. The footprint analysis must cover all manufacturing processes directly related to stone production at the quarry, onsite and offsite transportation during production, emissions relating to administrative processes (e.g. operation of onsite buildings) and transport of the sold product to the quarry gate or local transportation hub (e.g. train station or port).

Rationale:

This EU Ecolabel criterion is largely inspired by similar approaches defined by the Natural Stone Council (NSC) in the US. The NSC criteria consider the following elements that relate to energy consumption:

- Systematic monitoring and recording of energy consumption (mandatory)
- Specific energy consumption reduction plan (optional)
- Renewable electricity (optional)
- Carbon footprint analysis (optional)

The mandatory element already overlaps quite well with any organisation that would be EMAS certified, although it is unlikely that many natural stone quarries would be EMAS registered or ISO 14001 certified. In any case, the gathering of such data is vital for optimising energy consumption and would also be required anyway for any product-focussed carbon footprint or environmental product declaration.

The specific energy consumption reduction plan is optional in the NSC approach but is made mandatory in the EU Ecolabel just in case an applicant could potentially gain points for having ISO 14001 or EMAS certification and also claim points for having an energy reduction plan in place (this could be double counting of EU Ecolabel points).

<u>*What do other schemes say?*</u>

The Fair Stone international standard for the natural stone industry (4th edition, 2010) sets the following requirements that relate to energy consumption in stone processing factories:

> *"26.1. A study on how to save water and other consumables, and how to recycle waste water must be undertaken and documented.*
>
> *26.2. The company must take appropriate measures to ensure economical use of electrical energy and water. All staff must know how to save energy and water.*
>
> *26.4. Use only energy-efficient equipment and lighting systems.*
>
> *26.5. Machinery and equipment must be maintained regularly to stay energy efficient."*

The Natural Stone Council (NSC) standard 373 – sustainability assessment for natural dimension stone has more concrete requirements relating to energy in natural stone manufacturing facilities ((M) denotes mandatory and (O) denotes optional).

> *"**10.1. Energy Inventory (M):** The facility operator shall complete an inventory of energy use including the quantity and type of energy consumed (e.g., diesel, local power grid) organized by location or function (e.g., power use by building, equipment). Inventory shall include both electricity and fuel usage and identify factors important to consumption (e.g., number of tons shipped, hours of operation, etc.). Energy*

consumption shall be reported in energy consumed per unit processed (e.g., KWh per ton of dimension stone produced), and a total energy consumption for the facility operations (i.e., combined energy from all sources) shall be calculated.26.2. The company must take appropriate measures to ensure economical use of electrical energy and water. All staff must know how to save energy and water.

10.2.1. Energy Management (M): *The facility operator shall establish and implement a program to systematically improve energy consumption and associated greenhouse gas emissions. The quarry or processing facility shall measure and track energy consumption by energy source and purpose of consumption, identify opportunities and methods for reducing energy use, establish target goals, quantify changes, and monitor progress. This program shall cover but not be limited to the following topics: 1) Equipment operation and maintenance (e.g., minimizing idle times, improved maintenance, replacement of inefficient equipment); 2) Transportation and logistics (e.g., maximizing shipping loads, utilizing advanced logistics); and 3) Office and administration energy and lighting. This program shall track progress towards established goals on a rolling 5-year period based on percentage reduction, and shall be reported publicly (e.g., corporate sustainability report, website posting). Alternatively, this criterion shall be met if the facility operator has earned Energy Star Challenge recognition, or international equivalent.*

10.2.2. Total energy reduction (O) (max. 3 points): *The facility operator shall demonstrate, over a 6-year timeframe, the successful reduction of total energy use (i.e., combined energy from all sources). Points shall be earned for the following reductions:*

a) Achieved reduction of 10 - 20% of energy inventory (1 point);

b) Achieved reduction of 21 - 40% of energy inventory (2 points total); or

c) Achieved reduction of greater than 40% of energy inventory (3 points total).

All reductions shall be measured relative to total energy (e.g., KWh/ton of stone), as determined in section 10.1, and shall be measured and documented to receive credit. Achieved reductions shall be calculated by comparing the total energy consumption for the most recent completed year to that of the baseline year, and calculating the percent of total energy reduction achieved. The baseline year shall be the year 6 years prior, providing that a complete inventory meeting the requirements of section 10.1 exists for that year. Otherwise, the baseline shall be the most recent year for which a complete energy inventory meeting section 10.1 exists. Under no circumstances shall energy data from more than 6 years prior be used as a baseline in this criterion.

10.3. Carbon Management (O) (2 points): *The facility operator shall perform a carbon footprint analysis of its operations. Boundaries of the analysis shall include the manufacturing and transportation stages of the product life-cycle, as well as all stages upstream including materials extraction and processing and energy generation. Analysis shall include carbon emissions associated with all of the following:*

– Manufacturing processes directly related to stone production;

– On-site and off-site transportation during production; and

– Off-site support and administrative processes.

To qualify, carbon footprint shall have been performed in the last 3 years and shall be documented in a report meeting the specifications of ISO 14064. Carbon footprint shall be performed using any commercially available software package or by a credible, qualified third party. (2 points)

10.4. Renewable and alternative energy sourcing (O) (2 points): *The facility operator shall demonstrate the use of renewable energy in its operations. Renewable energy sources include energy derived from water, wind, and solar sources, as well as the use of renewable fuels such as biodiesel and those derived from sources such as switch grass.*

a) 1-10% of total energy use derived from renewable sources (1 point); or

b) 11-100% of total energy use derived from renewable sources (2 points total).

All contributions of renewable energy are measured relative to total energy use for entire operation, as determined in section 10.1, and shall be measured and documented to receive credit.

The 2018 draft version of hard surfacing criteria set by Good Environmental Choice Australia (GECA) state the following;

"***6.1. Direct energy consumption: Criterion 23.*** *Energy consumption during the production of*

certified products shall not exceed the limits specified in Table 7 when calculated using the method and figures given in Appendix B. Applicants shall undertake an energy audit including all energy flows in the production process for the purpose of informing future energy efficiency improvements and refining this criterion in future versions of the standard.

[Note that The only value in Table 7 relating to natural stone is: ...Flamed natural products: 65 MJ/m²"].

*"**6.2. Energy Management: Criterion 24**: In order to reduce energy consumption during installation, dimensional stone producers shall be able to provide stone to the exact thickness required for each order (± 2 mm).*

Overall, the Fair Stone, NSC and GECA approaches to criteria on energy consumption are completely different, but each scheme does at least have an approach in place. There were no criteria relating to energy consumption during natural stone production in the 2009 EU Ecolabel criteria.

A logical starting point would appear to be the mandatory NSC requirement on an energy inventory and so this has been inserted as a mandatory requirement for the EU Ecolabel. The simplest point, in terms of assessment and verification, would be to reward those processors with a higher % of renewable electricity and/or onsite renewables. Every producer has the option to increase their share of renewable electricity either via onsite generation (directly with wind turbines or solar panels or indirectly by purchased green electricity from suppliers).

Why no benchmarks?

Neither the NSC nor the EU Ecolabel criteria set specific benchmarks for energy consumption because this is notoriously difficult to do so for natural stone quarries. Actual energy consumption varies by the nature of the rock, the cutting technique and equipment used and the site topography. In turn, the choice of cutting equipment is partly dictated by site topography, rock type and rock quality, and thus the resulting specific energy consumption.

According to Bianco (2018), the following techniques can be applied to the quarrying of hard (H) and soft (S) rocks.

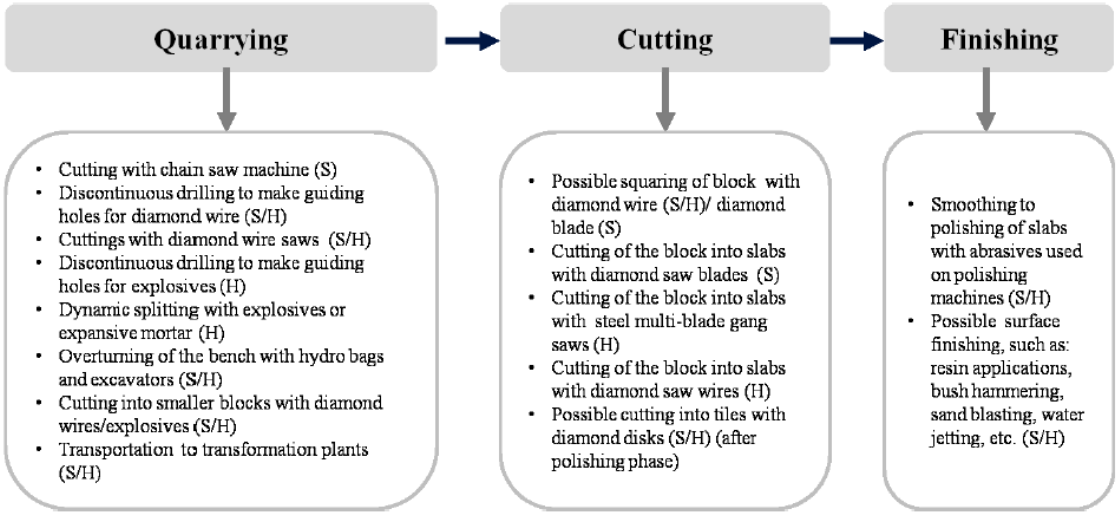

Figure 6. Different extraction technologies applied in natural stone quarries (see left hand side). Source: Bianco (2018).

Many cutting techniques can be applied to either hard or soft rocks although chain saw cutting can only be used on soft rocks (e.g. marble) and the use of explosives and dynamic splitting (with explosives or expansive mortars) is only used with hard rocks (e.g. granite).

Further description of the main cutting techniques (from a material efficiency perspective) can be found in the rational for criterion 2.2.

Carbon footprint

Stakeholders were in favour of a carbon footprint being required by the EU Ecolabel although this could result in significantly higher compliance costs for applicants. For this reason, a carbon footprint analysis is included as an optional requirement only. No benchmark for the carbon footprint is set for the same reasons as why none was set for specific energy consumption.

Renewable energy

Points are awarded for the use of renewable fuels and electricity. Although it is more difficult to use renewable fuels (e.g. biomass and bio-diesel) in natural stone quarrying activities, it is hoped that such a combination of fuel and electricity under the renewable energy requirement would inherently make it easier for those producers that have a greater extent of electrification among their cutting equipment and onsite vehicles to meet higher shares of renewables.

Distinction in ways to contract renewable electricity

Another new element introduced (and also for similar criteria for other sub-products within the hard coverings group) is a hierarchy of recognition relating to how renewable electricity is obtained. The general idea is that:

Onsite or near-site renewable electricity is better for the environment due to the lack of transmission losses from generating source to the point of demand. This could be especially relevant in remote quarries.

Contracting electricity supplies that are linked to investments in new renewable capacity have a greater benefit that simply tapping into renewables that are already online.

For information, a brief description of the main different means of contracting electricity supply is provided below (from lower to higher benefit to the environment):

1. **Green tariffs from utility supplier (grid renewables)** are the simplest option where the electricity is purchased from the utility at retail rates. The utility then guarantees the electricity is sourced from renewable generation and in general the utility cancels (i.e. retires) the Guarantee of Origin (see next point) on the consumers behalf. In this case the renewable energy is then assigned to the utility which in some Member States have a legal obligation to supply a certain proportion of renewable energy.
2. **Purchase of renewable energy certificates/Guarantees of Origin (GO/energy certificates)**. GOs are the EU mechanism for proving the origin of energy generation. These are tradable and every MS is required to issue and manage GOs. A company can purchase and cancel (retire) the GO to demonstrate use of renewables.
3. **Independent green energy certifications** (grid renewables) verify the environmental claims of the energy supplier and may require additional criteria. These include minimising the other environmental impacts of the generation site, requiring sourcing from new renewable sites and funding new renewable generation. The most widely available is the Eko certificate.
4. **Corporate power purchase agreements (PPA)** for new generation including on-site renewables. PPAs are contractual agreements whereby the customer agrees to buy the energy generated from a site for a long period of time, typically 15-20 years. For new generation, these contracts are signed before the generation is installed as follows:
    a. Onsite/near site via direct-wire. The generation is connected directly on the meter side of the data centre and the electricity is self consumed. However, a grid interconnection is still required since generation often does not match demand perfectly and the excess must be exported some of the time.
    b. Grid connected. The generation is on the same portion of the grid as the data centre but contributes to the overall grid electricity mix. As national electricity grids are interlinked, the renewable is no longer necessarily used in the same country.
    c. Remote grid. The generation and the consumption are not on the same portion of the grid. Therefore, the renewable electricity must be sold back via the grid without the

GO and is classed as residual mix and electricity purchased from the local grid. The company retains the GO and can cancel (retire) them.

5. **Private energy services agreement.** These are generally used for smaller renewable contracts compared to PPAs such as on-site installations. The client does not pay any capital costs and instead long term contracts for payments are based on the performance of the energy services and the savings realised on the utility bill.

Although considered separately in the list above, it is worth emphasizing that the same points are to be awarded for green tariffs and for the direct purchase of GO certificates. Even though the actual purchase of GO certificates is a more concrete action, the main reason for no distinction here is that purchasing the GO certificates is not really any option for SMEs and so they should not be penalized in this respect since both options are ultimately based on the GO certificate system.

Criterion 2.2. Material efficiency at the quarry

Criterion 2.2. Material efficiency at the quarry
The quarry operator shall provide the following data relating to the extraction and commercial activities at the quarry for the most recent calendar year or rolling 12 month period prior to the date of award of the EU Ecolabel license: - **A:** Total quantity of material extracted (m^3). - **B:** Saleable blocks produced from A (m^3). - **C:** Total quantity of extractive waste and materials produced from A that qualify as by-products (i.e. block fragments, stones and fines) that are sold (m^3). - **D:** Total quantity of extractive waste and materials produced from A that qualify as by-products (i.e. block fragments, stones and fines) that is used internally for useful purposes by replacing other materials which otherwise would have been used to fulfil that particular function or stored in the by-products deposition area (m^3). - **E:** Total quantity of extractive waste produced from A that are transferred to the extractive waste deposition area or landfill plus the total quantity of materials produced from A that qualify as by-products that are stored in the by-products deposition area (m^3). In cases where data is available in tonnes, it should be converted to m^3 using a fixed bulk density factor for the rock material being extracted. The extraction efficiency ratio shall be at least 0,50, and shall be calculated as follows: $$\text{Extraction efficency ratio} = \frac{\mathbf{B}+\mathbf{C}}{\mathbf{A}}$$ In addition, up to 25 points shall be awarded in proportion to how much the applicant demonstrates a higher extraction efficiency ratio up to the environmental excellence threshold of 1,00 (from 0 points for an extraction efficiency ratio of 0,50, up to 25 points for an extraction efficiency ratio of 1,00). ***Assessment and verification:*** *A declaration from the quarry operator shall be provided that states the values of A, B, C, D and E, expressed in m^3 and the calculation of the extraction efficiency ratio.* *For calculation purposes, it should be assumed that A-B = C+D+E. For any material calculated under C that was sold, invoices of the material delivery to the other sites shall be provided.*

Rationale:

The extraction efficiency is arguably the most important indicator relating to a quarry for ornamental stone or dimension stone. All quarrying impacts can be normalised to the functional output of tonnes or m^3 output of saleable material.

According to the European Environment Agency (EEA, 2016), around 4-5% of average domestic material consumption in the EU28 is due to the direct or indirect consumption of marble, granite and sandstone.

From an economical perspective, the value of saleable blocks is the dominant source of revenue. Marble from the Carrara region, which can be considered to be at the top end of the market, can be worth over 1600 €/m^3 while irregular blocks are not generally economical to transport (7 €/m^3) and extractive waste has no significant market value at all. With gneiss rock, regular blocks may command prices of around 265 €/m^3, and similar values for irregular blocks and extractive waste as for marble (Bianco, 2018).

It is clear that the quarry operator has a vested economical interest to maximize the extraction efficiency of dimension stone but not so much incentive to push the sale of by-products, due to their significantly lower intrinsic value.

Influence of technique on material efficiency of block extraction efficiency (B)

Although extraction efficiency will also be affected by the characteristics of each site (e.g. level of overburden, fissures etc.), it is worth mentioning here the different techniques that can be applied to the extraction of dimension stone at the quarry and their potential effect on extraction efficiency.

Table 6. Comparison of waste production by different extraction methods (Esmailzadeh et al., 2018).

Method	Relative waste generation	Brief description of technique
Plug and feather	High	Holes are bored at regular intervals along the area to be cut. Deeper holes that are closer together improve the ease of extraction. Two metal plugs are placed in the holes and struck via a metal "feather" (a long pole that pushes in-between the plugs) using a sledgehammer or hydraulic hammer, causing expansion and crack propagation from the borehole.
Blasting	High	Holes are bored in the vertical and horizontal axis and explosive charges are placed inside. Care needs to be taken to use the minimum amount of explosive necessary and for forces to act in the desired direction in order to minimise damage to the neighbouring rock.
Expanding materials	Low-medium	Holes are bored along the area to be cut and filled with a material that will hydrate upon reaction with water to create an expansive force (much better control offered than blasting).
Diamond cutting wire	Seldom	A diamond wire is looped through horizontal and vertical holes that coincide. The cutting action is controlled by a drive that pulls the wire in the vertical and horizontal axis. The wire needs to be cooled by water.

Significant differences exist for soft rock extraction (such as marble) depending on the extraction technique used. Dambov et al., (2013) reporting that marble extraction efficiency in Macedonia varied according to the technique used as follows:

- 0 to 2.5% for extraction by drilling, blasting and cutting
- 2.5 to 10% for extraction by cutting with a diamond wire saw and cutting machine
- 10 to 40% for extraction with a cutting machine
- >40% for cutting machines "in situ".

When rock is suitably soft, it is clear that the diamond wire cutting technique is most efficient (see illustration below).

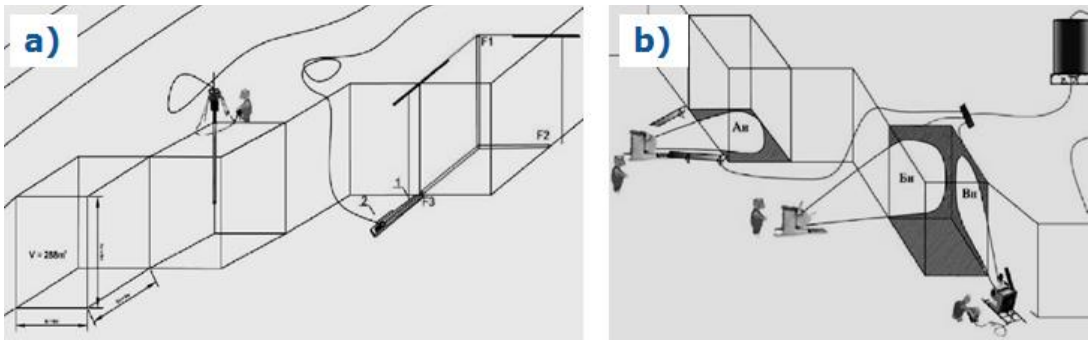

Figure 7. Illustration of diamond wire cutting a) drilling horizontal and vertical holes for wire loop placement, b) diamond wire loops cutting in action (Dambov et al., 2013).

Ambition level (B+C)

For a quarry producing ornamental or dimension stone blocks, a typical extraction efficiency would be 0,20 to 0,40. However, the efficiency could be very low for slate (e.g. 0,03). This is due to the fact that the main market for slate is roof tiles, and small pyritic impurities in the slate can lead to rejection of the entire slate tile. The rejection is because these impurities, over time, would lead to unsightly orange streaks of oxidised iron running along the slope of the slate. The impurities are not an issue with slate aggregate, which is a highly valued landscaping material and thus a valuable by-product of slate roof tile production.

The EU Ecolabel ambition level of 0,50 effectively requires all quarry operators to find markets for their by-products, which could be monoliths for artistic applications, irregular blocks for vehicle barriers on roadsides (off-site), crushed aggregate being used as geotechnical fill or road base, graded aggregates for making concrete or fine powder for agglomerated stone products. Marble powder could also be used in higher grade applications if of a sufficient purity (e.g. paper industry, pharmaceuticals and food and beverage sectors).

Such an approach (i.e. B+C) is considered as important to avoid the discrimination of quarries that produce both ornamental/dimension stone blocks and crushed material.

Sale of by-products (C)

The reuse of extractive waste generated in dimension stone quarries has historically been poor and continues to leave much room for improvement today. Dino et al., (2017) estimate that 3,0 million m^3 of waste are generated each year in the Carrara basin but only 0,5 million m^3 is actually sold and/or converted in secondary raw materials, despite the fact that the waste is high purity $CaCO_3$ with potential reuse in the asphalt, paper, paint, plastic and rubber sectors.

Marras et al., (2010) showed that marble fines from filter press sludge after quarry and transformation plant wastewater treatment was fine for use up to 10% of total raw material mass in the firing of clay bricks. Medina et al., (2017) showed that granite sludge could be used as a supplementary cementitious material, substituting 10 or 20% of the cement clinker content while still meeting the relevant technical requirements for Type II/A and Type IV/A cements despite potential concern about the relatively high alkali (Na and K) content in the sludge and the inconclusive results about whether the sludge exhibited pozzolanic activity or not.

In a comprehensive review of the potential reuse of dimension stone waste in concrete, Rana et al., (2016) concluded that the reuse potential was highest for the substitution of coarse aggregates (100%), then fine aggregates (5 to 100% depending on the type of waste) and then cement replacement (up to 20% for quarry dust).

Reuse for useful purposes onsite (D)

It was considered necessary to define better and distinguish the different potential fates of by-products in natural stone quarries. By-products should go first to the by-products deposition area, and then they are either sold, used for useful purposes onsite (like base material for ramps, landscaping etc.) or remain in the by-products deposition area. Since the sale of by-products is a better outcome from an environmental and economic perspective than its use onsite for useful purposes, these flows have been split into "C" and "D" respectively. Extractive waste is considered as "E".

Some examples of useful purposes may include the construction of access ramps or road bases for the access of vehicles and heavy machinery to certain parts of the quarry, the construction of berms for the onsite storage of fine extraction waste to reduce the possibility of fine material being blown off-site or the construction of safety barriers for road edges onsite. However, it would not be considered acceptable for a quarry operator to pile the by-product or extractive waste in a heap and claim that this heap is somehow providing a useful purpose.

Link to quarry footprint ratio in criterion 2.6

A better extraction efficiency implies less extractive waste (E) and fewer by-products going to the by-products deposition area – either by producing less by-products in the first place, by selling them (C) or

by using them onsite (D). Consequently, the space occupied by the BPDA will be less and more points could potentially be scored in criterion 2.6 for the quarry footprint ratio.

Criterion 2.3. Water and wastewater management at the quarry

Criterion 2.3. Water and wastewater management at the quarry
The applicant shall provide a description of water use in quarrying operations including strategies and methods for collection, recirculation and reuse of water. In general: - The site shall make provisions for the opportune collection of storm water run-off to compensate for water lost in wet sludge and evaporation. - The site shall make provisions for the diversion of storm water run-off via a drainage network to prevent the surface flow of rainwater across the working area from carrying suspended solid loads into any impermeable ponds (that supply water to the cutting equipment) or into natural watercourses. In cases where wet cutting techniques are used: - Water for use by wet cutting equipment shall be stored in an impermeable container (for example a tank, lined pond or an excavated pond set in impermeable rock). - The separation of solids from cutting wastewater shall be achieved by sedimentation systems, retention basins, cyclone separators, inclined plate clarifiers, filter presses or any combination thereof. Clarified water shall be returned to the impermeable pond or container which supplies the cutting equipment. - Settled sludge shall be dewatered prior to: internal use for useful purposes, external use for useful purposes or transport offsite to a suitable waste disposal facility. ***Assessment and verification:*** *The quarry operator shall provide a declaration of compliance with this criterion, supported by relevant documentation describing how water is used onsite and providing details of the water management system, sludge separation and sludge disposal operations and destinations.*

Rationale:

Water is used to dissipate the heat produced by the stone cutting process and to remove debris from the cut surfaces. It is still the most economical method so long as water supply is not an issue (i.e. not in arid climates and in high-altitude quarry sites).

Why no longer any requirement for water recycling ratio proposed?

During discussions with experts, it was revealed that the reuse of water for stone cutting in the extraction phase was the norm and that, as a general rule, all of the settled water was reused, which would mean a recycling ratio of 100%. The only losses from the system were due to possible seepage into the ground via cracks in basins or ponds, via evaporation and via wet sludge (see Figure below).

One example of the water cycle during wet cutting of marble in the Carrara region is shown below.

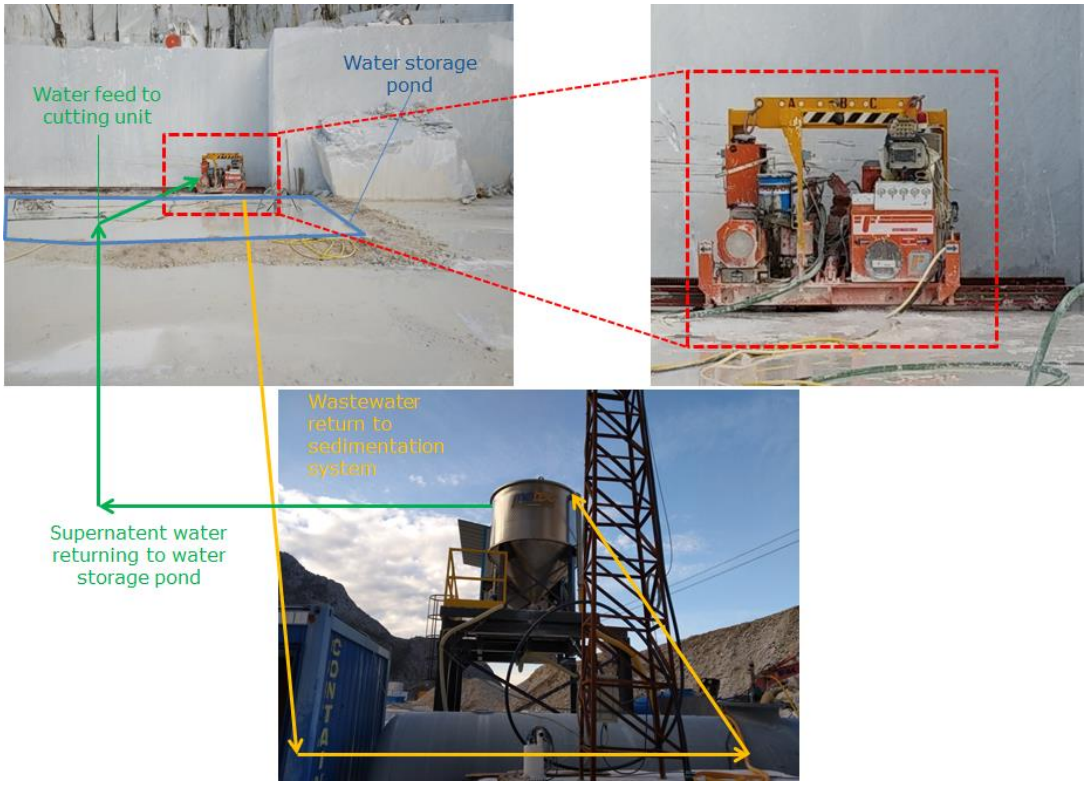

Figure 8. Example of water recirculation system at a marble quarry.

By requiring that all supernatant water after solids separation is returned to the container which supplies water to the cutting equipment, a recycling ratio of 100% is essentially being requested.

Why the general requirements?

The general requirements apply to all quarries, whether they use dry cutting or wet cutting techniques. In both cases, water is needed (e.g. for dust suppression in dry techniques, for actual cutting in wet techniques).

It is important to specify that the water container is impermeable. The main justification is that no matter how well wastewater is recycled or recirculated, the specific consumption rate of water can increase significantly due to losses via infiltration from the container or basin to the surrounding ground area.

Secondly, it is important to make the optimum use of water run-off so that it can top up the container to compensate for evaporative losses and water lost as moisture content in removed sludge. However, uncontrolled inflow of water run-off must be avoided as well because this could result in significant suspended solid loads being carried into the water that supplies the cutting equipment or into natural watercourses.

About wastewater treatment

Another important aspect is to require some minimum treatment of the wastewater from cutting equipment before it is returned – otherwise the solids load and other pollutants will just gradually build up if water is to be recirculated.

Methods for the recirculation and reuse not only lessen the environmental impacts of production but also lead to cost savings. According to the Natural Stone Council (NSC, 2011) solids separation (i.e. primary water treatment) and reuse of clarified water at the quarry or processing facility can be accomplished by a number of ways: filter presses, cyclone separators, sedimentation systems, retention basins, and combinations of these systems.

The selection of the most appropriate option depends on several factors such as, site topography, local climate, water demand, available footprint as well as water and solid loading rates to be processed. Quarries may use above ground or excavated settlement ponds to receive wastewater. If space is limited or other obstacles exist, filter presses, inclined plate clarifiers, or cyclone separators (hydrocyclones) may be the best option for filtration followed by storage in a tank or basin. These machines utilize a much smaller footprint than a series of ponds or basins and avoid the need for excavation as they are installed on the ground surface.

The use/non-use of flocculants

The suspended solids in wastewater from stone cutting operations generally have the same surface charge, which reduces the possibility of them colliding and sticking together. Since sedimentation rates are a function of particle size, the use of flocculants can greatly accelerate sedimentation processes by providing opposite surface charges which attract suspended solids into larger agglomerations.

There are two main types of flocculants: inorganic and organic. The inorganic type is typically alum ($Al_2(SO_4)_3$) or ferric ($FeCl_3$) and they react in water in normal pH ranges to precipitate as $Al(OH)_3$ and $Fe(OH)_3$ respectively. The new solids and their surface charges can, when dosed optimally, optimise the solids settling rate. The organic flocculants are typically based on polyamide polyelectrolytes that are available with cationic and/or anionic surface groups.

During site visits it was not possible to establish what flocculants were being used but operators were complaining about the stickiness imparted to the sludge in cases where the sludge was being used as a filler/binder of loose aggregates for site roads. While this property was potentially useful for reducing dust emission from vehicle movements when dry, it proved to be problematic when a sticky, cohesive mass is formed when wet, affecting vehicle traction.

What do other schemes say?

The Fair Stone international standard for the natural stone industry (4th edition, 2010) sets the following requirements for water:

> *"25.4. The company protects ground water and surface water and avoids any contamination during quarry operation or after-use.*
>
> *27.1. A study on how to save water and other consumables, and how to recycle waste water must be undertaken and documented.*
>
> *27.2. The company must take appropriate measures to ensure economical use of electrical energy and water. All staff must know how to save energy and water.*
>
> *27.3. The company uses quarrying and production methods that minimize water consumption."*

The 2018 draft version of hard surfacing criteria set by Good Environmental Choice Australia (GECA) state the following;

> *"3.1.1. Water Resource Use. Criterion 4: The quarry or mine pit must not interfere with a confined aquifer. Water may be drawn from confined aquifers provided that the bore is sealed and the flow rate is measured. Bore use must not be continued if the flow rate decreases by greater than 20 % of the initial rate, averaged over a five year period (or in case records are not dated as far back, a shorter period may be sufficient to calculate the initial flowrate). If a flow rate measurement followed by a consecutive measurement shows a flow rate below 80% of the initial flow rate; bore use shall be discontinued. Test pumping to monitor flow rates may be carried out to establish whether the rate improves again in which case the bore may be reopened.*
>
> *Surface water must not be used if the water body is located within, or is directly connected to a:*
>
> - *National Park,*
> - *Drinking water catchment area,*
> - *Ramsar Wetland*
> - *Area identified by the EPBC Act as containing threatened species or ecological communities.*
>
> *For areas outside Australia, reference to national classification frameworks comparable to the EPBC Act*

must be provided.

Quarrying and mining operations must be able to demonstrate procedures or measures to minimise the impact of water use. This may include, but is not limited to, water recycling, rainwater collection and settling ponds.

Water released off-site directly from quarrying and mining operations must not exceed 5 L/m3 of extracted material. This limit does not include natural runoff from the site during rain events or water consumed in closed loop recycling systems. Suppliers are requested to obtain and provide data on water release from the main quarrying operation for the purpose of refining this criterion in future versions of the standard."

3.1.6. Water Emissions: criterion 9: Suspended solids in effluent water must shall be less than 30 mg/L, where the operation discharges to surface waters that interact with a:

- *National Park*
- *Drinking water catchment area*
- *Ramsar Wetland*
- *Area identified by the EPBC Act as containing threatened species or ecological communities. For such areas, suspended solids in effluent water shall not exceed 40 mg/L.*

The test method must be in line with ISO 5667-17 or equivalent."

The Natural Stone Council (NSC) standard 373 – sustainability assessment for natural dimension stone, has two mandatory requirements and four optional requirements relating to water and wastewater:

5.1. Water inventory (mandatory): *The facility operator shall develop and maintain an annual inventory of water use including the quantity of water used on an annual basis, organized by water source (e.g., municipal potable, direct rainwater captured for reuse, on-site wells, or reclaimed grey water. Water used as a result of both manufacturing and non-manufacturing operations shall be included.*

5.2.1. Recycled water (mandatory): *A minimum of 25% of the water accounted for in the inventory for fabrication or quarry operations shall be captured and recycled.*

5.2.2. Recycled water (optional): *minimum of a) 26% to 90% of the water accounted for in the inventory for processing or quarry operations are captured and recycled. (1 point); or b) More than 90% of the water accounted for in the inventory for processing or quarry operations is captured and recycled. (2 points total)*

5.3.1. Enhanced water treatment (optional): *Demonstrate on-site systems that result in enhanced treatment of discharge water. Enhanced treatment shall be demonstrated by one of the following: a) Management of wastewater on-site resulting in no direct discharge of water (e.g., seepage ponds) (1 point); or b) Quality of discharged water, either to POTW or directly to the environment, is demonstrated to meet State drinking water standards (1 point); or c) Where no permits or regulations are applicable, the facility operators demonstrate that the quality of water discharged to the environment from their facility meets the US EPA's NPDES (National Pollutant Discharge Elimination System) requirements. (1 point). Facility Operators that do not utilize water in their manufacturing operations shall qualify for 1 point under this criterion.*

5.3.2. Enhanced sludge treatment (optional): *The facility operator shall demonstrate operation of a sludge management system that diverts a minimum of 50% of annual sludge produced by operations from traditional disposal methods by landfill or incineration, in favor of environmentally acceptable reuse applications (e.g., agricultural use). To qualify for this criterion, the facility operator shall provide documentation of the diversion, including a description of the end disposal method. (1 point)*

The GECA criteria are very similar to the EU Ecolabel criteria set out in Decision 2009/607/EC. However, the meaningful measurement of suspended solid concentrations in runoff has been questioned since most quarries do not have any intentional runoff at all (the water recycling system is closed). It is also difficult to try and estimate a water release rate (GECA sets a limit of 5 L/m3). Depending on how exactly the number is calculated, it could also include water lost in wet sludge transported offsite, as water evaporated from drying sludge or evaporating from the surface pond. It is not clear either if inflows of storm water to the retention pond would be counted as "free water" or not.

The above reasons also apply as complicating factors when attempting to carry out any water inventory or water recycling rate with the NSC criteria.

The Fair Stone requirements are only vague criteria that would need to be further explained in some detail to be able to be assessed and verified by competent bodies.

Criterion 2.4. Dust control at the quarry

Criterion 2.4. Dust control at the quarry
The applicant shall demonstrate that operational site measures that have been implemented for dust control at the quarry site. Measures may vary from site to site but should include the following aspects for all sites: - Use of dust suppression water sprays or vacuum hoods linked to dust filter bags/electrostatic precipitators for any dry cutting, crushing or other activities that are likely to generate significant quantities of dust. - A plan in place for the relocation, modification or stoppage of operations onsite in order to prevent or minimise dust emissions to air during periods of adverse weather (not applicable to underground quarries). - Inclusion of wind protection features in the quarry design that aim to reduce wind speed and thus minimise dust emissions and soil erosion onsite (e.g. wind fences or windbreaks consisting of one or more rows of plants along the border of the extractive waste deposition area, including the extractive waste facility and/or extractive waste handling area). - Provision of an enclosed storage area for all dewatered sludge from wet cutting and/or all dust from dry cutting operations prior to sale, prior to shipment to landfill or reuse onsite. - Covering of the most heavily used road surfaces with concrete or asphalt paving. - Provision of appropriate training to employees about good practice for dust control and the provision adequate personal protective equipment to employees and visitors. - Provision of routine medical check-ups for employees with the possibility for more frequent monitoring for the identification of respiratory problems and possible onset of silicosis (the latter point being applicable only to granite and other siliceous rock quarries). ***Assessment and verification:*** *The quarry operator shall provide a declaration of compliance with this criterion, supported by relevant documentation and (i) a description of the dust control measures implemented at the quarry site and (ii) details of the medical check-up system for employees, as appropriate.*

Rationale:

Why no longer monitoring for PM (particulate matter) emissions?

Monitoring of dust emissions is much more practical in chimneys, where all dust emissions are channelled through a central point and where air flow rates are well controlled.

When any attempt to quantify diffuse emissions of dust in an outdoor environment is made, it is virtually impossible to obtain what could be considered as a representative sample. This is due to facts such as: airflow rates and directions are highly variable but the sampling point is fixed; the source of dust emissions onsite is highly variable in both time and specific location; impossibility to distinguish dust from neighbouring sites and dust from monitored site.

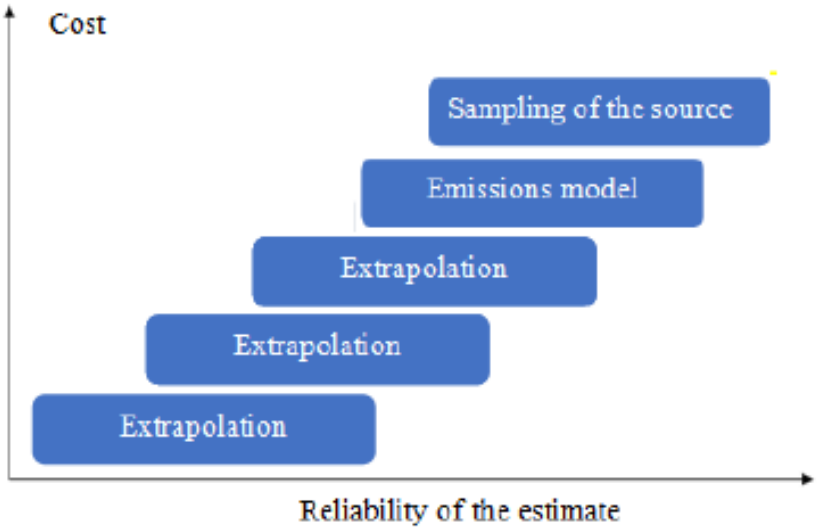

Figure 9. Cost and reliability relationship for estimating dust emissions (Source: INECC-SEMARNAT, 2005).

As indicated above, sampling is required in order to have the best estimate of actual dust emissions, but this entails a significant cost and the results are not guaranteed to be simply due to activities carried out at the quarry site.

The need for measures to minimise dust emissions

The minimisation of dust emissions is a key environmental issue and operational plans and equipment should be designed to reduce dust emissions both for worker health and safety and local residents.

Dust is managed on site through a variety of potential control measures. The exact combination of measures required at a site can vary widely, and depends on the production and shipping rates, size of the site, and distance to neighbouring residents. Therefore the criterion does not require a specific technique or measure to be implemented but the assessment and implementation of the most convenient techniques to minimise the air quality impacts.

Practical measures and best management practices must be implemented to prevent or mitigate impacts on the air quality within the local areas. Examples of potential control measures can include:

- Spraying, washing, vacuum sweeping and paving of haul roads, parking areas, entrances and exits.
- Reducing haul trips and limiting speeds on unpaved roads.
- Wetting material prior to processing or loading.
- Covering stock piles, conveyor belts, and loads in trucks.
- Locating stock piles in locations that limit their exposure to wind.
- Scheduling loading, unloading and blasting activities on days when there is less wind
- Proper loading of trucks.
- Lowering the drop distances at transfer points.
- Minimising the area of disturbance and progressively revegetating disturbed areas as soon as possible to reduce erosion and minimize dust.

Additionally, education, awareness and training of staff on dust prevention, control measures, monitoring and reporting are important in reducing dust emissions at a quarry operation.

What do other schemes say about dust/air pollution?

The Fair Stone international standard for the natural stone industry (4th edition, 2010) sets the following requirements for silica dust and mineral dust:

> *"9.1. The employer shall take all possible measures in order to eliminate exposure or reduce the concentration of silica dust in the workplace.*
>
> *9.2. Introduce technical measures such as wet processing or dust extraction and take organizational measures e.g. segregate areas with a higher level of concentration from those with a lower level, minimize periods/levels of exposure.*
>
> *9.3. Dry dust shall be extracted by vacuum dust collectors wherever possible.*
>
> *9.4. Regular cleaning of machinery, cabins and rooms in order to avoid dust accumulation is essential.*
>
> *9.5. To avoid the spread of dust, use water or a vacuum cleaner. Avoid using a broom.*
>
> *9.6. In case of wet drilling or sawing, water quantity has to be sufficient and water feed shall be initiated before processing.*
>
> *9.7. The workforce should be informed about the risks of silica dust and the suitable prevention measures in order to create awareness."*

The Natural Stone Council (NSC) standard 373 – sustainability assessment for natural dimension stone, only makes a very general reference that dust control measures should be included in the site management plan for quarries (under the required criterion 7.1 for site management plan).

The 2018 draft version of hard surfacing criteria set by Good Environmental Choice Australia (GECA) state the following;

> *"3.1.5. Dust emissions: Criterion 8. The PM10 dust emissions to air shall be less than 100 µg/Nm^3 where the main mine or quarry is located within 5 km of a: Populated Area; National Park; Drinking water catchment area; Ramsar Wetland or an Area identified by the EPBC Act as containing threatened species or ecological communities.*
>
> *[The measurement of dust in the GECA criterion is to be according to EN 12341 or equivalent method.]*

The Fair Stone, NSC and GECA approaches are completely different. The GECA approach most closely relates to the EU Ecolabel approach set out in Decision 2009/607/EC, while the Fair Stone requirement states specific measures and the NSC criteria are very general.

Sources of dust from quarry extraction activities

Although speaking about mineral extraction sites in general rather than dimension stone quarries, Petavratzi et al., (2005) made the following general classification of different potential sources of dust emission.

Table 7. Dust sources from mineral extraction sites

Operation / equipment	Emission mechanism	Relative potential contribution to total site dust levels	1st source	2nd source
Drilling & blasting	Air flush from drilling and from force of blast	Small	+	-
Loading and dumping	Dropping material from height	Moderate	-	+
Draglines	Dropping material from heights	Large	-	+
Crushing and preparation	Impact, abrasion and dropping from heights	Large	+	-
Conveyors	Dropping from heights	Small	0	-
Haulage roads	Raised by tyres, exhaust and cooling fans	Large	0	+
Storage piles	Wind blow, high wind speeds	Small	0	-

"+" indicates a major source, "-" indicates a minor source and "0" indicates a negligible source

The operations in the above table related to quarrying for coarse aggregate by the blasting method. Specifically for dimension stone quarrying, the cutting operation (especially dry methods) should be inserted in the table above and will be more relevant than blasting. With the arguable exception of haulage roads, all of these sources of dust emission can be actively managed by the quarry operator.

In cases where granite or other silica based rocks are being quarried, the potential health effects of dust emissions on site workers become much more severe due to the threat of silicosis.

Good practice for dust control

Dust control can incorporate a number of different strategies that can broadly be split into prevention, removal and suppression.

Prevention of dust emission in the first place is the preferred solution and can be achieved by employing techniques that produce less dust. When the generation of dust cannot be reduced *per se*, the next best approach is to remove dust particulates from the air via some sort of collection mechanism before correctly disposing of the collected dust. In cases where dust is not collected, its dispersion can at least be minimized via the use of water sprays so that dust concentrations remain concentrated in a small area.

Techniques can be either dry or wet. Dry techniques will tend to be favored in dry climates or sites where access to water is expensive or technically challenging. Dry techniques have a higher installation and operating cost but are less prone to failure and require less maintenance.

Both point sources and diffuse sources of dust emission will be present at or near the quarry site. Both types of emission can be controlled by implementing certain good management techniques. The specific variation of the technique (e.g. wet or dry) will primarily depend on factors such as the climate and the nature of the rock being extracted.

Dumping

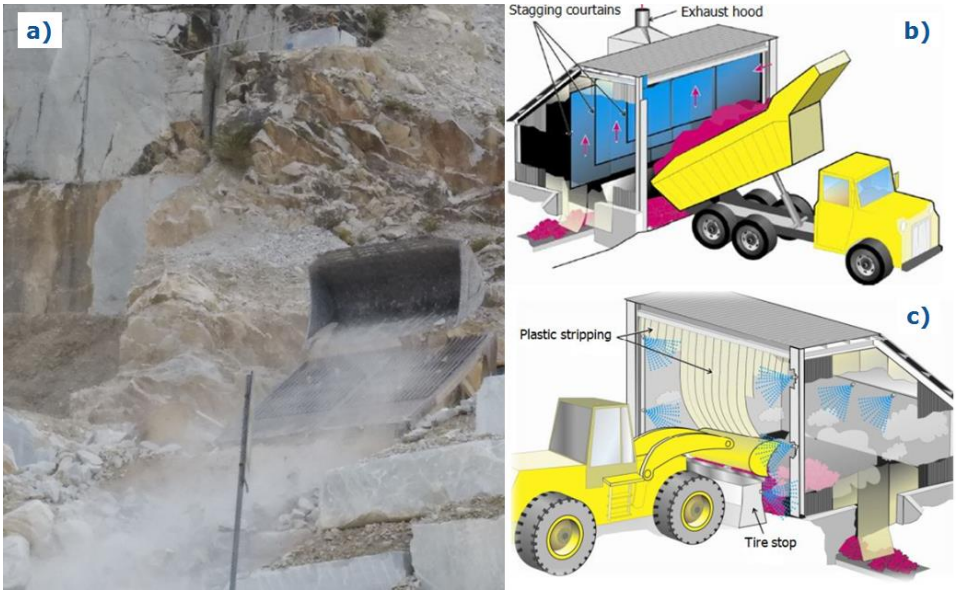

Figure 10. Examples of dust emission from screening at the quarry a) no dust control; b) dry dust control and c) wet dust control (Images for b) and c) taken from NIOSH, 2012).

Dumping of materials over a screen is a very basic process where waste material is passed by gravity over a slanted grid with fixed spaces than only permit the passage of material of a certain degree of fineness. The finer material can be periodically collected while the coarser material falls into the extractive waste deposition area. Although these operations are only carried out periodically, they result in plumes of dust in cases when the material is dry. Placing a temporary cover structure over the

screen can facilitate a major reduction in dust emissions, using either dry or wet methods. Dust control systems can be set to be automatically initiated by movement sensors.

Crushing

For irregular blocks and pieces that are considered as by-products or extractive waste from extraction activities for dimension stone, there may be a market for such material if it can be crushed into standard gradations.

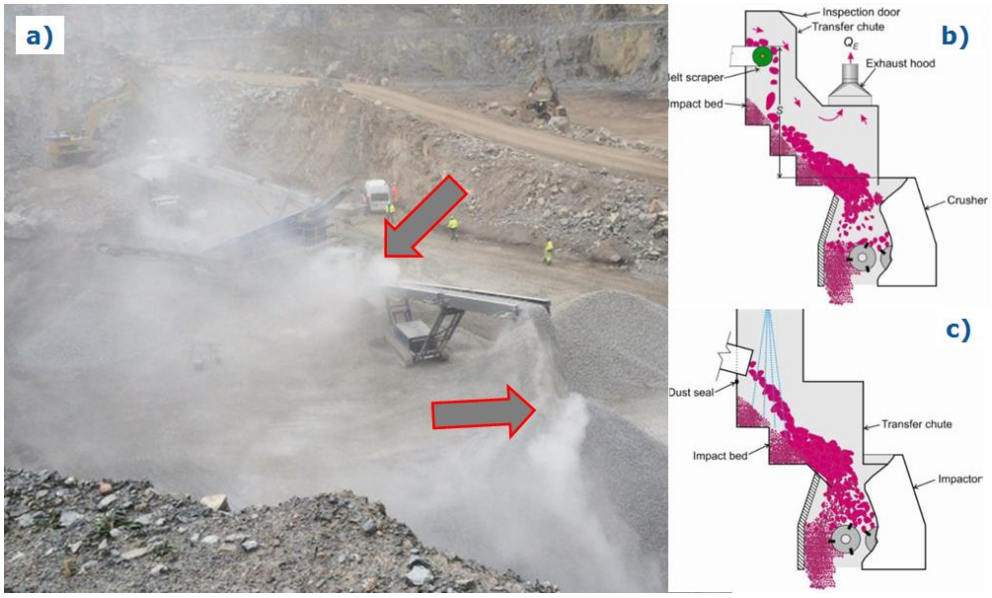

Figure 11. Examples of dust emission from crushing at the quarry a) no dust control; b) dry dust control and c) wet dust control (Images for b) and c) taken from NIOSH, 2012).

Crushing operations not only produce dust during the crushing operation but also during the subsequent stockpiling of material if the height difference between the conveyor belt and the top of the stockpile is significant enough. The potential for dust emission will also depend on weather conditions at the moment, the moisture content of the crushed material and the fineness to which the stockpiled material has been crushed.

Diffuse emissions of dust

Fines deposited onsite from any source can and pass to the air again as soon as a sufficient mechanical action is applied. The finer and drier the dust particle, the less significant the mechanical action required is and the further the particle can be transported.

According to Reed and Organiscak (2006), fugitive emissions of particulate matter are dominated (78 to 97%) by the movement of trucks onsite.

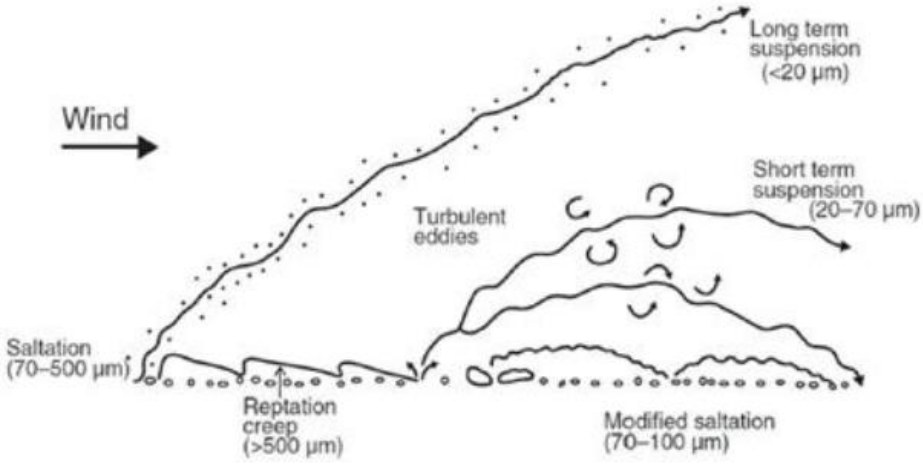

Figure 12. Dust particle transmission mechanisms of relevance to trucks on unpaved roads at quarry sites (from Neuman and Nickling, 2009).

Irrigation of unpaved roads is only a temporary solution and serious consideration should be given to the paving of the most commonly used haulage roads. Apart from fewer dust emissions, other advantages delivered by paved roads include:

- Improved visibility for drivers.
- Better traction for vehicle tyres (safer maneuvering and quicker transit possible).
- Better protection of the road base.
- Smoother road surface reduces rolling resistance (fuel savings for vehicles and less wear and tear on vehicle suspension and tyres).

Wind erosion from stockpiles

The wind erosion potential of material in a particular stockpile will mainly depend on its dryness and fineness. The higher the wind erosion potential, the lower the wind speed required to generate a given degree of dust emissions from the stockpile.

A variety of approaches can be taken to reduce dust emissions which can broadly be split as follows:

- Reduce the erosion potential of the stockpile (e.g. moisten the surface layer with water, establish vegetation cover by seeding).
- Reduce the velocity of wind reaching the surface area (e.g. construct wind breaks around the stockpile and fence off open areas).
- Prevent the wind coming into contact with the stockpile surface area (e.g. cover with tarpaulins, store fines in enclosed silos prior to transport offsite, deposit in inert landfills).

Criterion 2.5. Personnel safety and working conditions at the quarry

Criterion 2.5. Personnel safety and working conditions at the quarry
The applicant shall provide a description of the occupational health and safety policy in force at the quarry. The policy shall cover, as a minimum: - A systematic analysis of all risks and major hazards that may occur in the quarry. - A training plan for employees that is related to specific work procedures that are carried out at the quarry. - An inspection and maintenance plan for all machinery, tools, electrical installations, vehicles, ladders, walkways, staircases, safety barriers and other relevant equipment. - Placement of fixed guards around moving parts of machinery such as belts, pulleys, gears and adjustable guards for circular saws. - Quick-release controls to shut off power to handheld electric power tools and emergency stop buttons on control panels for all heavy machinery. - Safe storage of any explosives onsite. - Appropriate transportation and lifting gear for the movement and positioning of dimension stone blocks and large fragments of blocks. - Emergency plans and first-aid training for personnel. - Personal Protective Equipment provision for all personnel and site visitors. - Clear identification of areas with risks of high noise levels. The following aspects relating to working conditions shall be guaranteed: - Access to toilet, changing room and lunchroom facilities for workers and the provision of drinking water at all times. - Compliance with national laws and regulations or with the fundamental conventions of the International Labour Organisation (ILO), whichever is the more stringent. - Labour contracts for all employees that clearly describe the relevant work, maximum obligatory hours of work, salary, social insurance contributions (or other suitable insurance against accidents in countries where social insurance does not exist), holiday entitlements and notice period. - Full compliance with EU or national occupational health and safety legislation. ***Assessment and verification:*** *The applicant shall provide a declaration of compliance with this criterion, supported by a copy of their occupational health and safety policy.* *In cases where compliance with ILO conventions is provided, the applicant shall obtain third party verification, supported by site audits, that the applicable principles included in the fundamental ILO conventions identified below, have been respected at the quarry:* *Fundamental conventions of the ILO:* *a) Child Labour:* *i. Minimum Age Convention, 1973 (No 138);* *ii. Worst Forms of Child Labour Convention, 1999 (No 182);* *b) Forced and Compulsory Labour:* *i. Forced Labour Convention, 1930 (No 29) and 2014 Protocol to the Forced Labour Convention;*

ii. Abolition of Forced Labour Convention, 1957 (No 105);

c) Freedom of Association and Right to Collective Bargaining:

i. Freedom of Association and Protection of the Right to Organise Convention, 1948 (No 87);

ii. Right to Organise and Collective Bargaining Convention, 1949 (No 98);

d) Discrimination:

i. Equal Remuneration Convention, 1951 (No 100);

ii. Discrimination (Employment and Occupation) Convention (No 111).

In cases where the quarry is not located in a Member State, a third party verification (for example by Fairstone or other schemes with at least equivalent criteria on the occupational health and safety and working conditions listed above) shall be required.

Rationale:

This broader criterion replaces an initial requirement focussed solely on noise. Broader health and safety aspects are a particular concern in natural stone quarries both inside and outside the EU. The overall purpose of this criterion is to set some minimum requirements for health and safety for any EU Ecolabel natural stone product.

Imports of ornamental or dimension stone blocks to the EU can come from Turkey, Egypt, India or China amongst other countries. The aforementioned countries may have poorly enforced health and safety requirements for natural stone extraction. Concerns about health and safety in natural stone quarries within the EU were also expressed by some expert stakeholders.

The extraction activity takes place in remote, outdoor areas and often by micro-enterprises (i.e. companies consisting of less than 10 employees). Consequently, it is unlikely that strict health and safety policies are widely understood and applied by staff in day to day operation of the quarry.

Concern about health and safety and social issues is reflected by the development of the Fairstone standard (for non-EU quarries).

Why no quantitative limit on noise?

The primary source of noise from quarrying is from heavy machinery, cutting operations, deposition/screening of by-products/extractive wastes and breaking up of larger irregular blocks into smaller, more manageable pieces. The truck traffic carrying staff and materials or equipment to be delivered or collected is also a significant source of noise.

The impacts of noise on humans are highly dependent on the noise frequency, site topography, ground cover of the surrounding site, and climatic conditions. Topographic barriers can shield target areas or reflect noise waves in a different direction.

Trying to set quantitative limits on noise from a quarry activity is a challenging task due to the fact that the noise is highly intermittent and measured levels at a fixed point will depend not only on the activities onsite, but also on wind, traffic passing the site and noise from neighbouring quarries. This last aspect in particular can be significant since it is not uncommon to have dozens of quarries operating side-by-side in the same site. On hillside quarries, there will be a lot less noise from passing trucks in a site near the top of the hill than in a site near the bottom of the hill, because all trucks will be using a common same access road. Finally, controlling the noise level below a certain point at one fixed point on a site does not necessarily mean that it is controlled at other important points on or near the same site.

For these reasons, it is proposed to remove the criterion on noise.

Further research into noise at quarries

The impacts of noise can be mitigated through various engineering techniques:

- Landscaping, berms, and stockpiles can be constructed to form sound barriers.
- Noisy equipment (such as crushers) can be enclosed in sound-deadening structures.
- Conveyors can be used instead of trucks for onsite movement of materials.
- Noisy operations can be scheduled or limited to certain times of the day.
- The proper location of access roads, the use of acceleration and deceleration lanes, and careful routing of trucks can help reduce truck noise.
- Workers can be protected from noise through the use of enclosed, air-conditioned cabs on equipment and, where necessary, the use of hearing protectors.

Directive 2003/10/EC established the regulation for the Control of Noise at Work Regulations 2005. The main requirements are triggered by four "*action levels*":

- lower limit for daily personal noise exposures of 80 dB(A);
- upper limit for daily personal noise exposure of 85 dB(A);
- lower limit for peak noise exposure of 135 dB(C) and
- upper limit for peak noise exposure of 137 dB(C).

There are also daily exposure and peak exposure limits of 87 dB(A) and 140 dB(C) respectively, which take into account the effect of wearing hearing protection and which the regulations do not allow to be exceeded. These regulations are concerned with the protection of people at work, and do not, therefore, deal with exposure to noise for the public.

Sunita et at., (2017) recorded the noise produced during blasting and crushing activities for 10 days. The noise levels during blasting ranged between 102.8 and 130.8 dB. The noise levels were also recorded during crushing activities. The reading ranged between 97,0 and 116,2dB.

What do other schemes say about noise?

The Fair Stone international standard for the natural stone industry (4th edition, 2010) sets the following requirements for noise and vibration:

> *"10.1. Noise measurements should be used to identify the areas with noise risks. Noise zones must be clearly marked.*
>
> *10.2. Introduce technical measures such as low noise blades for circular saws and noise absorbers or take organizational steps e.g. segregate areas with a higher noise level from those with a lower level, minimize periods/levels of exposure.*
>
> *10.3. The installation of a new production line, new production methods or the redesign of workplaces, has to be planned in such a way that noise and vibration are minimized.*
>
> *10.4. Workers should be informed about the risks of noise and vibration as well as suitable prevention measures in order to create awareness.*
>
> *10.5. Drivers' seats of your mobile equipment (e.g. forklifts, trucks, excavators) have to be maintained properly or exchanged for new seats with good vibration absorbing performance."*

The Natural Stone Council (NSC) standard 373 – sustainability assessment for natural dimension stone, does not state any specific requirements on noise.

The 2018 draft version of hard surfacing criteria set by Good Environmental Choice Australia (GECA) state the following;

> *"3.1.7. Noise: Criterion 10. Where the main mine or quarry is located within 5km of a Populated Area, the noise level from the operation shall not exceed 70 dB(A), measured at the perimeter of the mine or quarry."*
>
> *For the purposes of the standard, a populated area is considered as any area with a habitant density of more than 50 habitants per square kilometre (>50 hab/km^2). The measurement of noise levels is to be*

carried out according to ISO 1996.

Overall, the Fair Stone, NSC and GECA approaches are completely different. The GECA approach closely relates to the EU Ecolabel approach set out in Decision 2009/607/EC, while the Fair Stone requirement is focused on health and safety requirements that should be common practice in Europe already.

Criterion 2.6. Quarry landscape impact ratios (optional)

Criterion 2.6. Quarry landscape impact ratios (optional)

The quarry operator shall provide the following data relating to the quarry site in order to permit the calculation of the quarry footprint ratio or the quarry beneficial land use ratio, based on a satellite view of the site no more than 1 year prior to the date of award of the EU Ecolabel licence.

- **QF:** Quarry Front (active) area (m^2).
- **EWDA:** Extractive Waste Deposition Area (m^2).
- **BPDA:** By-Products Deposition Area (m^2).
- **TAA:** Total Authorised Area for the site where the extraction activity takes place (m^2).
- **BA:** Biodiverse Area, where (i) topsoil and vegetation cover or wetlands/engineered reed-beds have been established using native species as part of progressive rehabilitation and/or (ii) where topsoil and vegetation has simply not been disturbed in the first place and is not isolated in pockets within the quarry (m^2).
- **REA:** Renewable Energy Area, where land has been occupied for the generation of electricity via solar, hydroelectric, wind or biomass energy (m^2).

	Quarry footprint ratio	**Beneficial land use ratio**
Calculation	$\frac{QF + EWDA + BPDA}{TAA}$	$\frac{BA + REA}{TAA}$
Threshold for 0 points	0,70	0,00
Threshold for 5 points	0,20	0,40

Up to a total of 10 points shall be awarded (5 for each ratio) in proportion to how much the applicant demonstrates that ratios approach or exceed the relevant thresholds for 5 points.

Assessment and verification: *A declaration from the quarry operator shall be provided, together with documentation including maps or satellite images in which the QF, EDWA, BPDA, TAA, BA and REA are outlined, and with estimations of the surface of each area.*

Rationale:

What is the criterion aiming to achieve?

Quarrying is an inherently invasive process that can endanger human health and uses processes that could harm the environment, creating particular potential risks to water, air, soil and fauna and flora and drastically affect the landscape both within the quarry and the surrounding area. The effects of this damage can continue for years after a quarry has closed, especially due to erosion processes and inhospitable habitats for flora and fauna. However, at the same time, the landscape alteration also creates opportunities for specific habitat creation or the generation of renewable energy.

The main purpose of this criterion is to recognise the efforts of quarries that:

- To stockpile extractive waste and by-products in such a way that occupies less land surface area;
- To encourage the use of extractive waste and by-products in the local area as road base and for the construction of access ramps and barriers;

- To indirectly encourage quarry operators to find markets for extractive waste and by-products off-site;
- To indirectly encourage more efficient extraction practices;
- Reward underground extraction activities, which avoid or drastically reduce impacts on flora and fauna at the ground surface;
- Reward progressive rehabilitation activities during the operational period in order to reduce the risk of erosion;
- Reward the use of potentially large areas of land for the generation of renewable energy in cases where climatic conditions and surrounding topography is adequate.

Different types of quarry

It is difficult to define a fixed ambition level for the quarry footprint ratio because there is a lack of published data regarding such metrics and the type of rock and strata ultimately defines the architecture of the quarry, which will have a major influence on these metrics. In general, marble, granite and massive limestone quarries have a high-step architecture, where the primary cut is approximately 8 metres high. Quarries for sandstone and slate, where smaller sized blocks are extracted, will have low-step architecture.

Ideally, an open cast quarry looks almost like an amphitheatre, where production can take place simultaneously on several levels. Some of the best planned quarries for large granite and marble deposits approximate this situation, with a high yield per area and volume of extracted rock. A "*good*" situation in an efficient quarry could be an annual production of 1000 – 2000 m^3 of commercial blocks per hectare. However, in many cases the deposits are narrow, inclined and/or occur beneath layers of non-exploitable rocks. A steeply inclined slate or marble deposit, for instance, causes a trench or well-shaped quarry layout, which have a lower productivity. The productivity is also depending on the internal structures of the rocks – e.g. cutting angles.

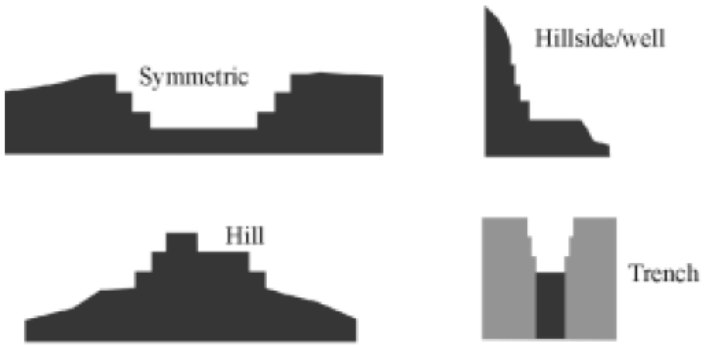

Figure 13. Different open quarries structures (Schematic view. Source: Arvantides et al)

In recent years, technological developments in quarrying equipment (particularly with chain saw and diamond wire cutting techniques) have made large scaled underground operations economically viable, especially for soft rocks such as marble. Underground quarrying has several advantages, of which less impact on the local surface environment is perhaps the most important one. The possibility of selective quarrying, leaving the poorest rock quality in pillars, is also important. Furthermore, local morphological conditions (steep terrain) and the occurrence of overburden, also favours underground operations.

Generally, underground quarrying produces less waste-rock than open-cast quarrying. The disadvantages (or rather challenges) of underground operations mainly relate to their higher cost, especially in the early stage of opening. A good knowledge of site specific conditions (e.g. deposit type, deposit size, rock characteristics and quality) is even more crucial with underground extraction activities. In addition, stress monitoring of fractures and the stability of pillars and walls is of even greater importance for safe operation. Underground quarrying has proven to be economically viable only for soft rocks to date (e.g. marble, limestone and slate). Approximately 30% of the marble

production in the Carrara Basin occurs, at present, underground. For granite and other hard rocks, the technology still needs improvement.

A rehabilitation/restoration plan is a mandatory requirement (see Criterion 1.1) but, as stated in the soon to be published BAT Reference Document on the management of waste from the extractive industries, if the progressive restoration is carried out during the operational phase adverse environmental effects are minimized. For example, if the extractive waste facility is progressively revegetated, erosion is reduced. The same logic for mining waste also applies to extraction of ornamental or dimension stone.

For clarity, the definition of an Extractive Waste Facility, for the purposes of these proposed EU Ecolabel criteria, should be considered as the same as that provided in Directive 2006/21/EC, which states:

"'waste facility' means any area designated for the accumulation or deposit of extractive waste, whether in a solid or liquid state or in solution or suspension, for the following time-periods:

—no time-period for Category A waste facilities and facilities for waste characterised as hazardous in the waste management plan;

—a period of more than six months for facilities for hazardous waste generated unexpectedly;

—a period of more than one year for facilities for non-hazardous non-inert waste;

—a period of more than three years for facilities for unpolluted soil, non-hazardous prospecting waste, waste resulting from the extraction, treatment and storage of peat and inert waste.

Such facilities are deemed to include any dam or other structure serving to contain, retain, confine or otherwise support such a facility, and also to include, but not be limited to, heaps and ponds, but excluding excavation voids into which waste is replaced, after extraction of the mineral, for rehabilitation and construction purposes;"

The criterion is established in such a way that a responsible use of the land, regardless of the nature of the material or the typology of the quarry, is rewarded. No minimum level is set but all beneficial use of quarry land is rewarded with points and any reduction of the quarry footprint ratio below 70% is rewarded. A greater weight is given the beneficial quarry land use since this is associated with greater direct environmental benefits than simply not having such large extractive waste and by-product deposition areas.

What do other schemes say about quarry footprint ratios?

The Fair Stone international standard for the natural stone industry (4th edition, 2010) does not set any specific requirements for the quarry footprint ratio during operation but have the following relevant general criteria:

> *"25.2. The company initiates rehabilitation of abandoned quarry areas as soon as possible.*
>
> *25.3. The company protects the topsoil and subsoil. Soil resources need to be protected from erosion and either reused on restoration areas as soon as possible or stored for a transitional period to avoid damage or loss.*
>
> *25.5. The company implements and carries out production policies that prevent and/or mitigate negative impacts on neighbourhood, flora and fauna."*

The 2018 draft version of hard surfacing criteria set by Good Environmental Choice Australia (GECA) state the following;

> *"3.1.8. Visual Impact. Criterion 11: Where the mine or quarry is located within 5 km of a Populated Area, the visual impact of the operation must not exceed 30 as defined in Appendix 3 of this standard.*
>
> *APPENDIX 3 – CALCULATION OF THE VISUAL IMPACT.*
>
> *The calculation of the Visual Impact of Mines and Quarries for the purpose of this standard is based on the calculation described in the Technical Appendix A1.9 of the EU Commission Decision 2002/272/EC.*

The calculation of visual impact lies in tracing cross sections passing through the quarry front and other external "visual points", which are important to determine the visual impact (for example either from nearby towns or from frequented places or major roads, etc.). The calculation of the final score, measured as a percentage, shall be taken from the highest value of originally calculated values (worst case situation). A short explanation for the finally chosen "visual point" should be submitted to the Competent Body. From each visual point (P), the "bottom radius" is traced, tangent to the topographic surface and intercepting the lowest point of the "visible quarry area". The visible quarry area is regarded as the area where the excavation is carried out or where there is an active dump. Already rehabilitated areas (both in front area and dumps) need not be considered. From the same visual point a second radius (called "top radius") is traced, intercepting the highest point of the quarry front. The top radius and bottom radius allow the identification on the section of the quarry of the limits of the height of the visible front (the vertical distance from top to bottom radius matching the front). The calculation could be made on the basis of the quarry project. These geometric data are put into the following formula and the result is the quotient of visual impact of the quarry affecting a specific visual point.

$$x\ (\%) = \frac{h^2}{(L\ x\ tan30°)^2}\ x\ 100\%$$

h = vertical height of front visible from visual point P (metres); L = horizontal distance between the worst visual point P and the front tan30° = tangent of the average angle of the human eye vision cone; x% = Percent of visual impact

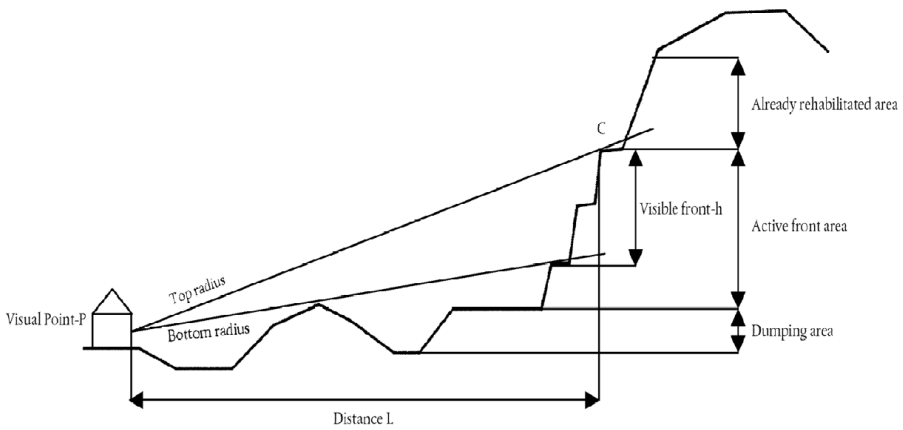

Figure 14. Graphical definition of the visual impact indicator in Decision 2002/272/EC and GECA criteria.

The Natural Stone Council (NSC) standard 373 – sustainability assessment for natural dimension stone, does not have any mandatory or optional criteria that address the aspect of quarry footprint ratio or visual impact.

Why is the visual impact ratio not continued?

The GECA criterion shows a very similar approach to visual impact indicator that was published in 2002 for the EU Ecolabel criteria for hard coverings.

One potential criticism of the visual impact approach mentioned above is the fact that the result is very much dependent on the choice of viewing point. Dentoni and Massacci (2012) concluded that the above approach to visual impact does not capture the impacts in terms of the breadth of the quarry altered landscape or the chromatic contrast between the quarry and the surrounding area. Other authors have also highlighted the importance of the chromatic difference between the quarry site and the surrounding area (Pinto et al., 2002; Bishop, 2003; Degan et al., 2014).

In the 2009 EU Ecolabel criteria, the quarry impact ratio aimed to look at the area affected by the quarry front and the "*active dump*" as a function of the total quarry area. The current approach is similar to the 2009 criteria but now makes it clearer how this should be calculated (i.e. from a satellite view). This way underground extraction of dimension stone is clearly favored as is any underground or compact storage of by-products and extraction waste.

A closer look at progressive rehabilitation options in quarries

The term rehabilitation encompasses any measures taken to repair disturbed or degraded land and return it to a stable and nonpolluting state; suited to the proposed future use of the land. Progressive rehabilitation refers to the rehabilitation of worked out, or surplus areas in a quarry while extractive operations continue at the same site. It helps to minimise the visual impact of a quarry and control dust, erosion, and the invasion of weeds. It also assists in fostering good community relations.

Rehabilitation works may be considerably more efficient if carried out while the necessary machinery is onsite and operating, rather than having machinery transported back to a site. As new quarry sections are opened, worked out areas could be progressively rehabilitated to avoid increasing the total disturbed area of a quarry. Overburden and topsoil can be stripped from areas being opened up and placed directly onto worked out areas which are being rehabilitated. This will avoid double handling of materials and prevent degradation of the topsoil

Unless preventative measures are implemented, erosion will continue long after extractive activities have ceased. Poor drainage can damage rehabilitation work. The best erosion prevention at a site is the establishment of vegetation on a stable landform. However, while vegetation is becoming established, it may be necessary to employ other erosion prevention techniques.

Recommended practices include:

- To slow down surface runoff retain drainage controls, like diversion drains, contour banks and rock filters upslope of the area being rehabilitated.
- Leave surfaces in a rough or uneven state. Rough surfaces will capture more water and allow rainfall to infiltrate rather than flow away. It may be beneficial to retain any sediment ponds onsite with the owner's consent. However, ponds will need to be periodically cleaned out for the first year or so.
- Apply surface mulches around growing seedlings on steep batters to reduce erosion, weed establishment and to conserve soil moisture and add nutrients to the soil.

Revegetation (i.e. establishing a self-sustaining cover of vegetation) is the best way to stabilise disturbed sites in the long term. Revegetation also minimises the visual impact of quarries. Generally, the vegetation type which existed before the disturbance, or a similar vegetation type will regenerate most successfully.

A closer look at the quarry footprint ratio

The proposal in TR 2.0 is based on how the quarry site is distributed as perceived from a satellite view. The exact outline of the quarry site boundary would need to match any operating permits issued by public authorities. Within the site boundary, it would then be up to the applicant (or quarry operator, if different) to indicate which areas on the site are being used for active quarry fronts (QF), by-product deposition areas (BPDA) and extractive waste deposition areas (EWDA). A potential example of how this could be split up is shown below.

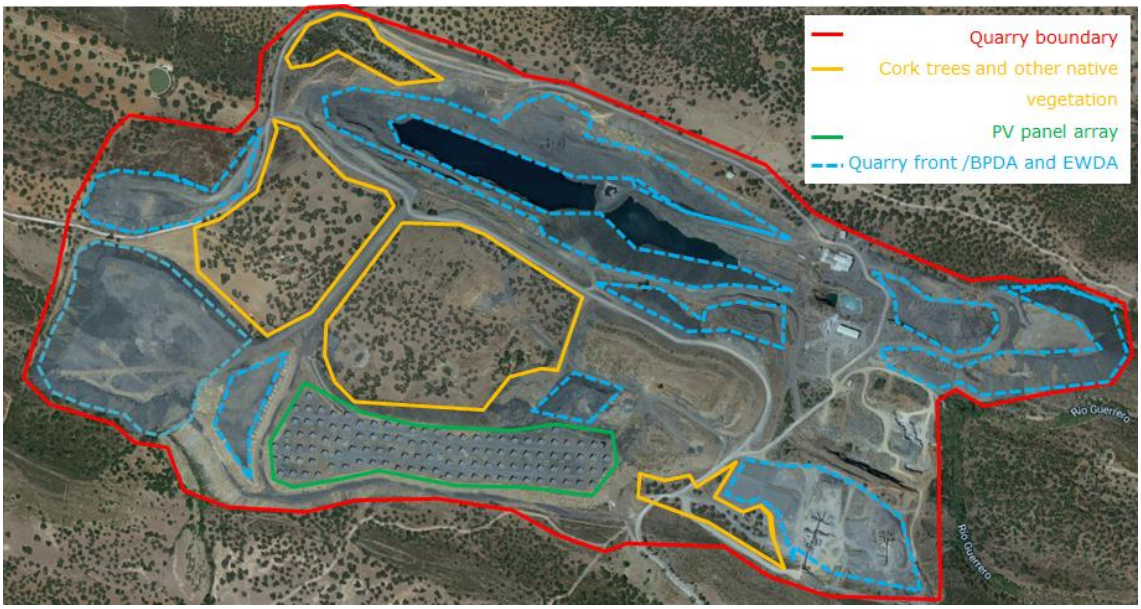

Figure 15. Overview of opencast slate and granite quarry in Spain.

The above site (all boundary estimates are very rough estimates, and only for the purposes of illustration) shows that the quarry footprint ratio would be calculated by dividing the total area within the dashed blue shapes by the total area within the red shape.

It is also interesting to note that this particular site has significant areas with established vegetation cover and even a photovoltaic panel array. The quarry footprint ratio could be used not only to limit the areas occupied by extractive waste and by-products but also to reward the beneficial use of unused land onsite (e.g. vegetation cover and renewable energy generation). It is also worth noting that roads, access ramps and areas for the circulation of heavy machinery are not counted as occupied areas, so the use of extractive waste as road base would be promoted by this criterion.

Natural stone transformation plant requirements

The requirements for criteria 2.7 to 2.11 apply to any natural stone products that are transformed from quarry blocks or slabs into final products in a transformation plant. These plants are normally independent of the quarry operators suppling the blocks and slabs.

Criterion 2.7. Energy consumption at the transformation plant

Criterion 2.7. Energy consumption at the transformation plant
The applicant shall have established a program to systematically monitor, record and reduce specific energy consumption and specific CO2 emissions in the transformation plant to optimal levels. The applicant shall report energy consumption as a function of energy source (e.g. electricity and diesel) and purpose (e.g. use of onsite buildings, lighting, cutting equipment operation, pumps and vehicle operation). The applicant shall report on energy consumption for the site both on an absolute basis (in units of kWh or MJ) and on a specific production basis (in units of kWh or MJ per m^3, m^2 or t of material sold/produced and ready for sale) for a given calendar year. A plan to reduce specific energy consumption and specific CO2 emissions shall describe measures already taken or planned to be taken (e.g. more efficient use of existing equipment, investment in more efficient equipment, improved transportation and logistics etc.). In addition, a total of 20 points may be granted as follows: – Up to 10 points shall be awarded in proportion to how much of the energy consumed (fuel plus electricity) is from renewable sources (from 0 points for 0% renewable energy, up to 10 points for 100% renewable energy). – Up to 5 points shall be awarded depending on the manner in which any renewable electricity is purchased as follows: via private energy service agreements for on-site or near-site renewables (5 points); corporate power purchase agreements for on-site or near-site renewables (5 points); long term corporate power purchase agreements for grid-connected or remote grid renewables[22] (4 points); green electricity certifications[23] (3 points); purchase of renewable energy guarantees of origin certificates for the full electricity supply or green tariff from utility supplier[24] (2 points). – 3 points shall be awarded where a carbon footprint analysis has been carried out for the product in accordance with ISO 14067 or 5 points if the Product Environmental Footprint method's elements related to greenhouse gas emissions[25] has been used. ***Assessment and verification:*** *The applicant shall provide an energy inventory for the transformation plant for a period of at least 12 months prior to the date of award of the EU Ecolabel license and shall commit to maintaining such an inventory during the validity period of the EU Ecolabel license. The energy inventory shall distinguish the different types of fuel consumed, highlighting any renewable fuels or renewable content of mixed fuels. As a minimum, the specific-energy consumption and CO2 emission reduction plan must define the baseline situation with specific energy consumption at the transformation plant when the plan was established, identify and clearly quantify the different sources of energy consumption at the transformation plant, identify and justify actions to reduce specific energy consumption and to report results on a yearly basis.*

[22] According to article 15(8) of Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (OJ L 328, 21.12.2018, p. 82).

[23] Based on guarantees of origin with independent third party verification of additional requirements according to article 19 of Directive (EU) 2018/2001.

[24] Renewable energy sources disclosed according to article 19(8) of Directive (EU) 2018/2001 and point 5 of Annex I to Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (OJ L 158, 14.6.2019 p. 125).

[25] https://eplca.jrc.ec.europa.eu/permalink/PEF_method.pdf

The applicant shall provide details of the electricity purchasing agreement in place and highlight the share of renewables that applies to the electricity being purchased. If necessary, a declaration from the electricity provider shall clarify (i) the share of renewables in the electricity supplied, (ii) the nature of the purchasing agreement in place (i.e. private energy service agreement, corporate power purchase agreement, independent green energy certified or green tariff) and (iii) whether the purchased electricity is from on-site or near-site renewables.

In cases where guarantee of origin certificates are purchased by the applicant to increase the renewables share, the applicant shall provide appropriate documentation to ensure that the guarantee of origin certificates have been purchased in accordance with the principles and rules of operation of the European Energy Certificate System.

In cases where points are claimed for a carbon footprint analysis, the applicant shall provide a copy of the analysis, which shall be in accordance with ISO 14067 or the Product Environmental Footprint method and have been verified by an accredited third party. The footprint analysis must cover all manufacturing processes directly related to stone production at the quarry and the transformation plant, onsite and offsite transportation during production, emissions relating to administrative processes (e.g. operation of onsite buildings) and transport of the sold product to the transformation plant gate or local transportation hub (e.g. train station or port).

Rationale:

The same rationale that applies to criterion 2.1 also applies to criterion 2.7. In both the quarry and the transformation plant, cutting of the rock is a major source of energy consumption. The cutting techniques are different due to the different situations that exist in the quarry and in the transformation plant.

The processing of quarry blocks of ornamental or dimension stone into natural stone slabs or tiles at the transformation plant requires a significant amount of energy for squaring and cutting of blocks and then also for polishing of the slab or tile surfaces.

Cutting technologies at the transformation plant

The technologies used for cutting ornamental and dimension stone blocks is broadly the same as used in the quarry, except that it is configured different in order to cut blocks into thinner slabs and sometimes slabs into smaller tile products. The main cutting techniques are: diamond mono-wire; diamond mono-blade; giant disk saw; steel grid gang saw; diamond blade multi-saw; diamond blade multi-wire and diamond disk. The choice of which technique is most appropriate will largely be determined by the type of rock to be cut, the slab dimensions that need to be cut (i.e. standard or custom) and, in the case of more recent techniques, if it is economical for the operator to upgrade to the newer technique.

Finishing operations

One part of the transformation process that does not have an equivalent stage in the quarry is surface finishing. The required finish depends not only on the final product specifications that must be met but also on the effect of the cutting technique on the rock surface. In this sense, gang saw cutting of hard stone will produce a rougher surface than say, diamond saw blade cutting of soft stone, and the former will require much more polishing than the latter to meet the same surface smoothness.

The simplest surface finishing operation is polishing although, depending on the surface characteristics that are desired, other techniques such as bush hammering, flaming, waterjet or sand blasting may be used to impart a certain texture or roughness.

Another potential treatment of blocks and slabs is impregnation with an epoxy or polyester resin in order to maximise the yield from fragile or partially fractured slabs and ensure that they will be protected from water infiltration. The resin treatment process involves drying the slab at a moderately elevated temperature (ca. 35°C), applying the resin and then drying again at a similar temperature to allow the resin to cure. This process could take a few hours.

Due to the great variety of cutting and finishing techniques that can be used and the general lack of specific energy consumption data, it was decided to not set any specific process energy requirement for natural stone slab and tile products. Nonetheless, it is recognised that energy consumption in the processing plant is an important issue and so applicants should be monitoring energy consumption closely. Such monitoring should undoubtedly already be a part of any Environmental Management System in place in the organization.

Criterion 2.8. Water and wastewater management at the transformation plant

Criterion 2.8. Water and wastewater management at the transformation plant
The applicant shall provide a description of water use in the natural stone transformation plant, including strategies and methods for collection, recirculation and reuse of water. The recovery of solids from wastewater from cutting operations must be carried out onsite using sedimentation and/or filtration principles. Clarified wastewater must be stored onsite and recirculated for cutting operations, dust control or other purposes. In addition, 5 points shall be awarded for the installation of a rainwater collection system to collect and store rainwater that lands on impermeable areas onsite and prevents the surface flow of rainwater across working areas, and carrying suspended solid loads into any impermeable ponds (that supply water to the cutting equipment) or into natural watercourses. ***Assessment and verification****: The applicant shall provide a declaration of compliance with this criterion, supported by the relevant documentation describing water use onsite, of the wastewater/rainwater collection network and of the wastewater treatment and recirculation system.*

Rationale:

Sources of wastewater.

Wastewater is produced by any one of several processing operations, for example:

- Cutting: Water can be used for cooling, for transport of abrasive particles or used under high pressure to directly deliver the cutting action itself, for example in CNC (Computer Numerically Controlled) drills.
- Finishing: Polishing is generally carried out in contact with water in order to carry loose fines away before the might impede the polishing action.
- Dust control: especially from cleaning of floor surfaces and vehicles tyres.

The main pollutant resulting from these operations are solid particles from the rock and from cutting blade teeth, diamond wire or polishing media. Solids separation (i.e. primary water treatment) at the transformation plant is different than the quarry in the sense that there is always much less available footprint at the transformation plant than the quarry. Consequently, more intensive solids separation techniques such as inclined plate clarifiers and/or flocculant dosing are more likely to be employed. The separated sludge is highly likely to be dewatered to reduce the sludge volume prior to collection and transport offsite, thus also reducing disposal costs.

Why no limits for emission of Cd, Pb, COD or Fe to wastewater?

The authors are not aware of any potential sources of Pb and Cd and suspect that this was carried over from the equivalent criteria for ceramic tiles, where Pb and Cd could be provided via certain glaze formulations.

Site visits revealed that onsite clarification and recirculation of wastewater in natural stone transformation plants was technically feasible. The only fresh water that is needed is for final polishing operations.

Consequently, the EU Ecolabel requires that wastewater is to be clarified onsite prior to being circulated for cutting and dust control operations, there is no wastewater to be discharged, just a sludge for disposal, which is addressed in criterion 2.10.

What do other schemes say?

The Fair Stone international standard for the natural stone industry (4th edition, 2010) sets the following requirements that relate to energy consumption in stone processing factories:

> *"25.6. Waste water and waste materials are disposed of properly so that they might not endanger workers and inhabitants close by.*
>
> *26.1. A study on how to save water and other consumables, and how to recycle waste water must be undertaken and documented.*
>
> *26.2. The company must take appropriate measures to ensure economical use of electrical energy and water. All staff must know how to save energy and water.*
>
> *26.3. The company uses production methods that minimize water consumption."*

The Natural Stone Council (NSC) standard 373 – sustainability assessment for natural dimension stone has more concrete requirements relating to energy in natural stone manufacturing facilities ((M) denotes mandatory, (O) denotes optional):

> *"5.1. Water Inventory (M): The facility operator shall develop and maintain an annual inventory of water use including the quantity of water used on an annual basis, organized by water source (e.g., municipal potable, direct rainwater captured for reuse, on-site wells, or reclaimed grey water. Water used as a result of both manufacturing and non-manufacturing operations shall be included.*
>
> *5.2.1. Recycled water (M): A minimum of 25% of the water accounted for in the inventory for fabrication or quarry operations shall be captured and recycled.*
>
> *5.2.2. Recycled water (O) Max. 2 points: A minimum of a) 26% to 90% of the water accounted for in the inventory for processing or quarry operations are captured and recycled. (1 point); or b) More than 90% of the water accounted for in the inventory for processing or quarry operations is captured and recycled. (2 points total).*
>
> *5.3.1. Enhanced water treatment (O) (1 point): Demonstrate on-site systems that result in enhanced treatment of discharge water. Enhanced treatment shall be demonstrated by one of the following:*
>
> *a) Management of wastewater on-site resulting in no direct discharge of water (e.g., seepage ponds) (1 point); or*
>
> *b) Quality of discharged water, either to POTW or directly to the environment, is demonstrated to meet State drinking water standards (1 point); or*
>
> *c) Where no permits or regulations are applicable, the facility operators demonstrate that the quality of water discharged to the environment from their facility meets the US EPA's NPDES (National Pollutant Discharge Elimination System) requirements. (1 point)*
>
> *Facility Operators that do not utilize water in their manufacturing operations shall qualify for 1 point under this criterion.*
>
> *5.3.3. Water Reuse (O) (2 points): The facility operator shall document as compared to the annual water inventory (see 5.1) for both manufacturing and non-manufacturing operations, that at least 25% of input water is sourced from rainwater, grey water, or other source that is non-potable. (1 point)"*

The 2018 draft version of hard surfacing criteria set by Good Environmental Choice Australia (GECA) state the following:

> *"5.1 Water Emissions: Criterion 21: Effluent waters discharged to the environment from processing or finishing operations shall not exceed the following limits. These limits apply after water treatment either on- or off-site. Municipal sewage treatment plant emission levels may be used if waste water is discharged directly to the sewer by permit from the relevant local authority.*
>
> *Suspended solids 40 mg/L; Cadmium 0.015 mg/L; Chromium (VI) 0.15 mg/L); Iron 1.5 mg/L and Lead 0.15 mg/L.*
>
> *The waste water produced by the processes included in the production chain shall reach a recycling ratio of at least 90 %. The recycling ratio shall be calculated as the ratio between the waste water recycled or recovered (by applying a combination of process optimisation measures and process waste water treatment systems, internally or externally at the plant), and the total water that leaves the process."*

Overall, the Fair Stone requirements on water and wastewater management were very vague, whereas the NSC and GECA requirements were much more specific. In both NSC and GECA, emphasis is placed on the recycling of waste water, so this approach should be taken forward into the new proposal for EU Ecolabel criteria.

In terms of pollutants in discharged wastewater, the GECA criteria appear to be a modelled directly on the older EU Ecolabel criteria. However, as mentioned above, many of the pollutants listed do not make sense for a natural stone transformation plant.

The NSC criteria also introduce an interesting optional requirement relating to rainwater harvesting that would be interesting to promote for the EU Ecolabel as well, especially considering the increasingly unpredictable swings in climate reported in many parts of Europe from longer drought periods to more intense storm events. In both extremes of weather period, a rainwater collection and storage capacity would be beneficial. For example, in a prolonged drought period, the previously collected rainwater would be used and would reduce the abstraction requirement from the local watercourse, which may already be under water stress. During heavy storm periods, any storm water hitting impermeable areas such as roofs or paved areas would be diverted to storage tanks onsite instead of contributing to the peak runoff flowing downstream, thus reducing flood risks downstream.

Criterion 2.9. Dust control at the transformation plant

Criterion 2.9. Dust control at the transformation plant
The applicant shall demonstrate that operational site measures have been implemented for dust control at the transformation plant. Measures may vary from site to site but should include the following aspects for all sites: - Use of dust suppression water sprays or vacuum hoods linked to dust filter bags/electrostatic precipitators for any dry cutting or shaping activities that are likely to generate significant quantities of dust. - Regular cleaning of dust from indoor floor areas using either water sprays on surfaces that drain to a water treatment system onsite or the use of a vacuum device for dry dust removal (sweeping of dry dust should not be carried out). - Provision of an enclosed storage area for all dewatered sludge from wet cutting and/or all dust from dry cutting operations prior to sale, prior to shipment for reuse, prior to reuse onsite or prior to shipment to landfill. - Covering the most heavily used road areas with concrete or asphalt paving. - Provision of appropriate training to employees about good practice for dust control and provision of adequate personal protective equipment to employees and visitors. - Provision of routine medical check-ups for employees, with the possibility for more frequent monitoring for the identification of respiratory problems and possible onset of silicosis (the latter point being applicable only to transformation plants processing granite and other siliceous rock). ***Assessment and verification:*** *The applicant shall provide a declaration of compliance with this criterion, supported by relevant documentation and: (i) a description of the dust control measures implemented at the transformation plant and (ii) details of the medical check-up system for employees, as appropriate.*

Rationale:

Much of the rationale stated in the section for criterion 2.4 (dust control at the quarry) also applies to the transformation plant. Although a transformation plant represents a much more controlled environment than a quarry, operations are still quite manual and variable. Consequently, dust emissions are highly variable, both in time and location.

So instead of setting a fixed concentration on dust in air (difficult to measure from diffuse sources), it was considered more pragmatic to define a series of practices that could be made mandatory for the purposes of obtaining the EU Ecolabel, as with criterion 2.4 for natural stone quarries. These proposals were strongly supported by stakeholders, especially where crystalline silica is a risk. However, it will be necessary to define certain terms in the User Manual, such as what is meant exactly by "*suitable prevention measures*" and "*regular cleaning*"?

What do other schemes say?

See the equivalent sub-section for criterion 2.4.

Criterion 2.10. Reuse of process waste from the transformation plant

Criterion 2.10. Reuse of process waste from the transformation plant
The applicant shall complete an inventory of process waste production for the transformation plant. The inventory shall detail the type and quantity of waste produced (e.g. process scrap and process sludge). The process waste inventory shall cover a 12 month period and, during that same period, the total product output shall be estimated both in terms of mass (kg or tonne) and surface area (m^2). At least 80% by mass of the process scrap generated from natural stone processing operations onsite shall be reused in other applications or stored onsite in preparation for future sale. In addition, a total of 10 points may be granted as follows: – Up to 5 points shall be awarded in proportion to how much the applicant demonstrates a higher reuse rate of process scrap, up a maximum of 100% reuse by mass (from 0 points for 80% process scrap reuse, up to 5 points for 100% process scrap reuse). – Up to 5 points shall be awarded in proportion to how much the applicant demonstrates any reuse of process sludge, up to a maximum of 100% (from 0 points for 0% process sludge reuse, up to 5 points for 100% process sludge reuse). ***Assessment and verification:*** *The applicant shall provide a waste inventory for the transformation plant for a period of at least 12 months prior to the date of award of the EU Ecolabel license and shall commit to maintaining such an inventory during the validity period of the EU Ecolabel license.* *The applicant shall provide a declaration of compliance with the mandatory requirement of this criterion, supported by a calculation of total production process scrap (in kg or t). Details about the destination of these process wastes shall also be provided with clarifications about whether it is external reuse in another process or sent to landfill. For any external reuse or landfill disposal, shipment notes shall be presented.*

Rationale:

It is important to distinguish between process sludge (contains traces of metals from cutting abrasion and grease) and process scrap (solid fragments and trimmings from cutting operations as well as reject projects). The latter is much easier to reuse because it has no undesirable pollutants and is essentially natural rock.

Resin impregnation to reduce process scrap for expensive natural rock

Generally, the systems commonly used in marble processing are not satisfactory for granite processing lines. Granite is much harder, with microscopic fissures and a different absorption rate. No polyester resin would have the capability to deeply penetrate in the very thin cracks of the granite stone, harden up and give a sufficient strength to the material but epoxy resins have shown the capability to fill all of the pits and micro-fissures present in the granite. Additionally, its long hardening time allows the glue to penetrate deeply into the stone before the complete curing will occur. Before being treated, the surface of a granite slab has to be honed; to allow the surface of the material to evenly absorb the resin. This process requires special convection ovens or two to three days in favorable dry working conditions. After being mixed in the right ratio (either using a scale or an automatic mixing dispenser), the resin is then spread on the whole surface. After the system is completely cured (usually it takes up to 24 hours, depending on the system and the equipment used) the slab is ready to be polished. During the polishing process, the first steps are focused on removing all excess resin poured on top of the slab, leaving only the resin that has filled into the cracks or the pits. In this way, the epoxy resin will not form a film on top of the granite, and it will be present only in the interspaces and in the micro-fissures.

Generation of process sludge

The processing stage involves splitting blocks into slabs and treating their surfaces. Cutting is performed by either: (i) the action of metal gang saws and the forced horizontal movement of abrasive pulp (rock dust, grit, and lime) or (ii) diamond wire looms, with water spraying for dust suppression. At this stage, approximately 25% of each of the cut blocks is converted into waste. The exact figure varies by technique used, the thickness of the cutting media (thinner cutting media produce less relative waste) and the desired thickness of the slabs (thicker slabs produce less relative waste).

Solid wastes generated by cutting and polishing operations are removed by cooling water and rinsing water respectively. These wastewater streams may be combined into a single sedimentation tank or be treated separately for discharge according to its composition. Waste solids may be with grit (from cutting with traditional looms) or without grit (from cutting with diamond wires and from polishing).

Use of flocculants

The use of a flocculant can increase sedimentation rates and result in a smaller footprint wastewater treatment plant onsite or improved suspended solid removal. However, the flocculant will also increase the quantity of sludge generated, especially if inorganic ferric chloride or alum sulphate are used, which react in water streams to form $Fe(OH)_3$ and $Al(OH)_3$ precipitates respectively. Organic flocculants may be particularly effective but could compromise the potential to reuse the sludge in certain applications, particularly in blended cements, where any organic matter can have a drastic and unpredictable effect on cement setting behaviour.

During the site visit to Carrara, the use of flocculants was common practice in process wastewater treatment, although the operators were not aware of the type of flocculant that was being used. Regardless of the type of flocculant used, its presence in the settled sludge may complicate its potential reuse or at least the market value of the waste material.

Unlike ceramic tile production, there is no real opportunity for the process waste to be reincorporated into the natural stone production process, although some sludges, if of a sufficiently high purity, may be suitable in the fabrication of agglomerated stone products.

The normal practice is that a plant may process blocks from a large number of quarries, resulting in a high heterogeneity of the process waste.

Reuse of process sludge

Given the costs of the potential transportation of this this waste and discharge and the environmental impact that can be caused by the large volume produced, studies have been performed examining its potential reuse in civil construction. In its natural state, after dewatering, the waste sludge has a moisture level between 20 and 30%.

Marras et al., (2010) showed that marble fines from filter press sludge after quarry and transformation plant wastewater treatment was fine for use up to 10% of total raw material mass in the firing of clay bricks. Mármol et al., (2010) investigated the use of granite sludge waste from a transformation plant as a partial cement substitute (up to 20%) and a filler (up to 100%) in cement mortars. They found that the iron content, which came from wear on cutting blades, varied significantly in samples (from 6 to 28% wt.). Nevertheless, the granite sludge did not produce any significant decrease in compressive strength when replacing up to 10% of cement, and actually increase strengths when used as an alternative filler. Gencel et al., (2012) showed that marble dust and coarse marble aggregates from a Turkish transformation plant caused a steady increase in mixing water content and decrease in compressive strength development as waste marble substituted natural aggregates from 0 to 40% by weight. Medina et al., (2017) showed that granite sludge could be used as a supplementary cementitious material, substituting 10 or 20% of the cement clinker content while still meeting the relevant technical requirements for Type II/A and Type IV/A cements despite potential concern about the relatively high alkali (Na and K) content in the sludge and the inconclusive results about whether the sludge exhibited pozzolanic activity or not.

In a comprehensive review of the potential reuse of dimension stone waste in concrete, Rana et al., (2016) concluded that the reuse potential was highest for the substitution of coarse aggregates (100%), then fine aggregates (5 to 100% depending on the type of waste) and then cement replacement (up to 20% for quarry dust).

What do other schemes say?

The Fair Stone international standard for the natural stone industry (4th edition, 2010) sets the following requirements that relate to waste management in stone processing factories:

> *"25.1. A study on how to reduce and recycle waste must be undertaken and documented.*
>
> *25.2. Minimise production of waste, use all possibilities of waste separation or recycling and ensure the responsible disposal based on principles of sustainability.*
>
> *25.3. Used cleaning rags are collected in flame-resistant containers with a lid.*
>
> *25.4. Waste must be disposed of at regular intervals.*
>
> *25.5. Combustible waste, debris, and rubble must be collected and promptly removed from the workplace.*
>
> *25.6. Waste water and waste materials are disposed of properly so that they might not endanger workers and inhabitants close by."*

The Natural Stone Council (NSC) standard 373 – sustainability assessment for natural dimension stone, only a number of references to criteria on waste management ((M) denotes mandatory, (O) denotes optional):

> *"5.2.3. Enhanced sludge treatment (O): The facility operator shall demonstrate operation of a sludge management system that diverts a minimum of 50% of annual sludge produced by operations from traditional disposal methods by landfill or incineration, in favor of environmentally acceptable reuse applications (e.g., agricultural use). To qualify for this criterion, the facility operator shall provide documentation of the diversion, including a description of the end disposal method. (1 point)25.2. Minimise production of waste, use all possibilities of waste separation or recycling and ensure the responsible disposal based on principles of sustainability.*
>
> *11.1. Inventory of excess process materials and solid waste (M): The facility operator shall create and maintain an inventory of excess materials generated by its operations. The inventory shall characterize the nature of the excess materials (e.g., sludge, fines, cuttings), the annual quantity generated (estimated or measured), the source of the excess materials (e.g., cutting operations, rejects), the percent or quantity reclaimed or recycled, and the disposal, storage, or reclaim method. In addition, the inventory shall also track general solid waste and recyclables generated on-site, characterizing the nature and annual quantity of the waste, the percent recycled or reclaimed, and the method of reclaim or disposal.*
>
> *11.2. Excess process material and waste management program (M): The facility operator shall establish and implement a program to track and manage excess process material and to systematically reduce or eliminate waste. Specifically, the program shall track and measure the amount of excess process material and solid waste produced by source and type, identify opportunities and methods for reducing generation rates, establish target goals, quantify changes in generation rates (normalized by production volume), and monitor progress of program efforts. At a minimum, the program shall address each of the following:*
>
> > *a) Material yield improvement;*
> >
> > *b) Management of stone excess material from dimensional stone production;*
> >
> > *c) Alternative uses for processing excess material;*
> >
> > *d) Management of solid waste including collection, separation, disposal and/or recycling;*
> >
> > *e) Reuse, recycling or reclaim of goods used in processing; and*
> >
> > *f) Office waste reduction.*
>
> *This program shall track progress towards established goals on a rolling 6-year period for both solid waste and excess process material. Progress shall be estimated or measured based on percentage reduction in generation rates (per unit of dimension stone produced), and be reported publicly (e.g., corporate sustainability report, website posting). If estimated, the facility operator shall provide method of estimation and documented data on which the estimation is based to receive credit.*
>
> *11.3. Demonstrated process reduction of excess process materials (O): The facility operator shall demonstrate, over a 6-year timeframe, the successful reduction of excess process material generated per unit processed. Methods for reducing such materials shall include but are not limited to, process modification, operational changes, efficient use of materials, and use of more sustainable materials*

(estimated or measured as ton of scrap per unit of dimension stone produced).

a) Achieved reduction of 10 - 24% of excess process material inventory (1 point);

b) Achieved reduction of 25 - 50% of excess process material inventory (2 points total); or

c) Achieved reduction of greater than 50% of excess process material inventory (3 points total).

All reductions shall be measured relative to total excess process material (e.g., ton of excess material/ton of stone product produced), as determined in section 11.1 and shall be measured or estimated to receive credit. If estimated, operator shall provide method of estimation and documented data on which the estimation is based to receive credit.

Achieved reductions shall be calculated by comparing the total excess material for the most recent completed year to that of the baseline year, and calculating the percent of total excess material reduction achieved. The baseline year shall be the year 6 years prior, providing that a complete inventory meeting the requirements of section 11.1 exists for that year. Otherwise, the baseline shall be the most recent year for which a complete inventory meeting section 11.1 exists. Under no circumstances shall data from more than 6 years prior be used as a baseline in this criterion.

11.4. Demonstrated solid waste production (O): The facility operator shall demonstrate, over a 6-year timeframe, the successful reduction of solid waste generated per unit processed. Methods for reducing waste include but are not limited to process modification, operational changes, efficient use of materials, and use of more sustainable materials (measured as lbs of solid waste per unit produced).

a) Achieved reduction of 25 - 60% of solid waste inventory (1 points total); or

b) Achieved reduction of greater than 60% of solid waste inventory (2 points total).

Reductions shall be measured relative to the inventory as determined in section 11.1, and shall be measured or estimated. If estimated, the facility operator shall provide method of estimation and documented data on which the estimation is based to receive credit.

Alternatively, for the purposes of this credit, a facility shall use as a baseline a solid waste inventory from a previous year, provided that the inventory meets the requirements of section 11.1, goes back no further than 6 years, and shall be properly documented. In such cases, credits shall be awarded for achieved reductions against the past inventory (see Foreword)."

The 2018 draft version of hard surfacing criteria set by Good Environmental Choice Australia (GECA) state the following;

"6.3. Waste Management. Criterion 25: Manufacturers shall be able to demonstrate the following elements, as minimum, in a waste management program covering all operational sites:

- *Functioning procedures for diverting recyclable and reusable materials from the waste stream.*
- *Functioning procedures for the recovery of waste materials for other purposes.*
- *Contracts with registered hazardous waste contractors, where hazardous waste is generated by the process.*
- *Waste recovery or diversion from landfill, where technically possible."*

The NSC criteria make an interesting distinction between process scrap and process sludge. Such a distinction seems justifiable because the materials are significantly different due to their sizes. The larger scrap materials can be crushed to specific size fractions prior to reuse as coarse aggregate but the sludge may be difficult to reuse, especially if flocculants have been used. Consequently, even just a low reuse percentage of process sludge should be encouraged while some mandatory requirement is needed for the process scrap reuse.

Criterion 2.11. Regionally integrated production at the transformation plant (optional)

Criterion 2.11. Regionally integrated production at the transformation plant (optional)
This criterion applies to the transport distance between the quarry gate and the transformation plant gate and is specific to natural stone products originating from a given quarry. Up to 5 points shall be awarded in proportion to the extent that applicants can demonstrate that the transportation distance for the intermediate dimension stone blocks from the quarry to the transformation plant is less than 260km (from 0 points if ≥ 260km, up to 5 points if ≤ 10km). ***Assessment and verification***: *The applicant shall provide the address of the transformation plant and the address or the geographical location of the relevant quarry gate. The applicant shall also describe the transport mode(s) used to bring the intermediate dimension stone blocks to the transformation plant.* *The transport route and total distance shall be estimated and indicated on a map using satellite image maps and freely available distance estimating software.*

Rationale:

The market for natural stone products is global, especially for high quality natural stone. Some extreme cases of natural stone blocks being extracted in Europe, sent to China for transformation and finishing and then being shipped back for sale on the European market have been reported – such approaches are obviously not optimum from an environmental perspective and would lead to disproportionate impacts in the A2 life cycle stage (transport to factory gate).

This point was only raised at the 2nd AHWG meeting but has a direct environmental relevance. When an ornamental stone or dimension stone block is transformed into typical hard covering products within the EU Ecolabel scope (e.g. tiles, slabs or pavers etc.) 30% of the material can be lost during the squaring, cutting and polishing operations (Bianco, 2018). So basically, for every 1 tonne of material that is transported to the transformation plant, around 700kg of final product can be expected. Around 30% of the energy that is spent in transporting the quarry blocks to the transformation plant is due to material that will be later lost in the transformation operations.

Consequently, when transformation takes place close to the quarry of origin, the transport energy will be less and the associated energy losses due to material losses during transformation will be smaller. The criterion is optional only in order to respect market freedom.

Criteria for agglomerated stone products based on resin binders

Scoring system

The scoring system and the minimum number of points necessary for EU Ecolabel agglomerated stone products are presented in the table below.

Table 8. EU Ecolabel scoring system for agglomerated stone products based on resin binders

Criteria where points can be awarded	Agglomerated stone products
1.7. Environmental Management System (optional)	0, 3 or 5 points
3.1. Energy consumption	Up to 30 points
3.3. Recycled/secondary material content	Up to 35 points
3.4. Resin binder content	Up to 20 points
3.5. Reuse of process waste	Up to 10 points
Total maximum points	**100**
Minimum points required for EU Ecolabel	**50**

Criterion 3.1. Energy consumption

Criterion 3.1. Energy consumption
The specific process electricity consumption for agglomerated stone production (including raw material batching, primary mixing, secondary mixing, moulding and finishing) shall not exceed 1,1 MJ/kg. If grinding of stone raw material is carried out, the specific electricity consumption of the grinding process (in MJ/kg) shall be reported separately but shall not be added to the total for the process. In addition, a total of 30 points may be granted as follows: - Up to 10 points shall be awarded in proportion to how much the specific process electricity consumption is reduced towards a threshold of environmental excellence of 0,7 MJ/kg (from 0 points for 1,1 MJ/kg up to 10 points for 0,7 MJ/kg). - Up to 10 points can be awarded in proportion to how much of the electricity consumed is from renewable sources (from 0 points for 0% renewable electricity up to 10 points for 100% renewable electricity). - Up to 10 points shall be awarded depending on the manner in which any renewable electricity is purchased as follows: via private energy service agreements for on-site or near-site renewables (10 points); corporate power purchase agreements for on-site or near-site renewables (10 points); long term corporate power purchase agreements for grid-connected or remote grid renewables[26] (8 points); green electricity certifications[27] (6 points); purchase of renewable energy guarantees of origin certificates for the full electricity supply or green tariff from utility supplier[28] (4 points). ***Assessment and verification:*** *Specific process electricity consumption shall be calculated by dividing the electricity consumption for relevant process equipment by the volume of production (in kg or m³). Data reported shall be representative of the product(s) applying for the EU Ecolabel. In cases where different products covered by the same application have significantly different values, the data shall be reported separately for each product. In cases where production data is available in m³, it should be converted to kg using the relevant bulk density factor (in kg/m³) for the agglomerated stone product.* *The applicant shall provide details of the electricity purchasing agreement in place and highlight the share of renewables that applies to the electricity being purchased. If necessary, a declaration from the electricity provider shall clarify (i) the share of renewables in the electricity supplied, (ii) the nature of the purchasing agreement in place (i.e. private energy service agreement, corporate power purchase agreement, independent green energy certified or green tariff) and (iii) whether the purchased electricity is from on-site or near-site renewables.* *In cases where guarantee of origin certificates are purchased by the applicant to increase the renewables share, the applicant shall provide appropriate documentation to ensure that the guarantee of origin certificates have been purchased in accordance with the principles and rules of operation of the European Energy Certificate System.*

Rationale:

The rationale for promoting renewable energy is effectively the same as stated in the rationale for criterion 2.1 (and also applicable to criterion 2.7) for natural stone.

[26] According to article 15(8) of Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (OJ L 328, 21.12.2018, p. 82).

[27] Based on guarantees of origin with independent third party verification of additional requirements according to article 19 of Directive (EU) 2018/2001.

[28] Renewable energy sources disclosed according to article 19(8) of Directive (EU) 2018/2001 and point 5 of Annex I to Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (OJ L 158, 14.6.2019 p. 125).

Energy consumption in agglomerated stone production

Energy is consumed first of all by crushing the natural stone to the required fineness. The crushed material is mixed with resins in batching mixers before it is fed into a mould. In the mould, vibration, vacuum/pressure and heat may be applied to create optimum and reproducible conditions for the resin/crushed rock mixture to set in a reproducible way. The technology is highly standardised via patented BretonStone technology, which is entirely electricity based. Improvements in specific electricity consumption have occurred via piecemeal improvements in successive generations of BretonStone technology. Newer models produce bigger slabs and offer better quality control. Further energy is consumed via surface treatment and finishing operations.

Ambition level

In 2009, a specific energy consumption of 1,6 MJ/kg (fuel and electricity) was considered appropriate. Feedback from stakeholders implied that the agglomerated stone production process is effectively 100% electricity based, although small amounts of fuel may be used in specialised finishing techniques (e.g. flaming).

Feedback from industry stakeholders in response to a questionnaire implied that a lower specific consumption of 1,1. MJ/kg would be possible and the lowest value achievable would be 0,7 MJ/kg. This lower value presumably reflects advances in the production process technology since 2009.

There was no apparent difference in energy values as a function of the type of rock material used (i.e. marble or quartz).

Due to doubts about the importance of energy consumption for grinding of raw stone material, and the variable values that could result depending on the grain size of feed rock and product powder, it was decided to set the specific electricity consumption values exclusive of the electricity consumed in grinding operations. However, in order to better inform researchers in any future revision of this criterion, the electricity consumption associated with grinding should be reported by the applicant if grinding is carried out onsite or by their supplier, if supplied material is already ground.

Criterion 3.2. Dust control and air quality

Criterion 3.2. Dust control and air quality
Any working areas where there is a risk of exposure to styrene, where the styrene concentration may exceed 20 ppm (or 85 mg/m^3) according to monitoring data, shall be clearly indicated and be well ventilated. Resin formulations shall be dosed and mixed using closed systems. The applicant shall demonstrate site measures that have been implemented for dust control at the site. Measures may vary from site to site but should include the following aspects for all sites: - Use of dust suppression water sprays or vacuum hoods linked to dust filter bags/electrostatic precipitators for any dry cutting, crushing or other activities that are likely to generate significant quantities of dust. - Regular cleaning of dust from indoor floor areas using either water sprays on surfaces that drain to a water treatment system onsite or the use of a vacuum device for dry dust removal (sweeping of dry dust should not be carried out). - Provision of an enclosed storage area for all dewatered sludge from wet cutting and/or all dust from dry cutting operations prior to sale, prior to shipment for reuse, prior to reuse onsite or prior to shipment to landfill. - Covering the most heavily used road areas with concrete or asphalt paving. - Provision of appropriate training to employees about good practice for dust control and the provision of adequate personal protective equipment to employees and visitors. - Provision of routine medical check-ups for employees, with the possibility for more frequent monitoring for the identification of respiratory problems and possible onset of silicosis (the latter point being applicable only to plants working with quartz-based products). ***Assessment and verification:*** *The applicant shall provide a declaration of compliance with this criterion, supported by relevant documentation and: (i) a description of any working areas with an exposure risk to styrene and details of the ventilation system in place; (ii) a description of the dust control measures implemented at the production site and (iii) details of the medical check-up system in place for employees, as appropriate.*

Rationale:

Emissions to air of NOx and SOx are irrelevant for agglomerated stone production since the process is based on electrical energy only (generally the same situation as with natural stone transformation plants and precast concrete production).

Due to the fact that the cutting and finishing operations carried out at the agglomerated stone production plant are very similar to those carried out in a natural stone transformation plant, and both generate dust in similar ways, the same rationale stated for criterion 2.9 applies here.

The one difference for agglomerated stone is the additional requirement for styrene. The resin binder used in agglomerated stone can give rise to significant styrene emissions is not stored and handled properly. The suggested limit of 20ppm styrene is based on the following data:

Table 9. National occupation exposure limits for styrene (UK, 2009)

Country	8-hour TWA (ppm)	STEL (ppm)
Austria	20	80 (15 min)
Belgium	50	100 (15 min)
Canada – Quebec	50	100
Czech Republic	47	234
Denmark	25	25
Finland	20	100 (15 min)
France	50	---
Germany	20	40 (15 or 30 min)
Hungary	~12 (given as 50 mg/m^3)	~12 (given as 50 mg/m^3)
Italy	50	100 (15 min)
Japan	50	--
Luxembourg	20	40 (30 min)
Netherlands	25	50 (15 min)
Norway	25	37.5 (15 min)
Poland	~12 (given as 50 mg/m^3)	~50 (given as 200 mg/m^3)
Spain	20	40 (15 min)
Sweden	20 (10*)	50 (15 min)
Switzerland	50	40
United Kingdom	100	250 (15 min)
USA OSHA	100	200
USA ACGIH	20	40
USA NIOSH	50	100

VOC emissions from polyester resin operations occur when the cross-linking agent (monomer) contained in the liquid resin evaporated from fresh resin surfaces into air during application curing. Styrene and methyl methacrylate are by far the principle and the most common monomers used in cross linking agents. Since emissions result from evaporation of monomer from the uncured resin, they depend upon the amount of resin surface exposed to the air and the duration of exposure. Thus the potential for emissions varies with the manner in which the resin is mixed, applied, handled, and cured among the different fabrication processes.

Criterion 3.3. Recycled/secondary material content

Criterion 3.3.Recycled/secondary material content
The applicant shall assess and document the regional availability of virgin material, of recycled material from wastes produced by different production processes and of secondary material from by-products of different production processes. The approximate transport distances of the documented material sources shall be stated. In addition, up to 35 points shall be awarded in proportion to the incorporation of recycled/secondary materials into the agglomerated stone product up to a threshold of environmental excellence threshold of 35% w/w content (from 0 points for 0% w/w, up to 35 points for ≥ 35% w/w of recycled/secondary material content). The incorporation of dust, cuttings and rejects of agglomerated stone products into new products shall not be considered as recycled content if it is going back into the same process that generated it. ***Assessment and verification:*** *The applicant shall provide a declaration of compliance with the mandatory requirement of this criterion, supported by documentation stating the identification and regional availability of virgin, recycled and secondary materials.* *Recycled or secondary materials shall only be counted as contributing towards the content of recycled/secondary material if they are obtained from sources that are ≤ 2,5 times distant from the agglomerated stone production site than the main virgin materials used (e.g. marble and quartz).* *A monthly balance sheet of recycled/secondary materials shall be presented for the 12 months of production prior to the date of award of the EU Ecolabel license and the applicant shall commit to maintaining such a balance sheet during the validity period of the EU Ecolabel license. The balance sheet shall provide the quantities of ingoing recycled/secondary materials (justified by delivery notes and invoices) and outgoing recycled/secondary materials in all sold or ready for sale agglomerated stone production with recycled/secondary material content claims (justified by product quantities and % claims).* *Claims for recycled and/or secondary material content shall be representative of the mix composition(s) used at the batch level for the EU Ecolabel product(s). A general allocation of recycled and/or secondary materials shall not be permitted.* *In cases where different products covered by the same license application have significantly different values, the data shall be reported separately for each product.*

Rationale:

<u>*What is meant exactly by "recycled material"?*</u>

The ISO 14021 definition of the term "recycled content" and related terms are as follows:

> **Recycled content**: Proportion, by mass, of recycled material in a product or packaging. Only pre-consumer and post-consumer materials shall be considered as recycled content, consistent with the following usage of terms.
>
> **Pre-consumer material**: Material diverted from the waste stream during a manufacturing process. Excluded is reutilization of materials such as rework, regrind or scrap generated in a process and capable of being reclaimed within the same process that generated it.
>
> **Post-consumer material**: Material generated by households or by commercial, industrial and institutional facilities in their role as end-users of the product which can no longer be used for its intended purpose. This includes returns of material from the distribution chain.
>
> **Recycled material**: Material that has been reprocessed from recovered [reclaimed] material by means of a manufacturing process and made into a final product or into a component for

incorporation into a product.

Recovered [reclaimed] material: Material that would have otherwise been disposed of as waste or used for energy recovery, but has instead been collected and recovered [reclaimed] as a material input, in lieu of new primary material, for a recycling or a manufacturing process.

So unless the agglomerated stone product has previously been transferred to other actors in the distribution chain, it cannot be considered as recycled content when it comes back to the agglomerated stone factory. Especially in the case of reject batches, this would normally be considered as process waste.

In terms of waste that is not in-house process waste, the agglomerated stone production process is capable of incorporating a significant amount of waste materials.

The main type of recycled/secondary materials or by-products of natural stone quarries (e.g. small stones and broken fragments from quarries producing ornamental or dimension stone blocks) or wastes produced from natural stone transformation plants (e.g. from squaring of blocks, cutting wastes, polishing wastes and from airborne dust control).

Other notable recycled/secondary materials for the agglomerated stone sector are pre- or post-consumer ceramic waste and glass waste, including the difficult-to-recycle mirror waste.

There are commercial products with high content of recycled content, from 5 % up to 30% in weight. The highest recycled content found during research was 50%.

Criterion 3.4. Resin binder content

Criterion 3.4.Resin binder content
The use of polyester, epoxy or other resins in the production shall be limited to maximum 10% of the total weight of the final product. In addition, up to 20 points shall be awarded in proportion to how much the resin binder content is reduced towards the threshold of environmental excellence of 5% (from 0 points for 10% binder content, up to 20 points for 5% binder content). ***Assessment and verification**: The applicant shall provide a declaration of compliance with the mandatory requirements of the criterion, supported by a calculation of the total use of resin binder as a % of the total weight of the agglomerated stone product.* *Claims for binder content shall be representative of the mix composition(s) used at the batch level for the EU Ecolabel product(s).* *In cases where different products covered by the same license application have significantly different values, the data shall be reported separately for each product.*

Rationale:

Why no mention of cement binders?

Agglomerated stone products are covered by EN 14618, which mentions both organic or inorganic chemical products used to bind aggregates and filler via an irreversible process, forming an agglomerated stone product.

Stakeholders from the agglomerated stone industry revealed that they did not use cement as a binder, but only resins. A typical agglomerated stone material will consist of 85 -95% stone aggregates by weight (i.e. 5 to 15% resin content).

The actual binder content is generally determined by the particle size of the stone material, with coarser stone material requiring less binder and finer stone material requiring more binder. This is directly related to the total surface area of stone material that is exposed within the slab microstructure.

For the purposes of this Decision, only agglomerated stone products with organic resin binders (see definition in Article 2(1) of the Act) are in the scope. Any product with a cement binder is considered as a precast concrete.

The resins used are unsaturated polyester resins, usually a polyester, epoxy or acrylic type thermoset organic resin, a petrochemical polymer, some quantity of synthetic diluents (such as styrene, toluene, Xylene, etc.) and other possible additives

Environmentally friendly resin binders

In recent years, an important part of research has been focused to searching for components coming from renewable and/or recycled raw materials that are more environmentally friendly and make the overall process cleaner and more efficient, and at the same time allow manufacturing a material with excellent mechanical and aesthetic features.

Bio-based resins (or bioresins) offer comparable mechanicals to petro-based resins, thus introduce sustainable materials reducing the dependence on petroleum based products and expanding options for end-of-life recycling and reuse.

Polyester resins free of reactive diluents (without styrene) with satisfactory physico-mechanical properties have been successfully prepared by the reaction between an epoxidized triglyceride and at least one carboxylic anhydride and in which the necessary triglycerides can be obtained starting from

vegetable or animal fats, allowing a bio-based content of around 30% to be introduced (Consentino, 2012).

However, it should be noted that bio-based resins would require the installation of suitable process infrastructure for the epoxidization of the fatty acids. Furthermore, the catalytic system needed for polymerizing this resin is completely different from the systems which are used today, which would make it necessary to make substantial mechanical changes to the established production processes and possibly affecting the potential to reuse recycled and secondary materials. Perhaps even more importantly, several stakeholders were not convinced about the merits of bio-based resins, referring to the issues encountered with the promotion of bio-diesel (e.g. possible food vs. fuel) as a reason.

Industry stakeholders also mentioned that resins with a fraction of recycled content based on recycled polyester were being developed, but these were still considered to be at the research stage.

Criterion 3.5. Reuse of process waste

Criterion 3.5.Reuse of process waste
The applicant shall complete an inventory of process waste production for the agglomerated stone production process. The inventory shall detail the type and quantity of waste produced (e.g. process scrap and process sludge). The process waste inventory shall cover a 12 month period prior to the date of award of the EU Ecolabel and, during that same period, the total product output shall be estimated both in terms of mass (kg or tonne) and surface area (m^2). At least 70% of process waste (scrap plus sludge) generated from agglomerated stone slab and block production shall be reused in other production processes. In addition, up to 10 points shall be awarded in proportion to how much the applicant can demonstrate reuse of process waste, up to a maximum of 100% (from 0 points for 70% process waste reuse, up to 10 points for 100% process waste reuse). ***Assessment and verification:*** *The applicant shall provide a waste inventory for the agglomerated stone production plant for a period of at least 12 months prior to the date of award of the EU Ecolabel license and shall commit to maintaining such an inventory up to date during the validity period of the EU Ecolabel license.* *The applicant shall provide a declaration of compliance with the mandatory requirements of this criterion, supported by a calculation of total production process scrap and sludge (in kg or t). Details about the destination of these process wastes shall also be provided with clarifications about whether it is external reuse in another process or sent to landfill. For any external reuse or landfill disposal, shipment notes shall be presented.* *In case it is not possible to provide specific data for a production line or product, the applicant shall refer to data for the entire plant.*

Rationale:

Waste from the agglomerated stone production process may originate from cutting operations, reject batches, finishing operations and so on.

Previous EU Ecolabel criteria established in Decision 2009/607/EC effectively set a requirement to recycle, reuse or use in reclamation/regeneration at least 85% of all process waste. However, since there is currently no licenses for agglomerated stone products, it is uncertain if such a requirement is feasible.

There is also likely to be a significant difference between process waste from quartz-based products and marble-based products. The former have the disadvantage of potentially containing crystalline silica fines, which may require special handling and disposal operations that restrict potential reuse and recycling options.

When asked if it was common for process waste to be reincorporated into the production process (as is the case with ceramics), an industry representative stated that this was not the case. It was unclear if the main reason for not reincorporating process waste into the production process was due to cost, aesthetics, technical limitations or simply due a lack of established experience.

However, industry representatives did state that the reuse of process waste was especially viable in cement production, due to the pure streams of Ca from calcium carbonate set in organic resin or of Si from quartz set in organic resin. For this reason, a mandatory minimum reuse of process waste was considered justifiable.

Criteria for ceramic and fired clay products

Scoring system

The scoring system and the minimum number of points necessary for EU Ecolabel ceramic and fired clay products are presented in the table below.

In cases where the applicant uses spray dried powder as a raw material and is not the producer of that raw material, the applicant shall declare the spray dried powder used to make the ceramic or fired clay product(s), supported by delivery invoices dating no more than 1 year prior to the application date. In that case, the applicant shall provide all relevant declarations from the producer of the spray dried powder that demonstrate compliance with all related EU Ecolabel requirements and any other relevant optional requirements that may result in points being granted.

For criteria 4.1 and 4.2, two sets of limits are defined for ceramic tiles depending on whether the EU Ecolabel license applies to a limited number of products (where stable operational data during the production run for representative periods should be submitted) or where the license applies to large numbers of product formats of a given product family[29] (where annual average data should be submitted). The limit values for annual average production are higher in order to account for energy needed to maintain kiln temperatures when the production line is not running (e.g. when changing tile formats) or when it is not running at full capacity (e.g. during night-shift, weekends or bank holidays).

Table 10. EU Ecolabel scoring system for ceramic and fired clay products

Criteria where points can be awarded	Ceramic and fired clay products
1.7. Environmental Management System (optional)	0, 3 or 5 points
4.1. Fuel consumption for drying and firing	Up to 20 points
4.2. CO2 emissions	Up to 25 points
4.4. Emissions of dust, HF, NOx and SOx to air	Up to 40 points
4.6. Reuse of process waste	Up to 10 points
Total maximum points available	**100**
Minimum points required for EU Ecolabel	**50**

[29] Three families of ceramic tile products are considered as per class I, II and III in EN 14411

Criterion 4.1. Fuel consumption for drying and firing

Criterion 4.1.Fuel consumption for drying and firing

Coal, petroleum coke, light fuel oil and heavy fuel oil shall not be used as fuels in dryers or kilns.

The specific fuel energy consumption for drying and firing processes shall not exceed the relevant mandatory limits defined below.

	Spray dryer		Ware dryer & kiln	
	Mandatory limit	**Threshold of environmental excellence**	**Mandatory limit**	**Threshold of environmental excellence**
Ceramic tile: individual product**	1,8 MJ/kg powder*	1,3 MJ/kg powder*	4,1 MJ/kg	3,2 MJ/kg
Ceramic tile: family of products***			5,5 MJ/kg	4,3 MJ/kg
Fired clay pavers	n/a	n/a	3,5 MJ/kg	2,1 MJ/kg

**limit applies only to fuel consumed in the spray dryer, 1 kg of dried powder includes any residual moisture content, which would typically be 5-7%*

***data measured under stable operating conditions that are representative of the product during the production run*

****data measured over a period of one year, including baseline fuel consumption between production runs*

In addition, up to 20 points shall be awarded in proportion to how much the specific fuel consumption for drying and firing processes is reduced towards the relevant threshold of environmental excellence in the table above (e.g. for fired clay pavers: from 0 points for 3,5 MJ/kg, up to 20 points for ≤2,1 MJ/kg).

For ceramic tile products where spray-dried powder is used (either produced onsite or offsite), two scores shall be calculated as per the previous paragraph: one for the spray-dried powder (SDP) and one for the ceramic tile kiln and ware dryer (KWD). The two scores shall then be converted into a single score as follows:

$$Fuel_{score} = 0{,}35(SDP) + 0{,}65(KWD)$$

Assessment and verification: *The applicant shall declare the specific fuel consumption value(s) for the relevant product(s) together with calculations to convert value(s) into a specific score. The specific fuel consumption shall be calculated by dividing the fuel consumption (in MJ) for relevant process equipment by production volume (in kg) during the relevant production period.*

In cases where production data is only available in m^2 but needs to be reported in kg, the value should be converted using a fixed bulk density factor (in kg/m^2) for the product or family of products.

Data for an entire family of products shall be representative of any production line(s) for a 12 month period prior to the date of award of the EU Ecolabel. Data for specific individual products, shall be representative of stable conditions during the actual production run(s).

Volumetric or mass inputs of fuel to the kiln and dryer systems shall be taken from site readings and be converted into MJ by multiplying the volume/mass of fuel consumed over the defined production period (e.g. in kg, t, L or Nm^3) by a specific or generic calorific value for the same fuel (e.g. in MJ/kg, MJ/t, MJ/L or MJ/Nm^3).

In cases where fuel used to generate heat for drying operations is fed to a cogeneration system, the electricity generated by the system during the defined production period (measured in kWh and converted into MJ) should be subtracted from the total dryer fuel consumption reading.

Rationale:

Regarding other sources of energy consumption in the process

Overall, a general rule of thumb for a ceramic product included in the scope is that total energy consumption is approximately 90% fuel and 10% electricity. Consequently it was considered justifiable for the energy criterion to continue to focus only on fuel consumption.

Expansion of scope to drying processes as well as kiln

Fuel consumption in drying processes is also considered in the new criterion since it is particularly significant to the total fuel consumption in ceramic tile production. For example, Mezquita et al., (2014) stated that around 45% of total fuel consumption for the production of ceramic tiles could be attributed to drying processes (36% due to spray drying and 9% due to ceramic body drying).

By having a criterion on the EU Ecolabel that is focused purely on 55% thermal energy consumption in the kiln, it could be argued that ignoring thermal energy consumption in spray-drying and green body drying stages would not be in line with Article 6(3)a of the EU Ecolabel Regulation, which states:

> *"3. EU Ecolabel criteria shall be determined on a scientific basis considering the whole life cycle of products. In determining such criteria, the following shall be considered:*
>
> *(a) the most significant environmental impacts, in particular the impact on climate change, the impact on nature and biodiversity, energy and resource consumption, generation of waste, emissions to all environmental media, pollution through physical effects and use and release of hazardous substances;"*

The process set-up is very similar for fired clay pavers and bricks. Tunnel kiln data reported by the Carbon Trust (2010) for brick production shows that dryers can be configured in different ways to take different amounts of waste heat from the kiln. Gas can be burned directly in the ware dryer to a greater or lesser degree depending on how much heat is recovered from the kiln exhaust gases.

Consequently, looking only at the kiln fuel consumption may penalize those production processes where a larger amount of kiln waste heat is reused in dryers. The potential significance of waste kiln heat flow to dryers is illustrated by Sankey diagrams for two different set-ups shown below.

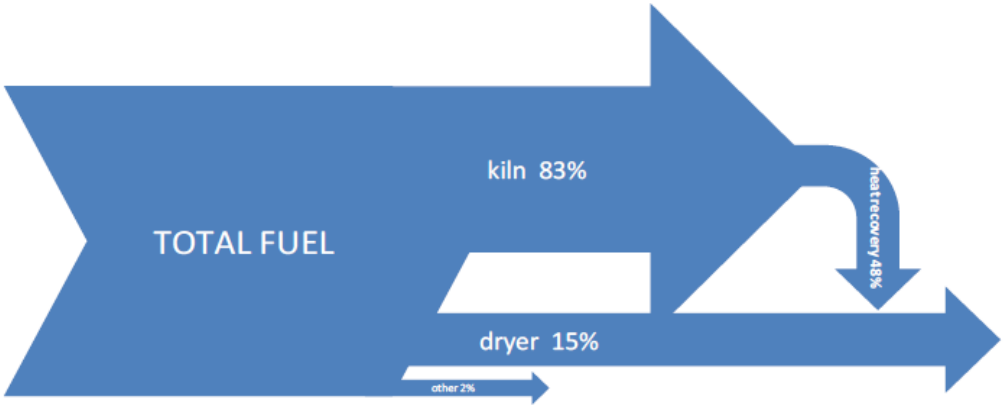

Figure 16. Sankey diagram for fuel energy flows in brick production with dedicated dryer burners and heat recovery from kiln (Source: Carbon Trust, 2010)

The purpose of the dryer is to reduce to moisture content of the green clay forms to between 0 and 1% in order to prevent cracking when it is fired in the kiln. Consequently, the energy required in the dryer will vary as a function of the ingoing moisture content of the green forms and their ambient temperature.

From the Sankey diagram above, it is clear that the heat recovered from the kiln is not sufficient to account for the full thermal energy requirements of the dryer. The potential for heat recovery from the kiln will depend on other losses from the kiln.

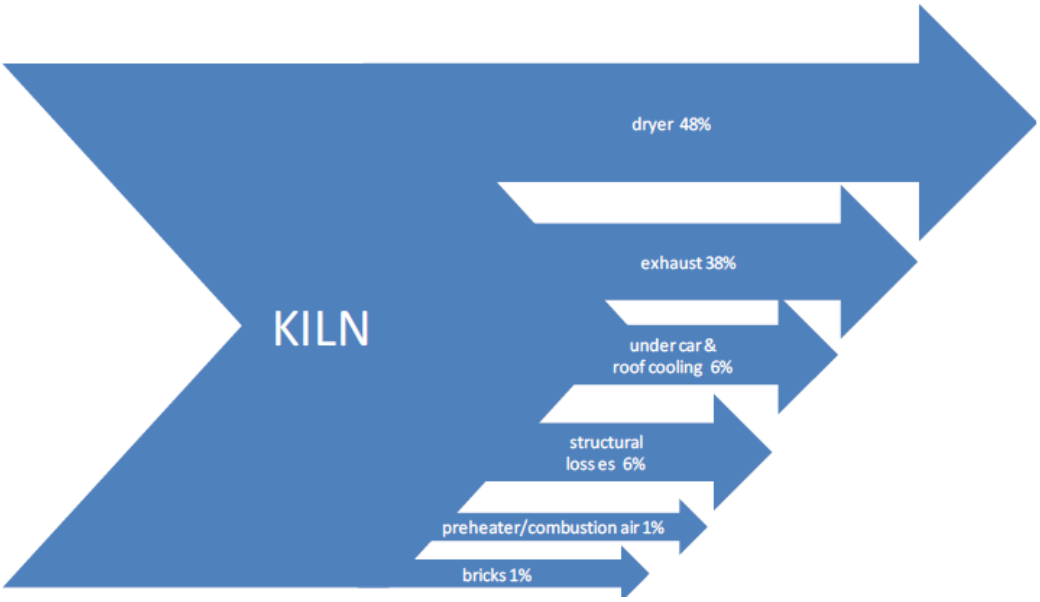

Figure 17. Sankey diagram for fuel energy flows from the kiln in brick production with no dedicated dryer burners (Source: Carbon Trust, 2010)

By having a criterion only focused on kiln gas consumption, it would be possible that more efficient kiln-dryer systems are not sufficiently recognized. Consequently, it is proposed that gas consumption data should look at the kiln-dryer system and not just the kiln alone.

Fuel consumption data for ceramic floor and wall tile production

The JRC prepared an excel spreadsheet for the purposes of a data gathering exercise for both specific energy consumption at the level of the product (via fuels fed to the kiln only).

Unfortunately no responses were received from stakeholders. This prompted the JRC to consult other sources of data:

- The draft ISO 17889-1 standard: which sets 4 tiers of ambition levels for "*specific fuel consumption for firing of kilns*" which are: ≥**8 MJ/kg**, **6-8 MJ/kg**, **4-6 MJ/kg** and **≤4 MJ/kg**.
- Anonymous data ranges from existing license holders (n=50). The following data distribution was found: Maximum = **3,46 MJ/kg**; 3rd quartile value = **2,80 MJ/kg**; Median = **2,42 MJ/kg**; 1st quartile value = **2,2 MJ/kg** and minimum = **1,11 MJ/kg**. The average value was close to the median (**2,48 MJ/kg**).
- Data from a cumulative cost assessment (CCA) of the European ceramics industry published by DG GROW (CEPS, 2017): which reports wide ranges of natural gas intensities from 0,3 to 4,8 MWh/t between the years 2006 and 2015, these ranges translate into **1,1 to 17,3 MJ/kg**.
- Data from a study by the Centro Ceramico in Italy (CC, 2017) that looked at average specific fuel consumption data each year over the period 2010-2017 for facilities that operate in partial cycles (i.e. class 3, ware dryer and kiln only) or full cycles (also including spray drying of powder). The full production data was further split into consumption that only accounted for spray-dried powder used in-house (class 1) and consumption that accounted also for spray-dried powder produced for 3rd parties (class 2). Subtracting class 3 averages from class 1 averages, the fuel consumption due to spray-drying for in-house consumption was around **1,0-1,5 MJ/kg**. Looking at data for the ware dryer and kiln only, the class 3 averages showed values consistently within the range of **3,0 to 3,5 MJ/kg**.
- Data from a study by the Agencia Valenciana de la Energia (AVEN, 2011) that looked at point measurements under stable conditions for the production of spray-dried powder, ware dryers and of firing of different types of ceramic floor and wall tile. Average values for ware

dryer+kiln were **2,98 MJ/kg** or **3,31 MJ/kg** depending on whether the lower or higher heating values for gas were used. Likewise, the average value for spray-drying was **1,66 or 1,84 MJ/kg**. However, the values for spray-dried powder were expressed as per tonne of final tile product (not per tonne spray dried powder), and so probably already account for any losses of material during the process.

It is worth noting that the ambition level for ISO 17889-1 applies to ceramic floor and wall tiles only. Likewise, it was understood that the data from current EU Ecolabel licenses were associated only with ceramic floor and wall tile products. The data reported in the CCA are specifically for ceramic floor and wall tiles, but the report also provides data for the brick and (fired clay) tile sector that is considered later. First of all, it is worth comparing the data for ceramic floor and wall tiles from the three sources listed above on the same graph.

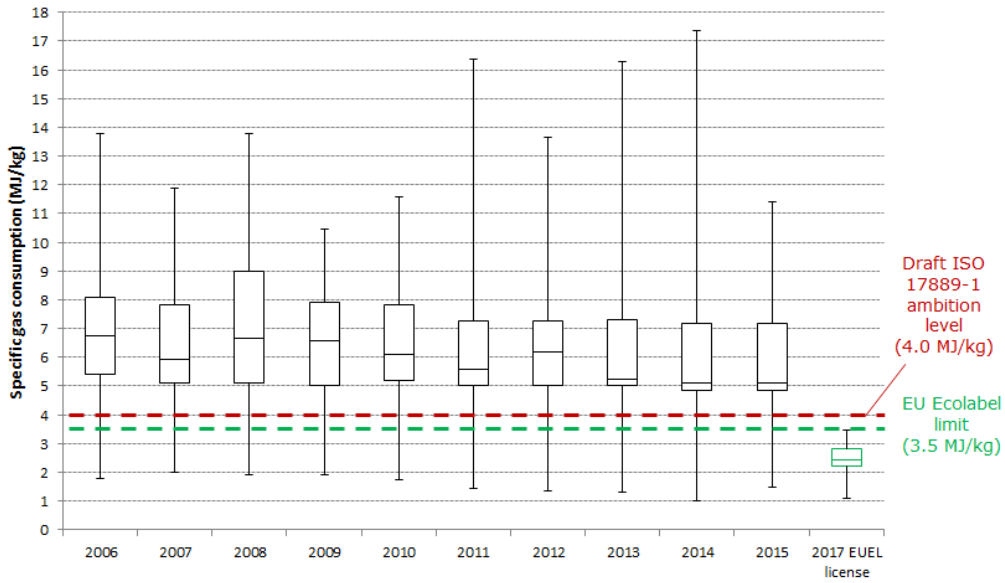

Figure 18. Specific gas consumption for ceramic floor and wall tile production

CEPS, 2017: The data in the Figure above for 2006 to 2015 were the results of a questionnaire exercise carried out by CEPS, Economisti Associata and Ecorys on behalf of DG GROW (CEPS, 2017). The boxplots represent the data received as follows:

- Upper error bar indicates maximum value received.
- Upper line of box represents the 3rd quartile value (i.e. 75% of all values are below this threshold).
- The line inside the box represents the median value (i.e. 50% of all values are below this threshold).
- Lower line of box represents the 1st quartile value (i.e. 25% of all values are below this threshold).
- Lower error bar indicates minimum value received.

For ceramic floor and wall tiles, a total of 16 responses were received and units were expressed as MWh/t of production. These results were converted from MWh/t into MJ/kg by multiplying by 3,6 (3600 MJ/MWh and 1t/1000kg).

When compared to the draft ISO 17889-1 maximum ambition level and the maximum EU Ecolabel limit, the values collected by CEPS seem very high. The CEPS data is centered from 5 to 7,5 MJ/kg level while the actual EU Ecolabel license data is centered from 2,2 to 2,8 MJ/kg, less than half of the equivalent CEPS values.

The CEPS data appears to have been reported at installation or even multi-installation level for a given company whereas the EU Ecolabel data only focuses on the kiln. Consequently, any gas consumed by drying units (for powdered raw materials or for ceramic/fired clay bodies) will not be counted in the EU Ecolabel data, but would be counted in the CEPS data.

The BREF document (BREF, 2007) states that kiln firing (**1,9–4,8 MJ/kg**) is the largest energy consuming process during ceramic tile production, followed by spray drying when relevant (**1,1–2,2 MJ/kg**). Mezquita et al. (2014) stated that the average thermal energy requirement for ceramic tile manufacturing was around 4,6 MJ/kg, which would typically be split as 55% kiln firing (**2,53 MJ/kg**), 36% spray drying (**1,66 MJ/kg**) and 9% drying of ceramic bodies (**0,41 MJ/kg**).

The significance of the spray drying on gas consumption and the fact that this was not included in the 2009 EU Ecolabel criteria explains why the EU Ecolabel ambition levels look a lot stricter than the CEPS data presented above in **Error! Reference source not found.**.

Some of the variation in specific gas consumption data may be associated with factories or companies that:

- produce spray-dried atomised powder onsite for their own consumption and for sale to third parties (much higher specific consumption);
- produce spray-dried atomized powder onsite only for their own consumption (higher specific consumption);
- only buy already-atomised powder from third party producers (lower specific consumption).

Centro Ceramico (IT): This distinction between the 3 main production modes is very well reflected by data recently published by Centro Ceramico (CC, 2017) where national averages over a 8 year period were reported for each production mode.

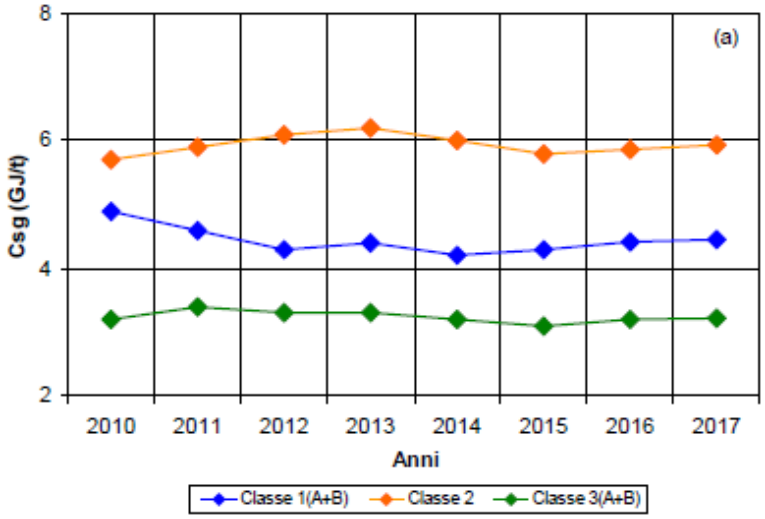

Figure 19. Average specific fuel consumption for ceramic tile production in Italy (CC, 2017).

Not to be confused with the Class I, II and III products defined in EN 14411, the data for Italian ceramic tile production shows a clear difference between the different production modes. The highest data corresponds to "Class 2" production mode, which means those facilities that produce spray-dried powder onsite for their own consumption and for sale to third parties. The next highest data is that of "Class 1" production mode, which corresponds to the production of spray dried powder for own consumption only. Finally, the lowest data corresponds to the "Class 3" production mode, where spray-dried powder is purchased and so the only fuel consumption is with the ware dryer and kiln.

The average Italian "Class 3" data is around **3,5 MJ/kg**, which is the same as the 2009 EU Ecolabel requirement. The average Italian "Class 1" data is around **4,5 to 5,0 MJ/kg**. This implies a specific consumption for spray-drying of **1,0 to 1,5 MJ/kg**.

The main reason for the wide difference in performance from CEPS (2017) is likely to be due to the varying degrees of:

- heat recovery that are achieved (higher recovery means lower specific gas consumption);
- average operating capacity as a % of maximum (closer to 100% means lower specific gas consumption);
- around the clock operation (closer to 24 hours per day / 7 days per week means lower specific gas consumption).

The only factor that can be directly controlled by the producer is the installation of heat recovery equipment. The other two factors listed above depend on demand-side signals and commercial strategies at the sectorial level.

AVEN (ES): Data published in 2011 about in-situ measured fuel consumption for spray-drying, ware drying and kiln firing processes during ceramic tile production are presented below.

Table 11. Specific thermal energy consumption values reported in Spain (AVEN, 2011)

Process stage	Thermal energy consumption (MJ/t tile)		Number of installations tested	Number of measurements
	LHV*	HHV*		
Spray-drying	1,66 ±0,072	1,84 ±0,083	12	24
Ware drying	0,40 ±0,040	0,45 ±0,043	5	13
Kiln firing	2,578 ±0,047	2,855 ±0,050	52	207
Total	4,64 ±0,158	5,14 ±0,176	69	244

**LHV = Lower Heating Value (38,79 MJ/m^3_N used) and HHV = Higher Heating Value (43,00 MJ/m^3_N used).*

The data for spray drying seems significantly higher (**1,6 to 1,9 MJ/kg**) than that in Italy (**1,0 to 1,5 MJ/kg**). However, it must be noted that the Spanish data is reported as per tonne of tile product, so there will be some losses of material that are being considered that are beyond the scope of the spray dryer unit.

The average data for the ware-dryer + kiln show ranges of **2,9 to 3,3 MJ/kg**, depending on the heating value for the gas that is used.

Considering that the average data presented from CC (2017) and AVEN (2011) already complies with the original EU Ecolabel limit of 3,5 MJ/kg, it was proposed to lower the threshold for EU Ecolabel further. However, feedback from industry representatives stated that the values reported by AVEN (2011) were based on spot measurements during production and that this is very different to measurements taken over an entire year. The key point to bear in mind is that kiln temperatures need to be maintained, regardless of the production rate. Consequently, higher values result from measurements taken over longer periods because it includes fuel consumption when production rates are not at a maximum level (e.g. during weekends and night shifts) and when production is temporarily halted (e.g. when changing tile format or type).

This led to a broader discussion about how EU Ecolabel licenses were being awarded. There are two main situations that can occur:

- Where specific individual products are licensed amongst a much broader range of products in a given installation or production line.
- Where a large group of products (family of products) for a complete production line(s) are to be licensed.

In the first case, lower values are justifiable because it would be necessary to take measurements for representative periods during actual production (losses of efficiency when changing to production runs of different formats are not considered).

In the second case, significantly higher values were proposed by industry representatives to account for losses in efficiency due to deviations from maximum production rates caused by day-to-day production planning. To support this argument, they stated that average ceramic tile production run lengths were decreasing as global demand decreased and as niche markets in customised products became more important. The scope for customisation has been greatly increased thanks to the possibility to decorate tile surfaces using inkjet printing.

Fuel consumption for fired clay paver production

No specific reports were found about energy consumption for fired-clay paver production. Since the technology is essentially the same as for brick production, data for brick production was used as a proxy.

Gas consumption data for brick and tile production was presented in the CEPS (2017) report as well (a total of 23 companies responded to the CEPS survey, see data below). One of the main purposes of this was to determine if different specific kiln energy consumption values can be justified for brick and (roof) tile products.

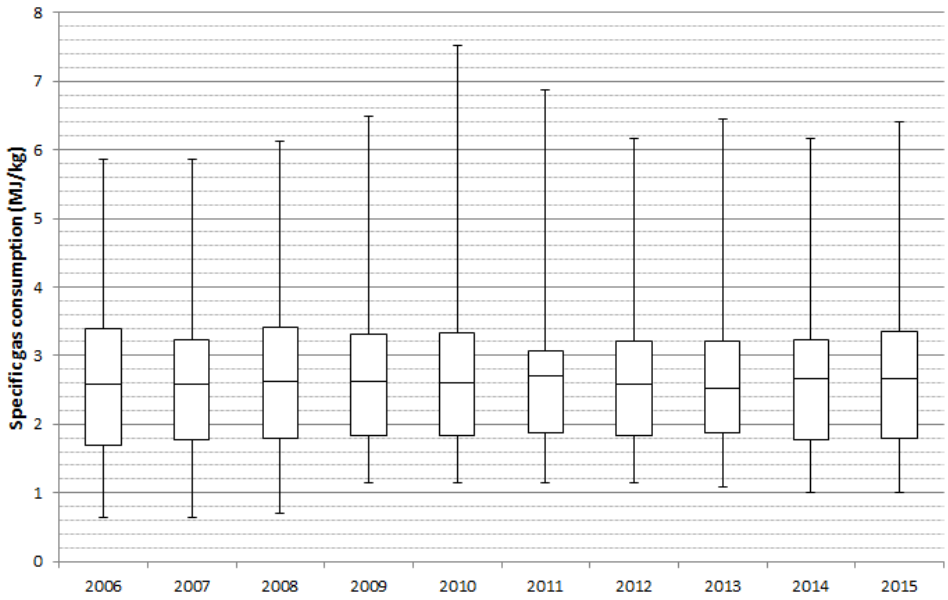

Figure 20. Specific gas consumption for ceramic brick and (roof) tile production

In general, the specific gas consumption values are much lower than the equivalent data for ceramic floor and wall tiles and also much more consistent. The following observations can be made:

- Maximum values ranged from around **5,8 to 7,5 MJ/kg** for brick and tile, much lower than floor and wall tile (10,5 to 17 MJ/kg).
- The data was centered (i.e. 1st to 3rd quartiles) around **1.8-3.4 MJ/kg** for brick and tile, again much lower than floor and wall tile (5,0 to 7,5 MJ/kg).
- The lowest values ranged from **0,6 to 1,2 MJ/kg**, again much lower than floor and wall tile (1,0 to 2,0 MJ/kg).

Overall, the CEPS data clearly indicate that a lower specific energy consumption limit should be set for brick (median 2,65 MJ/kg) than for ceramic tile type products (median 5,1 MJ/kg). Unfortunately the CEPS data do not describe any split between gas consumption in dryers and kilns. Furthermore, the data from the brick and tile sector is not broken down into the type of product required.

Data from 2007 regarding 73 brick kilns in UK revealed the following cumulative distribution of specific fuel energy consumption:

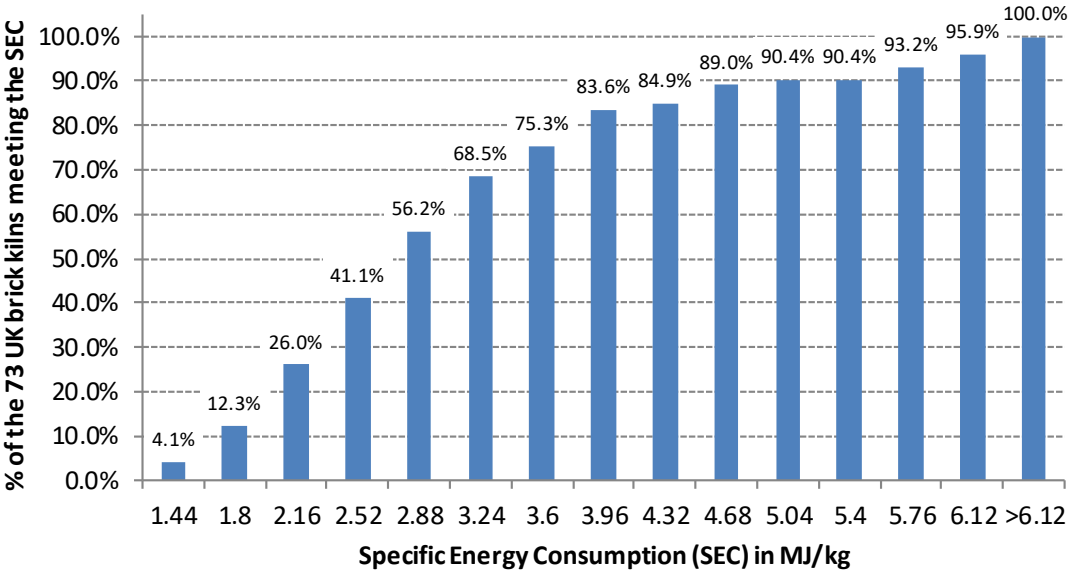

Figure 21. Specific energy consumption values for brick production in the UK (Source: Carbon Trust, 2010)

Looking at the data for UK brick kilns, a third quartile value that would serve as a basis for a mandatory upper limit for EU Ecolabel criteria would be around **3,6 MJ/kg** and a threshold for environmental excellence, corresponding to the top 25% of products, could be around **2,1 MJ/kg**. The same range of data could be expected to apply to fired clay paving blocks given the similarities in these types of product and how densely they can be loaded on kiln cars.

A more focused set of data is reported in section 3.3.1.2 of the BREF document (BREF, 2007), specific gas consumption values of **1,02-1,87 MJ/kg** for masonry units, **2,87 MJ/kg** for facing bricks and **1,97-2,93 MJ/kg** for roof tiles were reported by the Austrian Member of the Technical Working Group. The values depend on the final required density of the product (higher density means higher firing temperatures) and organic content (higher organic content could reduce fuel requirement but may affect product density).

A report published by the UK Carbon Trust (Carbon Trust, 2010) looked at three different brick kilns and reported the following data:

- Extruded brick process (using a green brick with a 15% moisture content dried to 1% and firing at 1060°C for 52 hours): 73 kWh/t electricity and 691 kWh/t gas, or **2,49 MJ gas/kg** of brick production.
- Extruded brick process (using a green brick with a 15% moisture content dried to 0% and firing at 1000°C for 75 hours): 161 kWh/t electricity and 596 kWh/t gas, or **2,15 MJ gas/kg** of brick production.
- Soft-mud process (using a green brick with a moisture content of 26% dried to 2% and firing at 1030°C for 140 hours): 57 kWh/t electricity and 657 kWh/t gas, or **2,37 MJ gas /kg** of brick production.

The Brick Sustainability Report (BDA, 2017) stated an average specific energy consumption of between 727 and 763 kWh/t for the years 2011 to 2016. These values were the sum of electricity and fuel consumption. Applying a fuel of thumb assumption that 90% of the total energy consumption is via fuels, and converting the units into MJ/kg, the values would be **2,35 to 2,47 MJ/kg** for brick production (drying and firing).

The importance of production run volume on specific fuel consumption

One aspect that influences the specific fuel energy consumption, but which cannot be directly controlled in continuously operating kilns, is the loading capacity which the kiln is run at (this will be influenced by stock levels and the variations in product demand). Example data from a real-life tunnel kiln producing bricks in the UK is reproduced below (Carbon Trust, 2010):

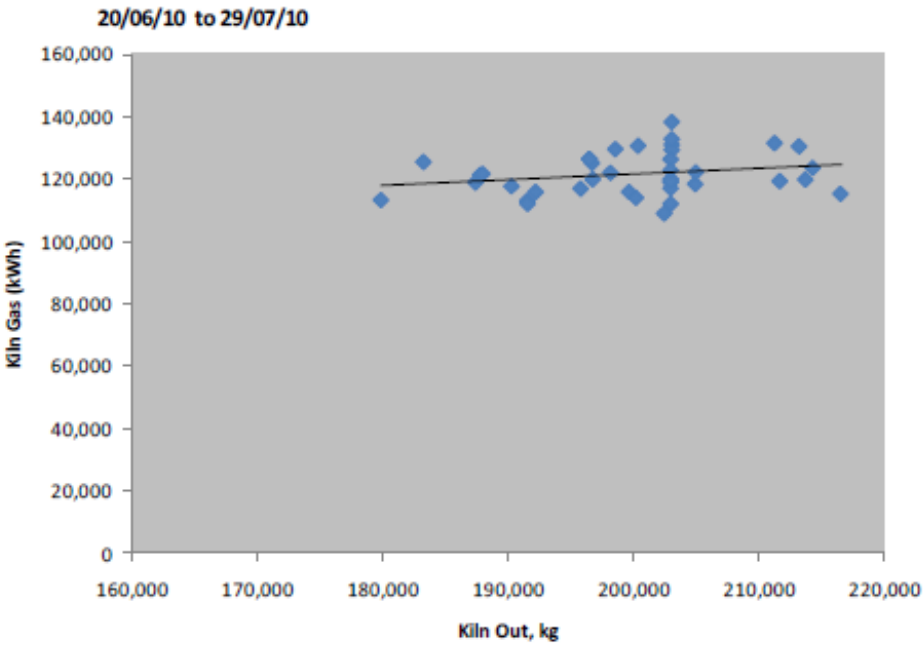

Figure 22. Kiln gas consumption as a variation with kiln output.

The data presented above show a very modest increase in kiln gas consumption when the kiln output increases from 180 to 215t. This data implies that the main losses of thermal energy from the kiln are almost independent of the loading rate. The modest increase can be expected simply due to the energy required for the heating of green ceramic bodies and to make the mineralogical transformations take place. However, as seen in Figure 17. further above, the heat transferred to bricks was only a small proportion of the total heat energy consumption in the first place.

Especially with roller hearth kilns, it is important to note that larger scale ovens are only rarely switched off (e.g. for annual maintenance works) due to the challenges of start-up and the time it takes to achieve a steady-state operation. Instead, the oven is also maintained at a baseline temperature and has firing sections where higher temperatures are applied that depend on the mineral composition of the tile and the final properties that are desired.

These points above lead to the conclusion that specific fuel energy consumption will be lowest in kiln/dryer systems that run closer to their maximum capacity.

A consideration of Combined Heat and Power (CHP) units in the ceramic sector

The proposed EU Ecolabel criteria allow for any electricity generated by onsite CHP units to be subtracted from the total specific fuel consumption. Industry stakeholders confirmed that CHP units were associated with spray-drying and drying units only, and not with the kiln itself.

According to Cerame-Unie (2012) there were around 250 CHP units installed in the European ceramic sector in 2012, with an average installed capacity of 3MW (the largest one being 15MW and many units having a capacity <1MW). Overall, it was stated that installed capacity was around 700MW and that 3000 GWh/yr (or 10800 TJ/yr) of electricity was generated (Batier, 2013).

Consequently, it can be understood that CHP technology is a reality in the production of spray dried powder for ceramic tile manufacture and the EU Ecolabel criteria should aim to capture the environmental benefits that are achieved by installations that have invested in such technology.

Criterion 4.2. CO2 emissions

Criterion 4.2. CO2 emissions

The specific CO2 emissions associated with fuel combustion and process emissions from raw material decarbonation during drying and firing processes shall not exceed the relevant mandatory limits defined below.

	Spray dried powder production		Ware dryer & kiln**	
	Mandatory limit	**Threshold of environmental excellence**	**Mandatory limit**	**Threshold of environmental excellence**
Ceramic tile: individual product***	84 $kgCO_2/t$ powder*	54 $kgCO_2/t$ powder*	280 $kgCO_2/t$	230 $kgCO_2/t$
Ceramic tile: family of products****			360 $kgCO_2/t$	290 $kgCO_2/t$
Fired clay pavers	n/a	n/a	192 $kgCO_2/t$	129 $kgCO_2/t$

**limit applies only to fuel consumed in the spray dryer, 1 kg of dried powder includes any residual moisture content, which would typically be 5-7%*

***limit applies only to fuel consumed in the ware dryer and kiln and estimated process emissions in the kiln*

****based on fuel consumption data measured under stable operating conditions that are representative of the product during the production run and assumed process emissions in the kiln from raw material carbonate content*

*****based on fuel consumption data measured over a period of one year, including baseline fuel consumption between production runs and assumed process emissions in the kiln from raw material carbonate content.*

In addition, up to 25 points shall be awarded in proportion to how much the specific CO2 emissions are reduced towards the relevant threshold of environmental excellence indicated in the table above (e.g. for fired clay pavers: from 0 points for 192 $kgCO_2/t$, up to 25 points for 129 $kgCO_2/t$).

For ceramic tile products where spray-dried powder is used (either produced onsite or offsite), two scores shall be calculated as per the previous paragraph, one for the spray dried powder (SDP) and one for the ceramic tile kiln and ware dryer (KWD). The two scores shall then be converted into a single score as follows:

$$CO2_{score} = 0{,}35(SDP) + 0{,}65(KWD)$$

Assessment and verification: *The applicant shall provide a declaration of compliance with the mandatory requirement of this criterion, supported by a statement of the calculated specific CO2 emission in accordance with the following relevant methodology described below.*

For products from installations within the scope of Directive 2003/87/EC of the European Parliament and of the Council[30], the calculation of specific emissions per tonne of product shall be based on the emissions level and activity levels as per the monitoring methodology plan established under Article 6 of Regulation (EU) 2019/331 of the European Parliament and of the Council[31] on free allocation rules.

[30] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (OJ L 275, 25.10.2003, p.32).

[31] Commission Delegated Regulation (EU) 2019/331 of 19 December 2018 determining transitional Union-wide rules for harmonised free allocation of emission allowances pursuant to Article 10a of Directive 2003/87/EC of the European Parliament and of the Council (OJ L 59, 27.2.2019, p. 8).

For products from installations not within the scope of Directive 2003/87/EC, results shall be declared in accordance with the relevant calculation methodology defined in Commission Regulation (EU) No 601/2012[32].

For ceramic products that use spray dried powder produced in a separate installation as a raw material, the applicant shall provide a declaration from the spray dried powder producer stating the value of the annual average specific CO2 emission value, in accordance with one of the two calculation methods described above for the most recent year of reporting.

In all cases, the specific CO2 emission value shall be estimated at the level of the EU Ecolabel product(s) covered by the EU Ecolabel license. The relevant fuel consumption values calculated for criterion 4.1, the carbon intensities of the fuel(s) used and the average carbonate content of the raw material shall be used as the basis for calculating CO2 emissions.

Rationale:

<u>*Links to policy*</u>

Emissions of CO_2 have been at the very top of the scientific and political agenda for climate change for well over a decade and will continue to be so (EC, 2018b).

Almost 19 Mt of CO_2 was estimated to be emitted from the European sectors for the production of brick and tile, of ceramic floor and wall tile and of refractories. These emissions were split as follows:

- 66% due to fuel consumption
- 18% due to electricity production
- 16% due to process emissions

This priority focus has led to the European ceramics sector publishing its own roadmap to 2050 (Cerame-Unie, 2012), with a strong focus on the options available to reduce CO2 emissions from the sector. Different mandatory and voluntary policies being applied to the ceramic sector (and other energy intensive sectors) to manage CO2 emissions.

At the most focused end of the policy spectrum is the mandatory reporting of CO2 emissions under the Emissions Trading Scheme (ETS), where only emissions from the site are included (i.e. not those from grid electricity or raw material production).

At the broader end of the policy spectrum are the Product Category Rules that are defined for voluntary Environmental Product Declarations, where all sorts of variables that influence the final CO2 "*footprint*" of the product can be considered (e.g. assumptions about electricity grid factors, assumptions about transport of raw materials, assumptions about embodied carbon in raw materials etc.).

All large scale ceramic tile and fired clay product producers are obliged to report on emissions of CO2 under the more focused ETS calculations. The coverage of EPD style calculations is less clear, although sectoral average EPDs for ceramic floor and wall tiles have been published by the German, Italian and Spanish sectors (covering over 75% of European ceramic tile production) the coverage of fired-clay pavers by EPDs was not so clear.

Some industry stakeholders representing the ceramic tile sector emphasized that they did not wish to see the EU Ecolabel become a type of EPD+ scheme. This was mainly because of the many different ways in which EPD numbers can be manipulated (e.g. convenient selection of primary and secondary data, assumptions for transport etc.) and because it would require companies to contract LCA experts. Consequently, if any criterion on CO_2 is to be inserted, it should be focused on actual emissions at the site and not the CO_2 footprint of the product.

[32] Commission Regulation (EU) No 601/2012 of 21 June 2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council OJ L 181, 12.7.2012, p. 30.

Overall, thanks both to the mandatory reporting requirements of the ETS and the voluntary requirements of EPDs, the ceramic and fired clay sector is well-placed to assess and verify the requirements on CO2 emissions that have been set under EU Ecolabel criteria.

Ambition level

The choice of ambition level has been based on discussions with Commission representatives in DG CLIMA and specifically about anonymized data submitted by relevant installations under ETS reporting requirements.

Thresholds for fired clay pavers and spray-dried powder have been set to match the mandatory requirement to the top 50% of relevant installations, while the threshold of environmental excellence aims to reflect the top 10% of installations.

The assessment and verification methodology is matched to that defined in the ETS legislation.

However, the same approach could not be applied for ceramic tiles because no ETS benchmark has been set. The choice of ambition level is therefore a direct translation of the fuel consumption data from criterion 4.1 into specific CO2 emissions plus an allowance for process emissions.

Ceramic tile ambition level approach in more detail

Translating the fuel energy reference values in criterion 4.1 (in MJ/kg product) into specific CO2 emissions (in kg CO2/t product) has been done by multiplying by a carbon emission factor of 56,1 tCO_2/TJ (equivalent to 56,1 $kgCO_2$/GJ or 56,1 gCO_2/MJ), which is typical of natural gas. It is also worth mentioning that an extra 50 $kgCO_2$/t product has been added to the reference values for fired products to account for process emissions (see sub-section below).

Table 12. Example translations of mandatory energy reference values into CO2 reference values

Product type	Criterion 4.1 reference value	Multiplying by 56.1 gCO2/MJ and then both sides by 1000 (i.e. g→kg and kg→t)	Adding 50 kgCO2/t for process emissions
Spray-dried powder	1,8 MJ/kg	101 kgCO2/t	n/a
ceramic tile: individual product	4,1 MJ/kg	230 $kgCO_2$/t product	280 $kgCO_2$/t product
ceramic tile: family of products	5,5 MJ/kg	309 $kgCO_2$/t product	359 $kgCO_2$/t product†
Fired clay pavers	3,5 MJ/kg	196 $kgCO_2$/t product	246 $kgCO_2$/t product†

All major ceramic tile producers (production capacity >75t/d) need to report on CO_2 emissions under the ETS. Specific CO_2 emissions can be simply calculated by multiplying the result for indicator 4.1 by the calorific value and carbon factor provided by the gas/fuel supplier, or by using default values in Annex VI to Regulation (EC) No 601/2012).

Table 13. Selected fuel emission factors and calorific values from Regulation 601/2012

Fuel type	Emission factor (t CO2/TJ)	Net calorific value (TJ/Gg)
Anthracite (coal)	98,3	26,7
Other bituminous coal	94,6	25,8
Sub-bituminous coal	96,1	18,9
Lignite	101,0	11,9
Liquified petroleum gas	63,1	47,3
Natural gas	56,1	48,0
Landfill gas	-	50,4

Fuel type	Emission factor (t CO2/TJ)	Net calorific value (TJ/Gg)
Sludge gas	-	50,4

The main fuel used by the ceramic tile sector in general is natural gas. Compared to other fossil fuels, it has the lowest carbon emission factor. Consequently the shift from fuels like coal and fuel oil to natural gas has helped the ceramic sector reduce its specific CO_2 emissions already.

By setting reference values based on fuel energy requirements (in MJ/kg) and linking this them to the carbon emission factor of natural gas (in kg CO_2/MJ), the EU Ecolabel criterion would encourage both improved energy efficiency and the use of biogas derived from non-fossil sources, such as sludge and landfills. However, it is claimed that biogas is currently 2-3 times more expensive than natural gas.

The exclusion of electricity from CO2 calculations

Emissions of CO_2 associated with electricity consumption are not considered for ceramic tiles since they are not considered in criterion 4.1 either. Trying to account for CO2 emissions from electricity consumption can be complicated due to the need to define assumptions for grid factors (which can change rapidly in real time) and from any changes in electricity supplier.

The exclusion of electricity can be further justified by the fact that it typically only accounts for around 10% of the total process energy consumption associated with the ceramic and fired clay products within this product group scope. The ETS calculation for other manufacturing sectors does not account for grid electricity used either.

Process emissions of CO2 (i.e. raw material decarbonation)

Process emissions of CO_2 are related to the thermal decomposition of carbonate minerals in the raw materials. Carbonate content can be assumed to be mostly broken down into CO_2 plus the residual oxide under the normal processing conditions of ceramic or fired clay product firing. Carbonate content is an important parameter to monitor and must be tightly restricted for low porosity products such as porcelain tiles. Monfort et al., (2010) presented results of CO_2 emissions associated with 4 different products (see below).

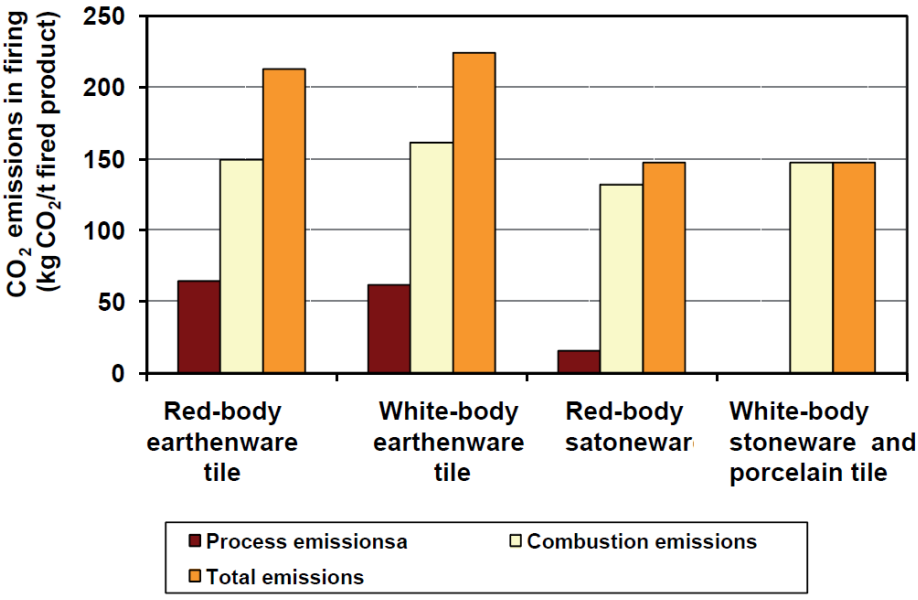

Figure 23. CO2 emissions for production of different ceramic tile products (Source: Monfort et al., 2010)

When looking only at fuel combustion in the kiln and process emissions, the graph above shows that decarbonation can vary from 0% to over 25% of total kiln CO2 emissions. The relevant data were:

- Red-body earthenware: carbonate content 13,1%; process emissions 64 $kgCO_2/t$
- White-body earthenware: carbonate content 12,5%; process emissions 61 $kgCO_2/t$
- Red-body stoneware: carbonate content 3,3%; process emissions 15 $kgCO_2/t$
- White-body porcelain and stoneware: carbonate content <0,5%; process emissions <1 $kgCO_2/t$

The same study also showed that CO_2 emissions from the spray dryer accounted for 27-36% of total fuel and process emissions and that CO_2 emissions from green body dryers accounted for 6-9% of total fuel and process emissions.

Due to the significant differences that can exist in carbonate content, it seems reasonable to account for this in the CO_2 criterion. For fuel consumption reference emissions, by assuming that all fuel used was natural gas, other fossil fuels are penalised and renewable fuels incentivised.

Criterion 4.3. Process water consumption

Criterion 4.3. Process water consumption

The facility producing the ceramic or fired clay product shall either:

- Have a closed loop wastewater recycling system for process wastewater that facilitates zero liquid discharge; or
- Be able to demonstrate that specific freshwater consumption is less than or equal to the consumption limits defined in the table below.

Product type	Is spray drying carried out onsite?	Consumption limit
ceramic tiles and fired clay pavers	Yes	1,0 L/kg
	No	0,5 L/kg

Assessment and verification: *The applicant shall provide a declaration of compliance with the mandatory requirement, stating by which means they comply.*

In cases where a zero liquid discharge system is in place for recycling process wastewater, they shall provide a brief description of the system and its main operating parameters.

In cases where such a system is not in place, total process water consumption data (in L or m^3) and the total ceramic or fired clay production data (in kg or m^2) shall be provided for the most recent calendar year or rolling 12 month period prior to the date of award of the EU Ecolabel.

In case it is not possible to provide specific data for a production line or product, the applicant shall refer to data for the entire plant.

Water consumption due to toilets, canteens and other activities not directly relevant to the production process should be metered separately and not be included in the calculation.

Rationale:

The importance of specific water consumption

According to the European Environment Agency, a total of 36 river basins in Europe, covering 19% of Europe's territory, suffered from water scarcity in the summer of 2015. An arbitrary definition of a water scare region is when more than 20% of the natural freshwater resources are abstracted for human activities (i.e. agriculture, power generation, manufacturing, service industries and urban consumption). The total abstraction of water for human activities as a fraction of the total available freshwater resources is expressed as the Water Exploitation Index (WEI).

Water scarcity, that is to say WEI, is measured at the level of the river basin by the European Environment Agency. It is interesting to consider the data for the river basins in which the two dominant ceramic producing regions in Europe are located: Castellón in Spain and Sassuolo in Italy.

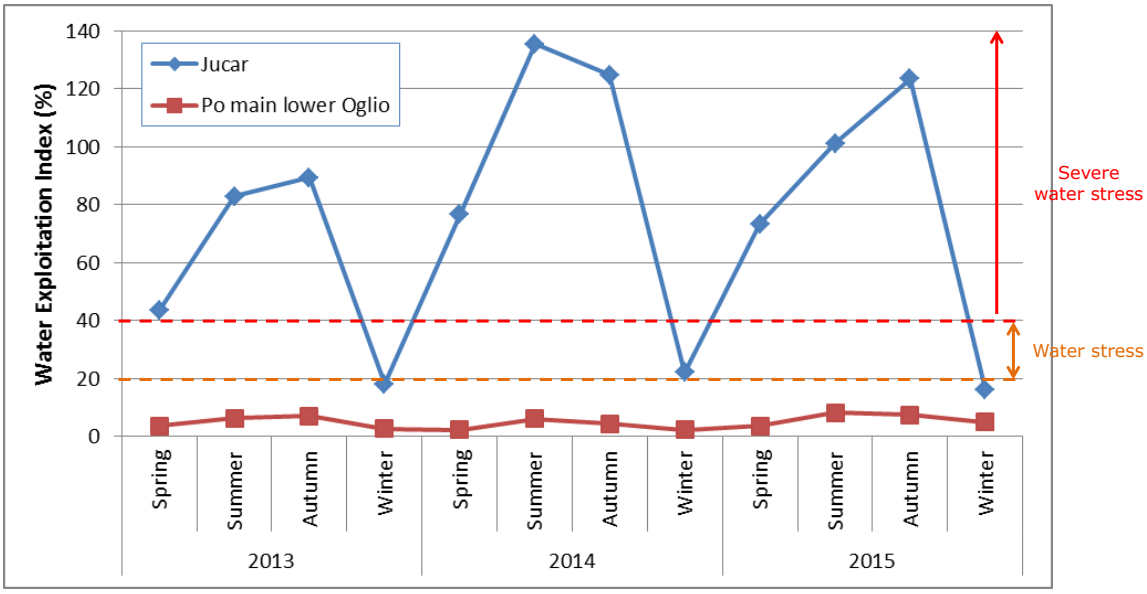

Figure 24. Trends in water stress in the Castellon and Sassuolo district river basins (Jucar and Po respectively). Source: EEA.

The data in Figure 24 show that the Jucar basin has been almost continually classified as being under water stress during the last 3 years, even during winter periods when demand for irrigation water for agriculture is greatly reduced. In some cases the human abstraction of freshwater actually exceeded 100%, which is either a methodological flaw or represents the tapping into not normally available freshwater reserves such as deep aquifers. In either case, the numbers serve to highlight the importance of efficient water consumption in the Castellon region, via ceramic tile production or any other water demanding activity.

On the other hand, the Po (main lower Oglio) river basin in which the Sassuolo ceramic cluster is located does not suffer from any obvious water stress. Even in this case, water recycling is important in order to lower costs associated with water abstraction and wastewater discharge.

Ceramic tile production requires a significant quantity of water for wet grinding, to prepare clay and glaze slips, to obtain the correct plasticity of clay bodies prior to pressing or extrusion and for general washing and cooling purposes.

Two separate limits have been specified depending on what processes are carried out at the applicant's plant. In cases where grinding and spray drying of raw materials is not carried out, because they instead purchase the spray dried material, there is a significantly reduced water demand. According to some industry stakeholders, this could be reflected by a 50% reduction in specific freshwater consumption rates.

Why no longer any requirement for water recycling ratio proposed?

One of the concerns about the water recycling ratio is that it will be easier to meet a high recycling ratio when large amounts of water are consumed in the first place. By having a fixed requirement on specific freshwater consumption only, potential applicants have a more flexible choice: either use dry processes in the first place or use wetter processes and recycle the water in an efficient manner. To illustrate this point, the dry and wet grinding processes can be considered.

The grinding stage consumes a significant quantity of water. Even with dry grinding, it is necessary to soak the ground powder to a moisture content of 7-12% prior to optimised drying of the moistened granules, which will carry a moisture content of around 6-7%. Wet grinding is generally considered to consume around 4 times as much water (wet ground raw materials will have a moisture content of 42-50%) which is then dried to a moisture content of 5-6%. Consequently, there is a much higher quantity of water available for recycling when wet grinding processes are used.

Alignment with draft ISO 17889-1 standard

The draft ISO 17889-1 standard for sustainable ceramic tiles sets a criterion for "*specific freshwater consumption*" and makes a distinction in values depending on whether the product unit is m^2 or kg. In total, 4 different limits are set:

- <20 L/m^2 or <1000 L/t;
- 20-24 L/m^2 or 1000-1200 L/t;
- 24-28 L/m^2 or 1200-1400 L/t and
- >28 L/m^2 or >1400 L/t;

The EU Ecolabel proposal aligns with this most ambitious level of the ISO 17889-1 draft standard (<20 L/m^2 or <1000 L/t).

Data consulted

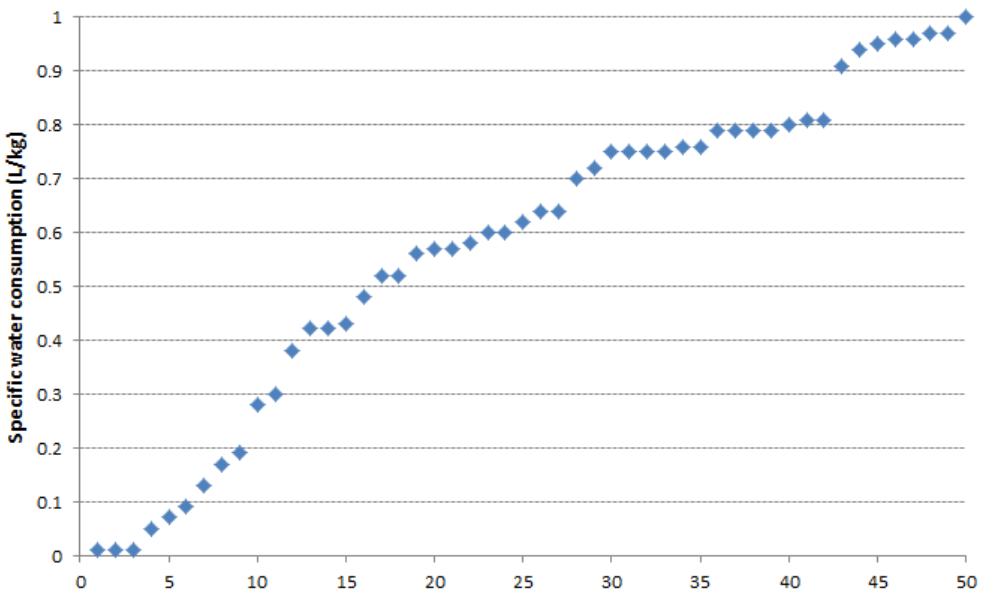

Figure 25. Anonymised data reported by existing EU Ecolabel license holders

Specific water consumption values range from 0,01 to 1,0 L/kg, a factor of 100 difference that surely cannot be accounted for by differences in process techniques alone (e.g. dry milling versus met milling and dry-pressing versus extrusion).

In terms of other fired clay products, data from the 2016 Brick Sustainability Report (BDA, 2017) suggests that a normal range of specific water consumption for brick production would be 125 to 200 L/t (see below).

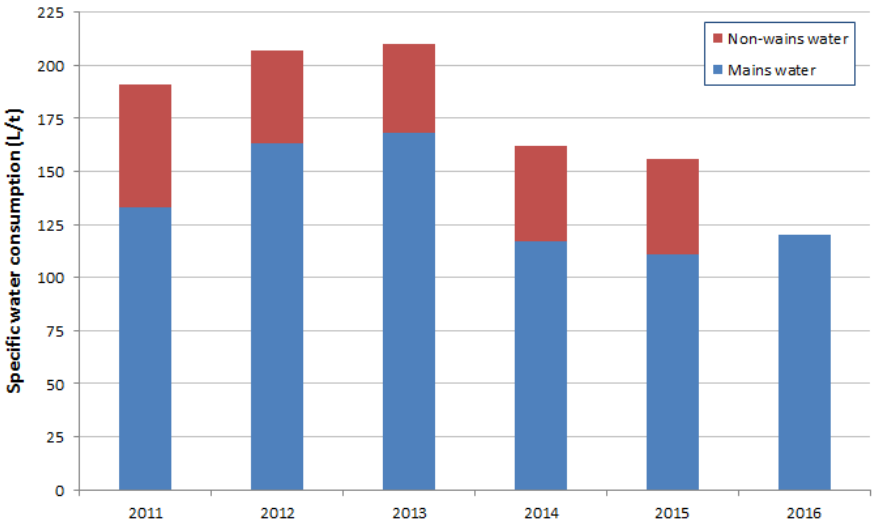

Figure 26. Trend in specific water consumption for the UK brick industry.

The value range for brick production is equivalent to 120 to 200 L/t (or 0,12 to 0,20 L/kg), which is considerably lower than the values reported for ceramic tile production. This could be considered surprising since bricks tend to be produced via the wet extrusion process, which results in green bodies with significantly higher water contents (e.g. 15-25%) than ceramic tiles (e.g. 5-7%).

In any case, based on this data, it is not considered necessary to define a separate higher specific water consumption threshold for other fired clay products.

Criterion 4.4. Emissions of dust, HF, NOx and SOx to air

Criterion 4.4. Emissions of dust, HF, NOx and SOx to air

Measures to reduce dust emissions from "cold" dusty operations at the ceramic tile production site shall cover at least the reception, blending and milling of raw materials and the shaping and glazing/decoration of tiles.

The specific dust, HF, NOx and SOx emissions to air associated with the production of ceramic or fired clay products shall not exceed the relevant mandatory limits defined in the table below.

Emission parameter	Mandatory limit	Threshold of environmental excellence	Test method	Points available
Dust (spray dryer)*	90 mg/kg	n/a	EN 13284	n/a
Dust (kiln)	50 mg/kg	10 mg/kg	EN 13284	Up to 10
HF (kiln)	20 mg/kg	6 mg/kg	ISO 15713	Up to 10
NOx as NO_2 (kiln)	250 mg/kg	170 mg/kg	EN 14792	Up to 10
SOx as SO_2 (kiln)	1300 mg/kg	750 mg/kg	EN 14791	Up to 10

**Only relevant for products that use spray-dried powder as a raw material*

In addition, up to 40 points shall be awarded in proportion to how much the actual specific emissions of dust, HF, NOx and SOx are reduced towards the relevant thresholds of environmental excellence indicated in the table above (e.g. for HF emissions: from 0 points for 20 mg/kg, up to 10 points for ≤6 mg/kg).

Assessment and verification: *The applicant shall provide a declaration of compliance with the mandatory requirements of this criterion, supported by (i) a description of the measures in place to reduce dust emissions from "cold" dusty operations and, (ii) site data in mg/Nm^3 and expressed as an annual average value calculated from daily average values. The data shall have been generated via continuous or periodic monitoring according to relevant EN or ISO standards. In cases of periodic monitoring, at least three samples shall be taken during stable running of the spray dryer or kiln for production runs of the EU Ecolabel product(s).*

In cases where production data is only available in m^2 but needs to be reported in kg, the value should be converted using a fixed bulk density factor (in kg/m^2) for the product or family of products.

Data for an entire family of products should be representative of any production line(s) for a 12 month period prior to the date of award of the EU Ecolabel. Data for specific individual products should be representative of stable conditions during the actual production run(s).

To convert exhaust gas monitoring results from mg/Nm^3 (at 18% O2 content) into mg/kg of ceramic/fired clay product, it is necessary to multiply by the specific gas flow volume (Nm^3/kg product). One Nm^3 refers to one m^3 of dry gas under standard conditions of 273K and 101,3 kPa.

In case it is not possible to provide specific data for a production line or product, the applicant shall refer to data for the entire plant and allocate emissions to the EU Ecolabel production on a per mass basis.

Rationale:

The existing emission to air limit values set out in Decision 2009/607/EC were considered in the context of data from a variety of sources.

Table 14. Data sources examined for criterion 4.4.

Data source	Comments
The reference document for BAT in the ceramics sector (BREF, 2007)	Currently under revision. Existing document reports values for "hot" and "cold" dust emissions, for HF, SOx and NOx, but in units of mg/Nm3 are used and to convert to mg/kg, it is necessary to multiply by specific air-flow rate, which can vary from 3-6 Nm3/kg. NOx values reported are nuanced based on firing temperature and SOx values are nuanced based on S content of raw material.
The draft ISO 17889-1 standard for sustainable ceramic tiles	Provides 3-4 ambition levels in units of g/t and g/m2 of ceramic tile product, but only for dust and HF, not for NOx and SOx. Dust emissions are split between "full" and "partial" cycle, which is different to the EU Ecolabel (which splits by "hot" and "cold" emissions.
The European Pollutant Release and Transfer Register (E-PRTR)	In principle very useful, values reported for dust, HF, SOx and NOx. However, in reality not useful at all because emissions only reported in kg NOx/yr and not linked to production volume (optional only and only 2% of reported data was linked to production volume. Even in those 2% of cases, the unit of volume was not specified.
Academic literature	Only a very limited number of papers reported specific enough details of emissions to air during ceramic production, the most relevant of which was Monfort et al., 2011.
Responses to a questionnaire designed by JRC for stakeholders	No responses received.
Anonymised data from existing EU Ecolabel licenses	A significant quantity of anonymised data was received, which helped assess the appropriateness of the ambition level.
A report published by Centro Ceramico for Italian ceramic tile production during 2010-2017	Average values for emissions of dust, SOx, NOx and HF are reported for different types of ceramic tile production process, the most relevant being the "Class 3" data, where only a ware dryer(s) and kiln(s) are used.

The rationale for this particular criterion proposal is presented in the following structure:

i. general environmental impacts associated with these air pollutants
ii. technical considerations relating to emissions;
iii. existing data to put the EU Ecolabel ambition level in context; and
iv. practical considerations about collecting, calculating and reporting data.

General environmental impacts associated with these air pollutants

Emissions of particulate matter (dust) are a hazard to human health via direct exposure and also via indirect effects where dust particles play a role in the formation of photochemical smog. Not all particulate matter (PM) is equal in diameter or in potential health hazards. The finer particles are much more of a concern due to their ability to penetrate into the human respiratory system when inhaled. Finer particles are more difficult to capture and will disperse further from points of release to the environment.

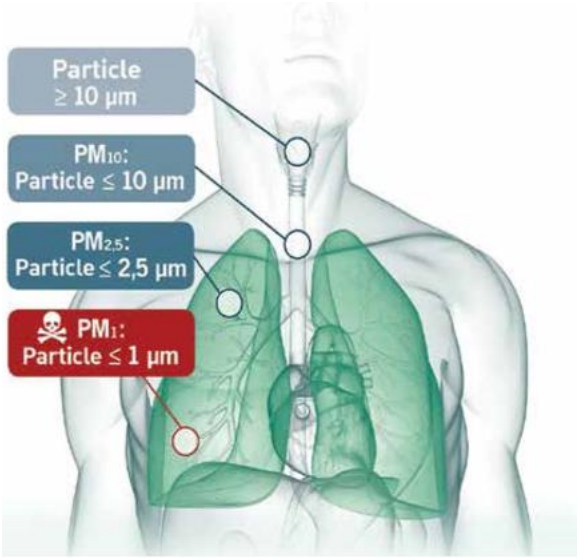

Figure 27. Potential pathways for particulate matter of different aerodynamic diameters into the human pulmonary system (Source: Eurovent, 2017)

Considering the above diagram, it is not surprising that that exposure to fine PM (i.e. $PM_{2.5}$ or finer) is associated most with mortality and hospitalisation for cardio-pulmonary disease (WHO, 2003). There is also evidence that PM in ambient air can become more harmful when present in elevated concentrations of NOx in the air and that effects on health in combination with other air pollutants are additive or greater than additive (WHO, 2013).

Although emissions of pollutants to air in Europe has improved significantly in recent decades (EEA, 2018), poor ambient air quality is still considered as the leading environmental factor linked to preventable illness and premature mortality in the EU (EC, 2013). A number of areas in the EU are failing to comply with limits set for a number of air pollutants on a regular basis. For example, a third of EU Air Quality Management Zones are exceeding limits for PM_{10} and a quarter of all zones are exceeding limits for NO2 (EC, 2013).

While many of the main contributions to poor ambient air quality are from vehicles, which is beyond the scope of these criteria, it is important to ensure that industry emissions to air do not contribute to acidification (HF, SOx and NOx) and eutrophication (NOx). Eutrophication is considered as a particularly acute problem in Europe's richest and most diverse natural areas (EC, 2013).

Technical considerations relating to emissions of dust, HF, NOx and SOx

The emissions to air are influenced by different factors due to the physicochemical environment of the production process and the process set up.

"Cold" emissions of dust will be greatly influenced by whether or not aspiration is used in areas where dusty operations are carried out. Examples of such operations are: raw material delivery and storage, blending of raw materials, milling of raw materials (dry or wet), shaping, glazing or decoration, rectification (squaring of fired tiles) and polishing.

With kiln gas, emissions of dust, HF and SOx in kiln gas can only occur when material is actively passing through the kiln. Levels of HF and SOx are especially sensitive to the F and S contents in the raw material. In contrast, NOx emissions occur continuously in the hot kiln gas almost independently of production rate and are especially sensitive to firing temperature.

EU Ecolabel limits in the context of other data sources

A comparison of the emission to air limits for dust, HF, SOx and NOx are compared between:

i. the limits set out in Decision 2009/607/EC for EU Ecolabel hard coverings;

ii. the new proposed EU Ecolabel criteria;

iii. relevant BAT ranges;

iv. ISO 17889-1, and

v. the report by CC (2017) and any relevant academic literature.

For a direct comparison to be made, a conversion factor is often necessary. In these cases, any assumptions behind the conversion factor are explained at the foot of the table and the values before and after conversion presented.

Cold process dust emissions: With controlled emissions, the BREF document defines cold emissions as: "*channelled dust emissions from dusty operations other than from drying, spray drying and firing*". The limit for EU Ecolabel cold dust emissions of 5g/m^2 set out in Decision 2009/607/EC is linked to "*emissions to air of particulates for pressing, glazing and* ***spray drying***". Industry stakeholders confirmed that dust from spray drying operations should not be considered as "cold" dust emissions.

A significant extent of the "cold" dust emissions (as defined in Decision 2009/607/EC) are actually associated with spray drying which, as mentioned earlier, may be carried out by third parties. Other dusty operations leading to cold dust emissions are:

- raw material delivery and storage,
- blending of raw materials,
- milling of raw materials (dry or wet),
- shaping,
- glazing or decoration, r
- rectification (squaring of fired tiles), and
- polishing.

The last four points on the list above are always related to the facility where the ceramic tile is produced. The first three points will be strongly influenced by whether or not spray-drying is carried out onsite.

One permitting expert explained that cold dust emissions are normally intermittent and occur at very distinct points in the factory. When dust emissions are channelled via an aspiration system, they do not all move to a central emissions stack, but pass through smaller individual stacks that are close to the source of emissions. There could be 20 individual stacks for cold dust emissions in a large ceramic tile factory and these emissions are only measured, for example, 3 times per year. Coupled with the difficulties of allocating these emissions correctly to the EU Ecolabel production, it was decided that setting specific limits on cold dust emissions per kg of production would present a disproportionate assessment and verification effort. Instead, it was considered more appropriate to simply place a mandatory requirement on which dusty operations should have measures in place to reduce dust emissions.

A limit for cold dust emissions has been removed and has been replaced by a specific limit for dust emissions from spray-drying processes.

ISO 17889-1 provides values in both mg/kg (actually g/t) and in mg/m^2 (actually g/m^2). The ISO 17889-1 values listed in the table above are the most ambitious values listed in the standard (there are 4 tiers of ambition level defined).

A direct comparison with ISO 17889-1 is not possible because of the way the relevant processes are divided (i.e. shaping is considered as a cold process for the EU Ecolabel but is included with the partial cycle by ISO 17889-1, which includes hot processes).

"Hot" process dust emissions: A check of applicable emission limit values (ELVs) for operating permits for ceramic tile production showed that specific limits for dust emission are also set for spray dryers and ware dryers in addition to kilns.

Table 15. "Hot" dust emission limits in mg/Nm3 (converted to mg/kg)*

	Kiln	Ware dryer	Spray Dryer
ES	30 (90-180*)	30 (90-180*)	30 (150**)
DE	20 (60-120*)	20 (60-120*)	20 (100**)
IT	5 (15-30*)	10 (30-60*) for glazing sections only.	30 (150**)

**multiplying value by a specific air-flow rate of 3-6 Nm³/kg ceramic tile*

***multiplying value by a specific air flow rate of 5 Nm³/kg spray dried powder*

Simply looking at the limits for spray-dryers and ware dryers, it would seem appropriate to also consider dust emission limits for ware dryers, However, due to a lack of clarity about how the different exhaust gas streams might be connected (or not) in different process configurations, it was decided to simply maintain a single limit for dust emissions from the kiln and now a new, separate limit for the spray dryer.

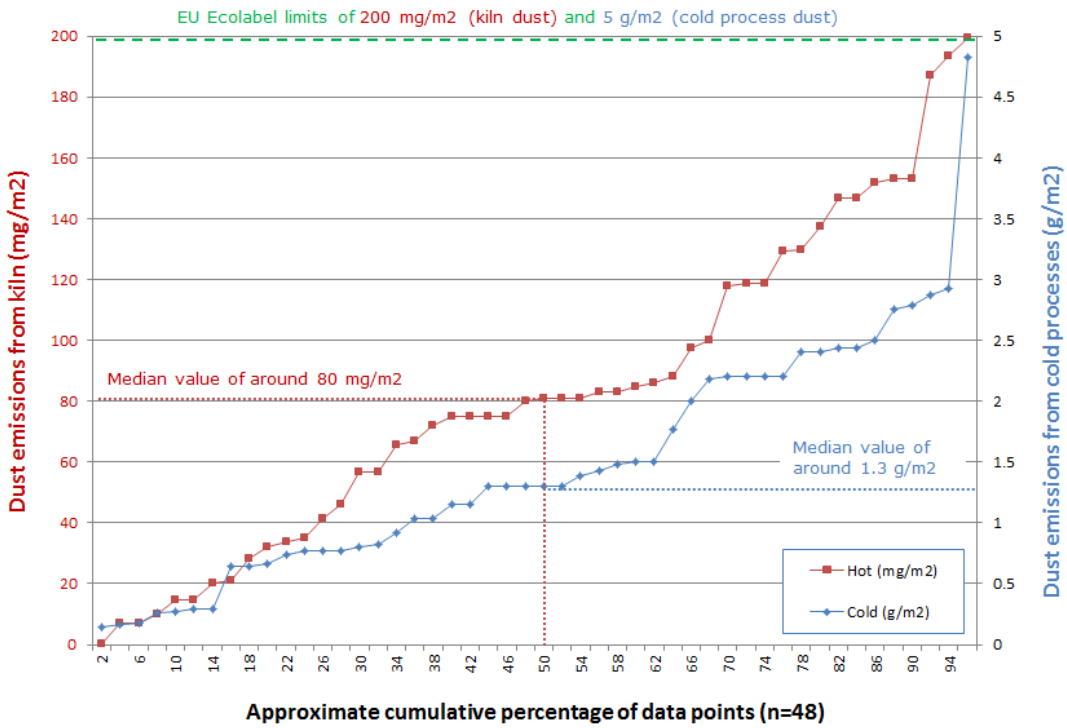

Figure 28. Specific dust emissions reported by existing EU Ecolabel license holders

Looking at the blue line (which includes emissions for spray drying plus cold sources) and comparing it to the blue axis, it is evident that almost all license holders easily complied with the 5 g/m² (250 mg/kg) limit for cold (+spray drying) emissions. This could be expected if it is assumed that "cold" dust emissions are the sum of dusty operations, spray drying and glazing, which have maximum upper BREF limits of 60, 150 and 60 mg/kg respectively (converted from mg/Nm3), summing to 270 mg/kg. Almost 90% of the data reported for the cold process dust emissions was less than half of the 5 g/m² limit set and only one data point was greater than 3 g/m². Which This gap between the upper limit for EU Ecolabel and the actual license holder data lends support to the limit for dust from spray-drying dust emissions from being 40% lower than the BREF upper ELV of 150 mg/kg (converted from 30 mg/Nm³).

Table 16. EU Ecolabel spray drying dust (top half) and kiln dust (bottom half) emission limits compared to BREF and ISO 17889-1

Source	Relevant processes (excl. kiln)	Units		
		mg/m³	mg/m²	mg/kg
BREF (2007)	Channelled dust emissions from spray drying processes (sec. 5.2.5.1)	1-30		5-150†
ISO 17889-1	Dust emissions from raw materials to final product (assumed for spray-drying plus raw material preparation by subtracting limit for partial cycle from limit for full cycle)	-	3750	190
Decision 2009/607/EC	Cold emissions (pressing, glazing and spray drying)	-	5000	250*
Existing license data	Cold emissions (pressing, glazing and spray drying)	-	200-4800 (median 1300)	10-240 (median 65)*
New EU Ecolabel criteria	Reception, blending and milling of raw materials and the shaping and glazing/decoration of tiles.	No limit set, simply requirements to have abatement system in place for these various sources of dust emission		
Source	**Relevant processes (kiln)**	**Units**		
		mg/m³	**mg/m²**	**mg/kg**
BREF (2007)	Dust emissions from kiln firing processes for floor and wall tile (Table 3.28)	-	-	10-20
	Dust emissions from kiln firing processes in general (Sec. 5.1.3.4)	10-20		30-120†
	Dust emissions from kiln firing processes for floor and wall tile (Sec. 5.2.5.2)	1-5		3-30†
ISO 17889-1	Dust emissions from shaping to final product	-	1250	60
Decision 2009/607/EC	Firing stage emissions	-	200	10*
Existing license data	Firing stage emissions	-	0-200 (median 80)	0-10*
New EU Ecolabel criteria	Firing stage emissions (kiln gas)	-	-	50 (10 for max. points)

**estimated by converting values from mg/m2 to mg/kg using an assumed tile density of 20kg/m2*

†estimated by converting values from mg/m3 to mg/kg using an assumed specific kiln air flow rate of 5 Nm3/kg for spray drying or 3-6 Nm3/kg for the kiln (see Table 3.28 of BREF, 2007).

Discussion with industry stakeholders suggested that the limits of 1-5 mg/Nm3 for kiln dust in the 2007 BREF were very ambitious and only representative of production in Italy. This argument is supported by the current upper emission limit values (ELVs) shown in Table 15. The industry proposal was to: (i) raise the mandatory limit for dust emissions from 10 mg/kg to 54-68 mg/kg, based on a typical emission of 12-15 mg/Nm3 and an assumed specific airflow rate of 4,5 Nm3/kg and (ii) raise the excellence threshold from 4 mg/kg to 22,5 mg/kg, based on an assumed emission of 5 mg/Nm3 and an assumed specific airflow rate of 4,5 Nm3/kg.

The new proposals compare reasonably well to the values for ISO 17889-1, which sets the highest ambition level for dust emissions at 60 mg/kg. However, it must be noted that the ISO 17889-1 has a broader scope for dust emissions, also including dust from ware dryers and shaping. The original threshold for environmental excellence was set at the median value (80 mg/m²) of license holder data

(see the red line and red axis in Figure 28.). This would translate into a value of 4 mg/kg (and to gas concentrations of just 0,6 to 1,3 mg/Nm3). Considering that the license holder data was exclusively from Italian companies, the higher emissions claimed to be occurring in DE and ES are not shown.

The excellence level has been raised slightly in consideration of the fact that Italian producers are, at least in terms of ELVs, considerably ahead of other countries. It can also be accepted that the mandatory limit should be increased (to 50 mg/kg) to allow companies from other countries with less stringent ELVs for kiln dust to apply for the EU Ecolabel, even if they will probably lose some points here.

Although no fired clay pavers have been awarded an EU Ecolabel license, it is assumed that these values can be applied as well. Other data from BREF (see tables 3.5, 3.6, 3.7, 3.8, 3.9 and 3.27) for dust emissions in abated exhaust gases showed that concentrations ranged from 7-12 mg/Nm^3 for clinker brick & roof tile, masonry bricks, facing bricks and porous clay blocks. A notably higher average concentration of 42 mg/m^3 was reported for clay bricks. The specific air flow rates could range from around 3-6 m^3/kg, similar to roller hearth kilns.

HF emissions: The source of fluoride emissions is the raw material, which contains traces of fluoride ions that can substitute for hydroxyl groups in clay minerals. The concentration of fluoride depends on the geological history of the clay deposit (e.g. marine sediment, alluvial sediment etc.). Emissions of HF are only relevant at the firing stage because a high temperature is required to release fluorides from clay minerals. For a given fluoride content in the raw material, a number of factors influence the potential for HF emissions:

- Temperature: mineral-F is released as HF at temperatures around 550 to 700°C and CaF2 hydrolyses to HF + CaO at temperatures exceeding 900°C.
- Moisture content: the main reactions for HF formation require the presence of moisture.
- Setting and specific surface area of the ware to be fired: this will increase or decrease the rate of diffusion of H2O into the ware and HF out of the ware.
- Glazing: acting as a physical barrier to HF emission from the glazed surface area in any firing after glazing application.

Consultation of applicable emission limit values (ELVs) for operating permits for ceramic tile production showed that specific limits for HF emission are only applied to the kiln emissions.

Table 17. HF emission limits in mg/Nm3 (converted to mg/kg)*

	Kiln	Dryer	Spray Dryer
ES	10 mg/Nm3 (30-60 mg/kg*)	-	-
DE	5 mg/Nm3 (15-30 mg/kg*)	-	-
IT	5 mg/Nm3 (15-30 mg/kg*)	-	-

*multiplying value by a specific air-flow rate of 3-6 Nm^3/kg ceramic tile

Limits of either 5 or 10 mg/Nm^3 are set for the three main ceramic tile producing countries in the EU. The BREF limits, together with limits for ISO 17889-1, the 2009 EU Ecolabel criteria, the final 2020 proposal for EU Ecolabel and existing license holder data is compared in the table below.

Table 18. EU Ecolabel HF emission limits compared to BREF and ISO 17889-1

Source	Relevant processes	Units		
		mg/m^3	mg/m^2	mg/kg
BREF (2007)	HF emissions from kiln firing processes general (Table 5.1)	1-10	-	3-60†

Source	Relevant processes	Units		
		mg/m³	mg/m²	mg/kg
	HF emissions from kiln firing processes general (Table 3.28)	-	-	10-50
ISO 17889-1	HF emissions from shaping to final product	-	200	10
Decision 2009/607/EC	Firing stage emissions	-	200	10*
Existing license data	Firing stage emissions	-	0-200 (median 70)	0-10 (median 3,5)*
New EU Ecolabel criteria	Firing stage emissions (kiln gas)	-	-	20 (6 for max. points)

**estimated by converting values from mg/m2 to mg/kg using an assumed tile density of 20kg/m2*

†estimated by converting values from mg/m3 to mg/kg using an assumed specific kiln air flow rate of 3 -6 m3/kg (based on Table 3.28).

The threshold for HF emissions from the kiln gas has been increased from 10 to 20 mg/kg to account for higher potential emissions flagged up in BREF (2007). The data from existing license holders (Italy only) is shown below.

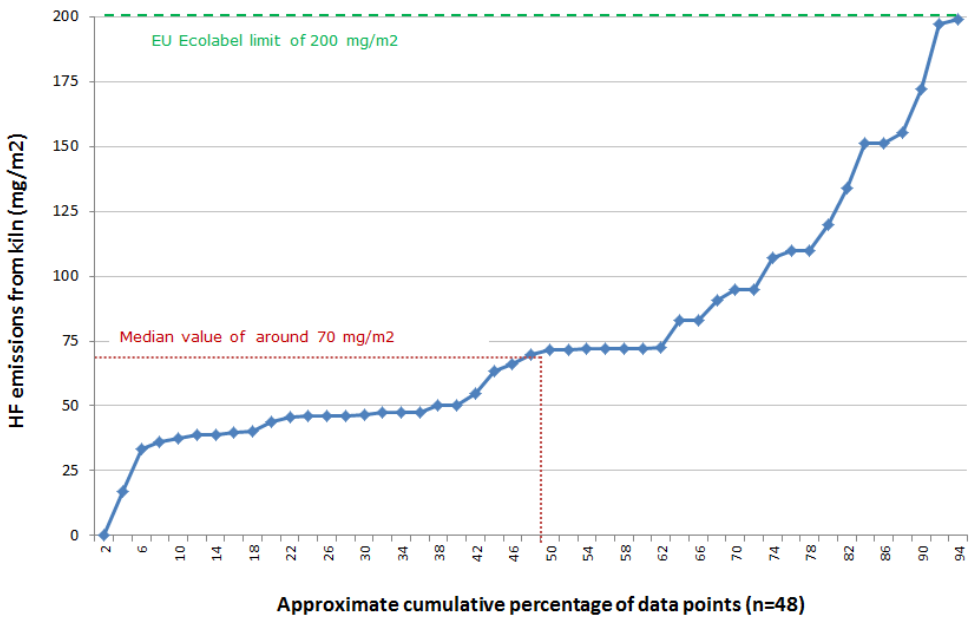

Figure 29. Specific HF emissions reported by EU Ecolabel license holders

Figure 29 showed results ranging from the upper limit of 200 mg/m² down to zero (median value 70 mg/m²). Typical emission ranges in DE and ES were unknown, but industry stakeholders claimed that concentrations of 3-6 mg/Nm³ were common (i.e. 9-36 mg/kg), with lower limits applying when the ELV is 5 mg/Nm³ and the higher value when the ELV is 10 mg/Nm³. A closer look at average data reported for HF emissions in IT during the period 2010 to 2017 is shown below for different types of production setup.

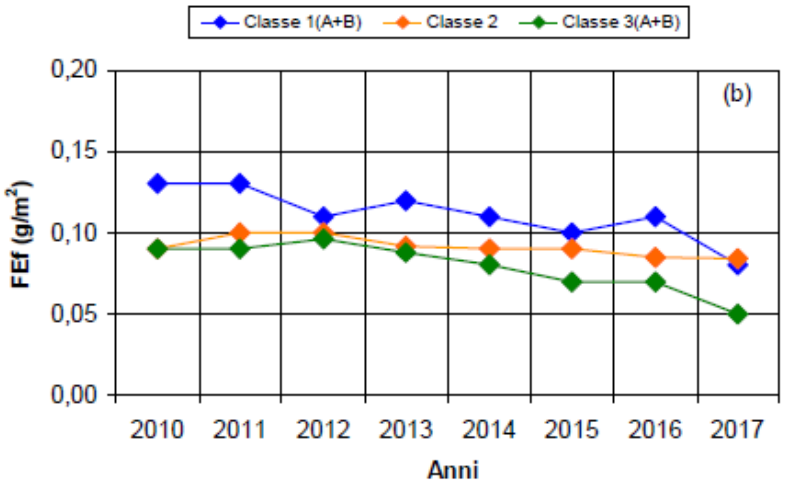

Figure 30. Average HF emissions in the Italian ceramic tile sector.

The average Italian data ranged from 0,05 to 0,13 g/m2, which is well within the middle of the range of EU Ecolabel data reported for Italian licenses. These average values correspond to 2,5 to 6,5 mg/kg.

Industry stakeholders proposed to: (i) raise the mandatory limit for HF emissions from 10 mg/kg to 27 mg/kg, based on a typical emission of 6 mg/Nm3 and an assumed specific airflow rate of 4,5 Nm3/kg and (ii) raise the excellence threshold from 4 mg/kg to 13,5 mg/kg, based on an assumed emission of 3 mg/Nm3 and an assumed specific airflow rate of 4,5 Nm3/kg.

The proposals seem high compared to the 10 mg/kg limits set in ISO 17889-1 standard but seem reasonable according to the controlled emission limits of 10-50 mg/kg stated in Table 3.28 of the BREF (2007). The industry proposal has therefore been partly accepted (increase mandatory limit to 20 mg/kg and not to 27) but the excellence level should continue to reward the best performers (only increase excellence level to 6 mg/kg and not to 13,5). Although no other ceramic products are currently covered by EU Ecolabel licenses except ceramic tiles, it is assumed that these values can be applied to fired clay paver production as well.

NOx emissions: Wide ranges of NOx emissions can occur in the raw gas from ceramic kilns (e.g. 5 to 150 mg/m3) as shown in Table 3.27 of the BREF document (BREF, 2007). The concentration will depend on specific air flow rates (e.g. 3 to 6 Nm3/kg), maximum kiln firing temperatures, burner technology and any nitrogen content in fuels, additives or raw materials. Kiln temperature and specific air flow rate are the main factors influencing NOx emissions though. The thermal reaction between N_2 and O_2 from the combustion air in the regions close to the flame:

- $N_2 + O \rightarrow NO + N$
- $N + O_2 \rightarrow NO + O$
- $N + OH \rightarrow NO + H$

Thermal NOx formation becomes significant when the flame temperature and the excess oxygen in the combustion air.

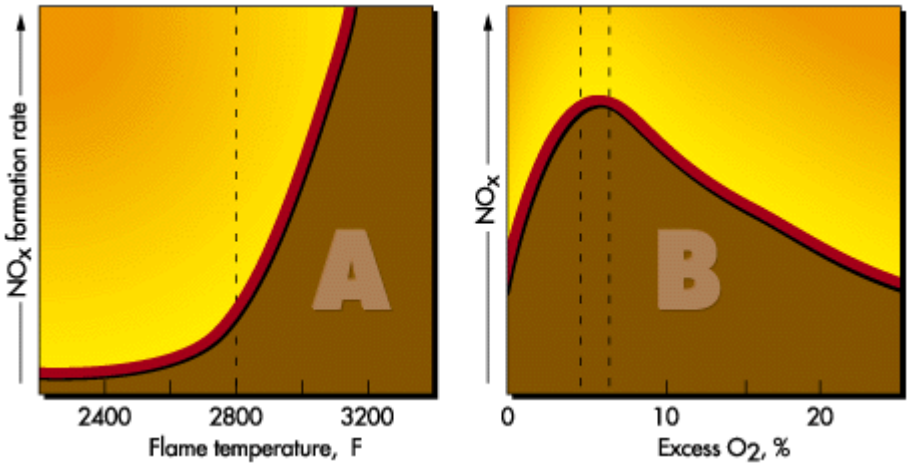

*Figure 31. NOx formation as a function of flame temperature and excess O2 (Source: **Alentecnic**).*

The data above clearly show that as the flame temperature rises above 1300°C, and especially from 1500°C (2800 F) onwards, thermal NOx formation increases. For a given situation, the potential for thermal NOx formation is highest when the excess oxygen content is 5-7% (i.e. 25-45% excess air). A lower oxygen excess starves the NOx formation reaction of oxygen while oxygen levels above 7% lower the flame temperature. Care should be taken with the substitution of natural gas for any other fuels with a careful consideration of their nitrogen content, since this could result in a significant increase in NOx emissions from the kiln.

A check of applicable emission limit values (ELVs) for operating permits for ceramic tile production showed that specific limits for NOx emissions are set not only for kilns but also for spray dryers in ES and IT and also for ware dryers in ES.

Table 19. "NOx emission limits in mg/Nm3 (converted to mg/kg)*

	Kiln	Dryer	Spray Dryer
ES	250 (750-1500*)	250 (750-1500*)	250 (750-1500*)
DE	350 (1050-2100*)	-	-
IT	200 (600-1200*)	-	200 (600-1200*) Or 350 (1050-2100*)

**multiplying value by a specific air-flow rate of 3-6 Nm^3/kg ceramic tile*

Although NOx emissions from spray dryers could be highly significant, because these systems are often operated by third parties and because measuring NOx emissions from them is not always mandatory, it was considered simplest to maintain the focus on kilns only.

Table 20. EU Ecolabel NOx emission limits compared to BREF and ISO 17889-1

Source	Relevant processes	Units		
		mg/m^3	mg/m^2	mg/kg
BREF (2007)	NOx emissions from kiln firing processes < 1300°C (section 5.1.4.1)	250	-	750-1500†
	NOx emissions from kiln firing processes > 1300°C (section 5.1.4.1)	500	-	1500-3000†
ISO 17889-1	NOx emissions from shaping to final product	-	-	-

Decision 2009/607/EC	Firing stage emissions	-	2500	125*
Existing license data	Firing stage emissions	-	0-2700 (median 1750)	0-135*
New EU Ecolabel criteria	Firing stage emissions (kiln gas)	-	-	250 (170 for max. points)

**estimated by converting values from mg/m2 to mg/kg using an assumed tile density of 20kg/m2*

†estimated by converting values from mg/m3 to mg/kg using an assumed specific kiln air flow rate of 3-6 m3/kg (based on Table 3.28).

ISO 17889-1 does not set any requirements on NOx emissions. The BREF values emphasise the importance of firing temperature on NOx emissions by having separate limits for > and < 1300°C. Data from existing license holders is shown below.

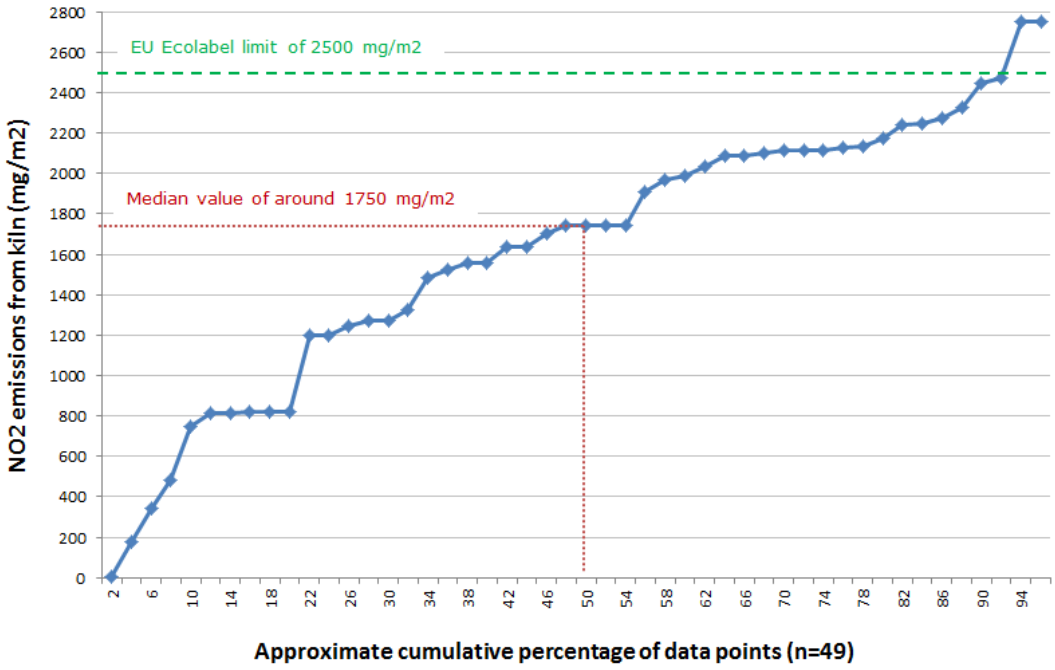

Figure 32. Specific NOx (as NO2) emissions reported by EU Ecolabel license holders

Two data points in the Figure above for specific NOx emissions exceeded the EU Ecolabel limit, this is presumably a temporary non-compliance issue. Compared to dust and HF emissions, the limit for NOx in general appears to be the most challenging for existing license holders. Most data lies within the 1200 to 2200 mg/m^2 range and one data point appears to be nearly zero, which seems highly unusual. A median value of around 1750 mg/m^2 for NOx emissions was identified and was initially proposed as a threshold for environmental excellence.

Regarding emissions of NOx, it was explained by an industry expert that actual concentrations in the exhaust gas only vary by a factor of around 3 (from 25 to 80 mg/Nm^3) although the specific NOx emissions (in mg/kg) can range by larger factors due to differences in the loading rates (kg tile/h) and airflow rates (Nm3/h) and thus specific airflow rate (in Nm3/kg).

Data reported by Centro Ceramico (CC, 2017) about average values for ceramic tile production in Italy showed the following trends:

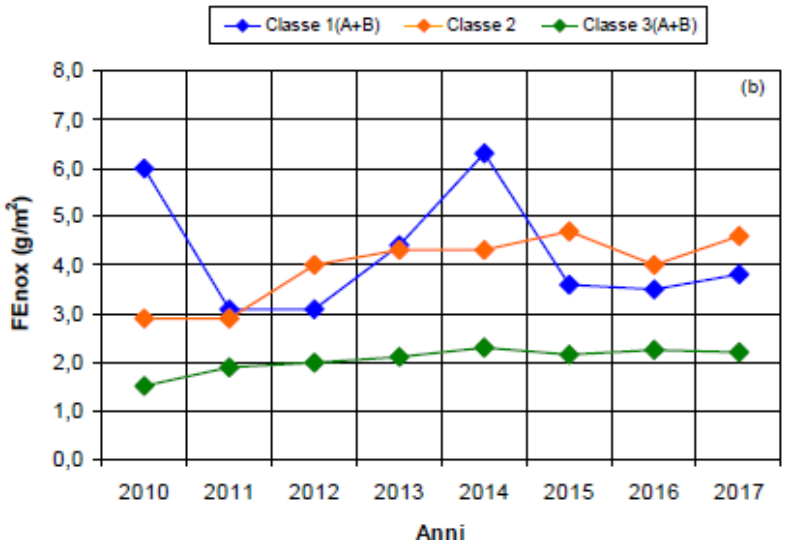

Figure 33. Average NOx emissions in the Italian ceramic tile sector (CC, 2017)

The Italian data show values ranging from 2,0 to 6,0 g/m2, although the values in the green line (ca. 2,0 g/m2) are most similar to emissions that can be expected for a kiln only. The 2,0 g/m2 translates into a value of **100 mg/kg** if a typical tile density factor of 20 kg/m2 is assumed. This is comparable to the limit of EU Ecolabel in 2009, which was set at **125 mg/kg**.

Very late intervention from the Italian ceramic tile industry in the criteria revision process claimed that the mandatory NOx limits needed to be increased by 100% to **250 mg/kg**. This was based on the provision of 30 data points that were anonymously taken from different Italian operating permits. The lowest value of the 30 points was **198 mg/kg** and the highest was **648 mg/kg** (average **335 mg/kg**). These anonymous operating permit data are significantly higher than the CC (2017) data from the same country.

One of the arguments for the higher industry proposal was based on the actual limits that are currently allowed for BREF (the ELV data shown for kiln gas in ranges from **600 to 2100 mg/kg**). The possibility of a mistake in the 2009 EU Ecolabel criteria for NOx, where the correct values were used but with the wrong units (i.e. mg/m2 should have been mg/kg) was discarded because the new industry proposal of 250 mg/kg would still cut out most existing license holders and there should have been no results above 350.

Upon further discussion, industry stakeholders emphasized that the main reason license numbers and numbers of licensed products were declining for such products, was due to difficulties in complying with NOx and SOx emissions. Although detailed data or references were not applied, multiplying the typical ranges of 25-80 mg/Nm3 by the range of specific airflow rates of 3-6 Nm3/kg would give a maximum range of 75-480mg/kg. The new upper limit for EU Ecolabel of 250 mg/kg sits well in the middle of that range. Consequently, the JRC decided to accept the industry proposals for NOx emissions, which were still well within allowable BREF limits.

Although no other ceramic products are currently covered by EU Ecolabel licenses except ceramic tiles, it is assumed that these values can be applied to fired clay paver production as well. Other data from BREF (see tables 3.5, 3.6, 3.7, 3.8, 3.9 and 3.27) for NOx emissions in abated exhaust gases showed that concentrations ranged from 18 to 187 mg/Nm^3 for porous clay blocks, masonry bricks, clinker brick & roof tile, clay blocks and facing bricks. Because the specific airflow rates for the values are unknown, they could not be converted into reliable averages in units of mg/kg.

SOx emissions: Table 3.27 of the BREF document (BREF, 2007) shows that SO2 has the largest range of raw gas concentrations (1 to 300 mg/m3) of all the pollutants listed. Specific airflow rate variation (3 to 6 Nm3/kg) is only a factor of 2, which does not come close to accounting for the factor of 300 variation in SOx emissions. The two main reasons for this variability is the difference in S content of

raw material and the S content of fuels. Since natural gas is the main fuel used in the ceramic industry and is virtually free of S, the variation will mainly be due to S content in the raw materials.

It should be noted that the BREF document reported S contents in (brick) clay ranging from less than 0,01% S to as high as 2,05% S (i.e. from <100 mg/kg to around 20000 mg/kg). This corresponds to a factor of 200 difference. The split between high and low S content raw materials in the general BAT conclusions (see section 5.1.4 of BREF, 2007) seems quite arbitrary (i.e. above or below 0,25%) considering that in reality the range is from <0,01% to 2,05% for European (brick) clays. Sulphur containing impurities in clay may be pyrite (FeS) and, to a lesser extent, as Ca or Mg sulphates.

A check of applicable emission limit values (ELVs) for operating permits for ceramic tile production showed that specific limits for SOx emissions are set not only for kilns but also for spray dryers in ES and IT and also for ware dryers in ES.

Table 21. SOx emission limits in mg/Nm3 (converted to mg/kg)*

	Kiln	Dryer	Spray Dryer
ES	200 (600-1200*)	200 (600-1200*)	200 (600-1200*)
DE	250-500 (750-3000*)	-	-
IT	500 (1500-3000*)	-	35 (105-210*)

*multiplying value by a specific air-flow rate of 3-6 Nm^3/kg ceramic tile

Although SOx emissions from spray dryers could be significant, because these systems are often operated by third parties and because measuring SOx emissions from them is not always mandatory, it was considered simplest to maintain the focus on kilns only. The relevant data for SOx emissions from kilns are presented below.

Table 22. EU Ecolabel SOx emission limits compared to BREF and ISO 17889-1

Source	Relevant processes	Units		
		mg/m^3	mg/m^2	mg/kg
BREF (2007)	SOx emissions from kiln firing processes if S content in raw material is <0,25% S	500	-	2500†
	SOx emissions from kiln firing processes if S content in raw material is >0,25% S	500-2000	-	2500-10000†
ISO 17889-1	SOx emissions from shaping to final product	-	-	-
Decision 2009/607/EC	Firing stage SOx emissions if S content in raw material is <0,25% S	-	1500	75*
	Firing stage SOx emissions if S content in raw material is <0,25% S	-	5000	250*
Existing license data	Firing stage SOx emissions	-	0-3900 (median 1150)	0-10*
New EU Ecolabel criteria	Firing stage SOx emissions (independent of S content in raw material)	-	-	1300 (750 for max. points)

The data in red in the table above appear to have been reported as mg/m^2 when in reality a result of mg/kg would have been more appropriate. Consequently, when translating them into mg/kg, the numbers appear very low compared to limits defined elsewhere.

**estimated by converting values from mg/m2 to mg/kg using an assumed tile density of 20kg/m2*

†estimated by converting values from mg/m3 to mg/kg using an assumed specific kiln air flow rate of 5 m3/kg (based on Tables 2.2 and 3.28, specific flow rates tend to range from 3-6 Nm3/kg).

As with NOx, ISO 17889-1 does not set any limits for SOx emissions. The BREF values, taken from Table 5.1 of that document, seem extremely high compared to the EU Ecolabel values but license holder data meets these very low limits. The spread of data from current licence holders (in Italy), is shown below.

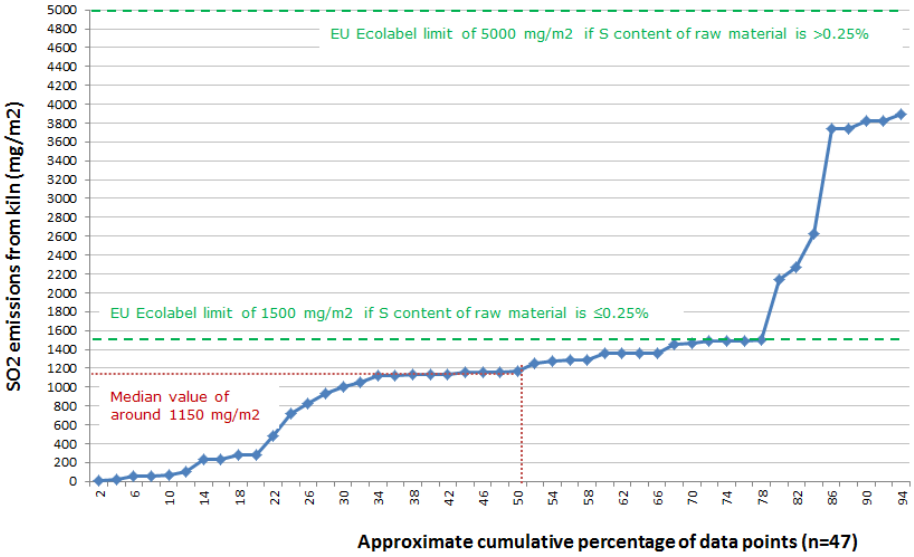

Figure 34. Specific SOx (as SO2) emissions reported by EU Ecolabel license holders

The data for S emissions are more difficult to interpret because there are two limits set in the EU Ecolabel depending on the S content of the raw material. The data provided did not say if the higher limit or lower limit applied to each data point. While it is self-evident that the 8 data points that exceed 1500 mgSO_2/m^2 product must be associated with higher S contents in the raw material, it is not clear what correlation between S contents and SOx emissions might exist.

In-depth discussions with industry stakeholders implied that the current limits would need to be increased (i) from 55 mg/kg to 1000 mg/kg for the environmental excellence threshold and (ii) from 75 mg/kg to 1300 mg/kg. The JRC investigated to see if this major difference might have stemmed by the wrong choice of units in the 2009 criteria – this seems to be the case.

As a final cross-check, translating values in mg/kg into mg/Nm3 was done. Assuming specific airflow rates of 3 to 6 Nm3/kg would lead to maximum ranges of 166 mg/Nm3 to 433 mg/Nm3. These are well within the BREF ranges of 250 to 500 mg/Nm3. It was proposed to partially accept the industry proposal, but the environmental excellence threshold should not be raised too much. So the JRC proposes a limit of 750 mg/kg for environmental excellence. The upper limit of 1300 mg/kg is proposed to be maintained and now no distinction is made based on S content in the raw material.

Although no other ceramic products are currently covered by EU Ecolabel licenses except ceramic tiles, it is assumed that these values can be applied to clay paver production as well. Other data from BREF (see tables 3.5, 3.6, 3.7, 3.8, 3.9 and 3.27) for SOx emissions in abated exhaust gases showed that concentrations ranged from 1,2 to 635 mg/Nm^3 for porous clay blocks, masonry bricks, clinker brick & roof tile and facing bricks while notably higher ranges of 1336 to 2295 mg/Nm^3 were noted for clay blocks. Because the specific airflow rates for the values are unknown, they could not be converted into reliable averages in units of mg/kg.

Practical considerations for calculating emissions to air

In cases were production for any particular licensed product or family of products occurs across multiple production lines, it is possible that there may be more than one chimney to take measurements from for any given emission parameter. In these cases, the emission concentrations should be calculated using a weighted summation approach in the same way as ISO 17889-1 prescribes (e.g. for HF):

$$Total\ HF\ emissions = \sum_{i=1}^{n} \left(C_{HF,i}\ x\ Q_i\ x\ T_i\right) / P_{kg}$$

Where:

- Total HF emissions is the emissions of HF in mg/kg;
- n is the number of chimney stacks;
- $C_{HF,i}$ is the dust concentration in the abated exhaust gas of the ith chimney stack (in mg/Nm^3);
- Q_i is the volume flow rate of the ith chimney stack (in Nm^3/h);
- T_i is the operation time of the ith chimney stack (in h/year);
- P_{kg} is the production volume (in kg/year).

When assessing compliance with regulatory limits under BREF, it is very important to use standard volumetric units (Nm^3) that are associated with a specific O_2 content. This is to prevent the deliberate dilution of exhaust gases with clean air being possible to manipulate the data since this would also increase the O_2 content of the air.

Although continuous monitoring of SOx emissions was expected, a uniform approach has not been taken by all Member States. For example in Italy, monitoring of SOx emissions is not required at all if the fuel used is natural gas, regardless of the S content of the raw material. In such cases where no continuous monitoring is required, the EU Ecolabel would require at least 3 representative measurements each year under stable operating conditions. Results should be reported as SO2 for SOx and as NO2 for NOx.

Criterion 4.5. Wastewater management

Criterion 4.5. Wastewater management

Process wastewater from the production of ceramic or fired clay products shall be treated in line with one of the following options:

- Option 1: be treated onsite to remove suspended solids, with treated wastewater being returned to the production process as part of a zero liquid discharge system; or
- Option 2: be treated onsite to remove suspended solids (or not treated at all) prior to wastewater being sent to a third-party operated treatment works; or
- Option 3: be treated onsite to remove suspended solids prior to wastewater being discharged to local watercourses.

In cases where options 2 or 3 apply, the applicant or the third party wastewater treatment plant operator, as appropriate, must demonstrate compliance with the following limits for final treated effluent that is discharged to local watercourses.

Parameter	Limit	Test methods
Suspended solids	40 mg/l	ISO 5667-17
Cadmium	0,015 mg/l	ISO 8288
Lead	0,15 mg/l	ISO 8288

Assessment and verification: *The applicant shall provide a declaration of compliance, specifying which option applies to the production site.*

In cases where a zero liquid discharge system is in place for recycling process wastewater, they shall provide a brief description of the system and its main operating parameters.

In cases where the treated or untreated wastewater is sent to a third party operated treatment plant, the operator of the plant shall declare the average concentrations of suspended solids, cadmium and lead in the final treated effluent and provide test reports based on weekly analysis of the discharged wastewater according to the standard test methods defined above or equivalent in-house laboratory methods. Less frequent testing may be permitted in cases where the operating permit allows.

In cases where process wastewater is treated onsite and effluent is discharged to the local watercourse, the applicant shall declare the average concentrations of suspended solids, cadmium and lead in the final treated effluent and provide test reports based on weekly analysis of the discharged wastewater according to the standard test methods defined above or equivalent in-house laboratory methods. Less frequent testing may be permitted in cases where the operating permit allows.

Rationale:

It is expected that all ceramic production plants will have some type of onsite wastewater treatment in order to remove the suspended inorganic particles carried in process wastewater although it is possible that smaller producers operating in clusters may discharge to a common wastewater treatment plant. Even after the solids have been settled and recovered as a dewatered sludge, it is likely that the process water will be recycled to a significant degree (this was confirmed at the 1st AHWG meeting). When wastewater recycling is effectively 100%, there is no need to test the effluent because it is not actually being discharged to the environment.

Industry representatives for ceramic tile producers stated that in Italy and Spain, it was common practice to have zero liquid discharge wastewater treatment systems. Consequently the wastewater criterion could be completely irrelevant to some producers. It was also confirmed that Cr(VI) is not relevant to the ceramic sector, neither in wastewater or sludge.

The criteria set out in Decision 2009/607/EC imply that test data is required for suspended solids, Cd and Pb in final treated effluent. This is fine so long as it is the same applicant that has control over the wastewater treatment system and has full access to obtain samples (i.e. option 3).

However, when the wastewater goes to a third party operated treatment plant, the applicant has no control on removal performance or any means to obtain final effluent data. The potential influence of other wastewaters received from other sources cannot be isolated either. In any case, analytical results of the final effluent shall be required in line with the operating permit of the wastewater treatment plant. If the operating permit does not require testing of Cd or Pb, then the applicant shall need to pay for one-off testing of the final effluent for these metals.

As part of attempts to streamline the EU Ecolabel criteria, the JRC proposed to remove this criterion, since many ceramic producers were already operating zero liquid discharge systems and the wastewater emissions was not considered as an important life cycle hotspot in general.

However, stakeholders expressed support to maintain the criteria on water and wastewater because, even though these criteria are relatively easy to comply with for the good performers in Europe, they still prevent less well performing companies (in terms of water consumption and wastewater emission) from obtaining the EU Ecolabel.

Criterion 4.6. Reuse of process waste

Criterion 4.6. Reuse of process waste
The applicant shall complete an inventory of process waste production for the ceramic or fired clay production process. The inventory shall detail the type and quantity of process waste[33] produced. The process waste inventory shall cover at least a 12 month period prior to the date of award of the EU Ecolabel and, during that same period, the total product output shall be estimated both in terms of mass (kg or tonne) and surface area (m^2). At least 90% by mass of the process waste generated by ceramic or fired clay product manufacturing shall be reincorporated into the production process onsite, be reincorporated into ceramic or fired clay production processes offsite or be reused in other production processes. In addition, up to 10 points shall be awarded in proportion to how much the reuse rates of process waste are increased towards the environmental excellence threshold of 100% reuse (from 0 points for 90% process waste reuse, up to 10 points for 100% process waste reuse). ***Assessment and verification:*** *The applicant shall provide a declaration of compliance with the mandatory requirements of this criterion, supported by a waste inventory for the ceramic or fired clay production plant for a period of at least 12 months prior to the date of award of the EU Ecolabel license and a calculation of total production process scrap and sludge (in kg or t). The applicant shall commit to maintaining such an inventory up to date during the validity period of the EU Ecolabel license.* *Details about the destination of these process wastes shall also be provided with clarifications about whether it is internal reuse, external reuse in another process or sent to landfill. For any external reuse or landfill disposal, shipment notes shall be presented.* *In case it is not possible to provide specific data for a production line or product, the applicant shall refer to data for the entire plant.*

Rationale:

Process waste from ceramic production has a high potential to be reused within the same process. In particular, sludge and dust from "*cold processes*" can be directly returned to wet grinding processes as new raw materials or dried first before being incorporated into dry grinding processes.

Allowance has to be made for the external reuse of these materials since some ceramic tile producers simply buy spray dried material and so do not have a significant material grinding capacity onsite.

In terms of onsite reuse, sludge production has been estimated to be in the range of 0,09 to 0,15 kg/m^2 which, if completely reincorporated to the production of ceramic tiles of 20kg/m^2 density, would amount to approximately 0,4 to 1,0% of the total produced ceramic tile mass (BREF, 2007). Such small additions are not expected to have any adverse effect on the predictability of raw body physical properties.

Unfired reject material can easily be reincorporated into the ceramic tile production process as well as small amounts of fired materials. Due to the toughness of fired material, it may be considered as a very useful secondary aggregate in road base, geotechnical fill or concrete.

Wastes from flue gas treatment will be more difficult to find reuse applications for. However, in cases where SO_2 emissions are a concern and hydrated lime is used in gas scrubbed, the generated flue gas

[33] Process waste shall be considered as sludge/dry solids from grinding, body preparation and glaze preparation, reject/broken material from shaping, drying, firing, rectification and surface finishing operations and residues from exhaust gas abatement systems such as separated dust/ashes, gas scrubbing residues and peelings from cascade adsorber bed materials.

desulphurisation residue can potentially be used in other industries such as plasterboard and cement production.

An analysis of data relating to existing EU Ecolabel license holders is presented below.

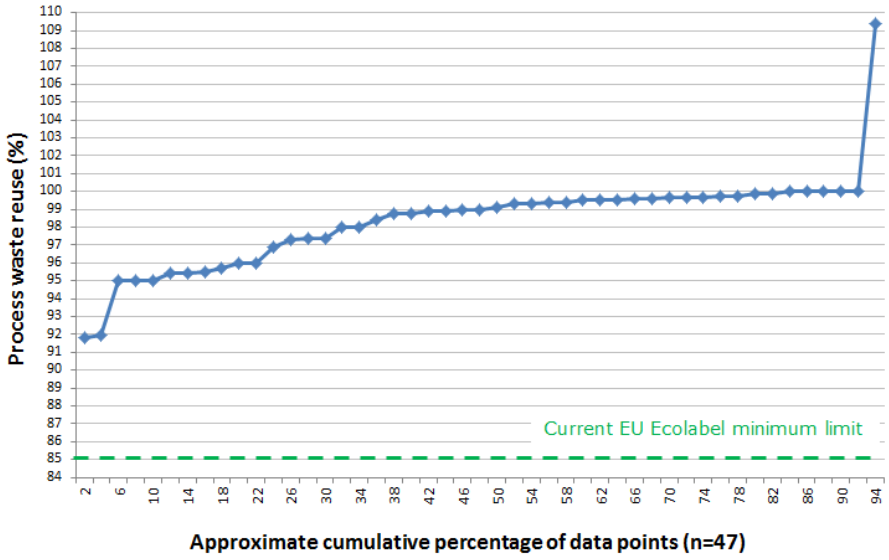

Figure 35. Process reuse rates reported by existing EU Ecolabel license holders

Apart from one outlier where process reuse somehow exceeds 100% (maybe due to the importing of waste from other sites?), the data provided show that ceramic tile producers are easily complying with the 85% reuse rate requirement for process waste. Consequently, it was deemed suitable to raise the minimum requirement to 90% and offer 10 points for reaching a maximum of 100% waste reuse.

Criterion 4.7. Glazes and inks

Criterion 4.7. Glazes and inks
In cases where ceramic tiles or fired clay products are glazed or decorated, the glaze formulation or ink shall contain less than 0,10% wt. Pb and less than 0,10% wt. Cd. ***Assessment and verification:*** *The applicant shall provide a declaration of compliance with the mandatory requirement of this criterion, supported by a relevant declaration or safety data sheet from the glaze or ink supplier.*

Rationale:

Requirements on the migration of Pb and Cd from glazed tiles have been removed since they imply a significant assessment and verification cost and are only intended to apply when used as food contact materials. Ceramic wall and floor tiles are unlikely to be considered as food contact materials unless larger format pieces are used as table-tops or kitchen-worktops. However, the producer cannot realistically know how these larger format pieces would be used or marketed by their customers. The limits for migration are still under consideration (Simoneau et al., 2017). Food contact requirements are mainly intended for ceramic tableware.

Use of lead in ceramic glazes

The use of lead oxide in silicate glaze compositions imparts a number of desirable physical properties to the glaze such as: lower fusion point and reduced surface tension which in turn permits the formulation of a broad range of compositions that are capable of delivering chemically durable and smooth surfaces with high brilliance which are highly resistant to devitrification and with the ability to heal defects in the clay surface (Lehman, 2002).

According to the Glass Manufacturing BREF (BREF, 2013a) a typical low melting point frit could consist of 50% by weight red lead (Pb_3O_4), with the remainder being due to quartz (ca. 20%), zinc oxide (ca. 15% and boric acid (ca. 15%).

The main source of Cd and Pb is in the frits, most producers of which are based in Castellon, Spain. Discussions with these producers revealed that Cd and Pb based frits are very rare today and only used when very specific colours are required. One final point was to potentially reconsider the use of the terms "*glazed/unglazed*" due to technological evolution in the production process - a better distinction may be "*decorated/undecorated*" when tile surfaces are printed using inkjet technology.

Adverse health effects of lead

Even if lead in the final ceramic product is well immobilised and not likely to migrate into foodstuffs during the use phase, the very creation of demand for lead glazes drives a production process, from mining through smelting and frit production to glaze formation and firing where larger or smaller amounts of lead are emitted to the environment. At the End of Life of the glazed ceramic tile, it is also possible that emissions of lead may be possible via leaching or inhalation of crushed tile dust or via emission to exhaust gases should old tiles end up in municipal solid waste incinerators.

Some of the health impacts associated with exposure to lead stated by the World Health Organisation are staggering, for example in 2016, it was estimated that lead exposure was responsible for 540 000 deaths and 13,9 million years of healthy life lost. The effect of lead exposure is especially pronounced on children, due to their increased specific uptake of lead (x4-5) compared to adults under the same exposure conditions.

Development of lead-free ceramic glazes

Research into low-lead or lead-free glazes were prompted by lead shortages during World War II and later due to health and environmental concerns about lead exposure. Two possible alternatives are (Lehman, 2002):

- Zinc/Strontium-based glazes: although these glazes can fire well, they do not deliver great colour development.
- Alkali borosilicate (ABS) based glazes: the use of approximately 10% B_2O_3 and 10% $(Li,Na,K)_2O$ by weight is required although higher firing temperatures are required and defect rates are higher.

It must be highlighted that these alternative glazes have been presented for use in the production of ceramic tableware and it is not sure how they would carry over to the process for floor and wall tile manufacture.

Analysis of data provided from EU Ecolabel license holders

Of the 50 data sets provided, only 13 provided numerical results (expressed as below prescribed limits, not as concrete values). It is assumed that the other 37 data sets covered unglazed products or did not use glazes containing Pb or Cd.

Criteria for precast concrete products or compressed earth blocks based on hydraulic binders or alternative cements

Scoring system

The EU Ecolabel may be awarded both to the intermediate hydraulic binder or alternative cement product placed on the market and to final hard covering products made by mixing such binders or cements with aggregates and water, followed by further processing and curing.

In cases where the applicant is not the producer of the intermediate hydraulic binder or alternative cement product and the binder or cement product has not been awarded the EU Ecolabel, the applicant shall declare the binder(s) or the cement(s) used to produce the EU Ecolabel hard covering product(s), supported by delivery invoices dating no more than 1 year prior to the application date.

In that case, the applicant shall provide all relevant declarations from the producer of the hydraulic binder or the alternative cement that demonstrate compliance with all related EU Ecolabel requirements and any other relevant optional requirements that may result in points being granted.

The scoring system for each case and the minimum number of points necessary is presented in the table below.

Table 23. EU Ecolabel scoring system for intermediate binder/cement products and final precast products based on cement or lime

	Hydraulic binder	Alternative cement	Cement-based hard covering products	Lime-based hard covering products
1.7. Environmental Management System for hydraulic binder production plant (optional)	0, 3 or 5 points	n/a	n/a	n/a
1.7. Environmental Management System for hard covering production plant (optional)	n/a	n/a	0, 3 or 5 points	0, 3 or 5 points
5.1. Clinker factor	Up to 15 points	Up to 15 points	Up to 15 points	n/a
5.2. CO2 emissions	Up to 20 points	Up to 20 points	Up to 20 points	Up to 20 points
5.3. Emissions of dust, NOx and SOx to air	Up to 15 points	n/a or Up to 15 points	Up to 15 points	Up to 15 points
5.4. Recovery and responsible sourcing of raw materials	n/a	n/a	Up to 25 points	Up to 25 points
5.5. Energy consumption	n/a	n/a	Up to 20 points	Up to 20 points
5.6. Environmentally innovative product designs (optional)	n/a	n/a	Up to 10 points	Up to 15 points
Total maximum points available	**55**	**35 or 50**	**110**	**100**
Minimum points required for EU Ecolabel	**27,5**	**17,5 or 25**	**55**	**50**

Criterion 5.1. Clinker factor

Criterion 5.1. Clinker factor

This criterion does not apply to lime-based hydraulic binders.

For hydraulic cement binders:

A clinker factor or at least the relevant EN 197-1 notation (which can be used as a proxy for the clinker factor according to the table below) shall be reported by the applicant or the supplier of the hydraulic cement binder.

EN 197-1 notation	Clinker factor assumed	EN 197-1 notation	Clinker factor assumed
CEM I	0,96	CEM II/A-L	0,83
CEM II/A-S	0,83	CEM II/B-L	0,68
CEM II/B-S	0,68	CEM II/A-LL	0,83
CEM II/A-D	0,88	CEM II/B-LL	0,68
CEM II/A-P	0,83	CEM II/A-M	0,80
CEM II/B-P	0,68	CEM II/B-M	0,68
CEM II/A-Q	0,83	CEM III/A	0,47
CEM II/B-Q	0,68	CEM III/B	0,25
CEM II/A-V	0,83	CEM III/C	0,09
CEM II/B-V	0,68	CEM IV/A	0,73
CEM II/A-W	0,83	CEM IV/B	0,52
CEM II/B-W	0,68	CEM V/A	0,72
CEM II/A-T	0,83	CEM V/B	0,57
CEM II/B-T	0,68		

Up to 15 points can be awarded to applicants in proportion to how much the clinker factor of the hydraulic cement binder is reduced towards the threshold for environmental excellence of 0,60 (from 0 points for clinker factor ≥0,90, up to 15 points for clinker factor ≤ 0,60).

For alternative cements:

Up to 15 points can be awarded to applicants in proportion to how much the clinker factor of the cement is reduced towards the threshold for environmental excellence of 0,00 (from 0 points for clinker factor 0,30, up to 15 points for clinker factor 0,00).

Assessment and verification: *The applicant shall provide a declaration of the specific clinker factor for the hydraulic binder or the relevant notation for the binder as per Table 1 of EN 197-1, for the hydraulic binder(s) supplied.*

In cases where more than one hydraulic binder or alternative cement is used in the hard covering product (e.g. in dual layered terrazzo tile products), the applicant shall calculate the points that would apply to each hydraulic binder or alternative cement as if it was the only one used, then calculate a weighted average points total based on the relative addition of each hydraulic binder or alternative cement to the product.

Rationale:

The importance of the clinker factor

The clinker factor is basically a measure of how much Portland cement clinker is present in the Portland cement. The three main clinker phases (tri-calcium silicate, di-calcium silicate and tri-calcium aluminate – or C3S, C2S and C3A for short) are responsible for the cementitious behavior of Portland cement.

These vital clinker phases can only be formed via the high temperatures generated in the cement kiln (i.e. around 1450°C in the kiln) which results in environmental impacts due to the high fuel energy consumption requirements.

Furthermore, due to the high calcium content in the clinker phases, this requires the use of limestone (i.e. $CaCO_3$) raw material which decarbonates in the kiln, releasing substantial amounts of process CO_2, on top of the emissions due to fuel combustion.

In a "*pure*" Portland cement (i.e. CEM I according to EN 197-1), the only material that is ground together with clinker is calcium sulfate in the form of gypsum or anhydrite in order to control the setting and hydration reactions of the clinker phases once they come into contact with water. A typical content of gypsum or hemihydrate is from 3-5%, which would result in a cement with a "*clinker factor*" of 0,97-0,95.

Decades of research (Malhotra and Kumar Mehta, 1996; Siddique and Khan, 2011; Thomas, 2017) have shown that a number of other materials, herein referred to as supplementary cementitious materials (SCMs), can be blended with clinker to produce blended cements that have equivalent or sometimes superior properties to those of a pure, CEM I type cement. The main SCMs are defined by EN 197-1 and represent a mixture of industrial by-products and natural materials that may or may not need to be processed prior to blending with clinker.

- Industrial by-products: blast furnace slag (from iron production); silica fume (from silicon metal production); coal fly ash (from coal combustion).
- Natural materials: natural pozzolana (e.g. volcanic ashes) calcined pozzolana (e.g. kaolin clay calcined at 500-700°C), burnt shale and limestone (the latter is essentially "free" since it can be sourced from the same quarry as the raw meal).

From a practical and market-based perspective, all of these materials have considerable environmental benefits (especially those which are industrial by-products) and economic benefits (especially limestone obtained from the same quarry operated by the cement producer). BAT 8 in the BAT Conclusions for the production of cement, set out in Commission Implementing Decision 2013/163/EU, states the following:

> *"8. In order to reduce primary energy consumption, BAT is to consider the reduction of the clinker content of cement and cement products."*

Data from EPDs published by CEMBUREAU for "*average*" CEM I, CEM II and CEM III (Cembureau 2015a, 2015b and 2015c) produced in several European countries illustrates very clearly the influence of clinker factor on the life cycle environmental impacts when looking at the cradle-to-gate life cycle stages. The average clinker factors were 0,925, 0,76 and 0,44 for CEM I, CEM II and CEM III EPDs respectively.

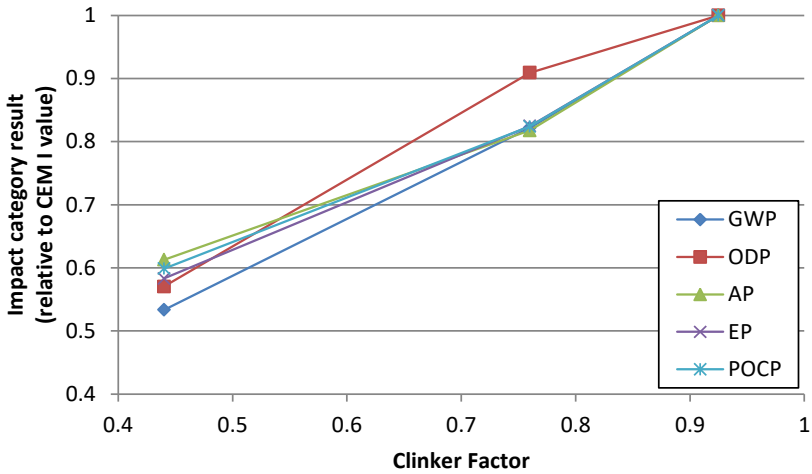

Figure 36. Influence of clinker factor on EPD impact category results (Sources: CEMBUREAU 2015a, b and c).

For the sake of comparing numbers that vary widely in scale between different impact categories, all results for CEM I in Figure 36 have been normalized to 1,00 and the CEM II and CEM III data expressed as a decimal of the CEM I data. A clear proportional relationship between the clinker factor and the environmental impacts can be seen, although there are only 3 points on the line, the R^2 values for best fit linear trendlines were all 0,97 or higher.

With the notable exception of limestone, the choice of SCM will be influenced by regional availability, material quality and market fluctuations in SCM prices. Consequently, the EU Ecolabel criteria seek to reward any blended cements in a manner that is proportional to how well they manage to reduce their clinker factor, without preferring or prioritizing one type of SCM over another.

Data available from "Getting the Numbers Right" (GNR) database

Although the GNR database reports on clinker factors and counts both own produced clinker as well as clinker purchased from other sites. The formula used for calculating the clinker factor (CF) in the GNR reporting format is as follows:

$$CF = \frac{Total\ clinker\ consumed}{Own\ clinker\ consumed + (gypsum, limestone, CKD\&SCMs\ in\ blending) + bought\ clinker\ consumed}$$

**where CKD stands for Cement Kiln Dust and SCM stands for Supplementary Cementitious Material (e.g. coal fly ash etc.).*

Table 24. Clinker factors reported in the GNR database (GNR, 2018)*

Region	2012	2013	2014	2015	2016
Africa	78%	77%	76%	77%	77%
Asia (n.e.c.) + Oceania	81%	80%	80%	80%	80%
Brazil	68%	69%	69%	69%	71%
Central America	73%	74%	74%	74%	73%
China + Korea + Japan	77%	77%	77%	77%	77%
CIS	79%	80%	80%	82%	82%
Europe	75%	76%	76%	76%	76%
India	71%	71%	70%	69%	70%
Middle East	83%	84%	84%	84%	85%
North America	91%	91%	90%	90%	89%
South America ex. Brazil	70%	70%	68%	69%	66%

**Data from indicator "92AGWce – Clinker to cement equivalent ratio – Weighted average – Grey and White clinker in Portland and blended cements (%).*

The weighted average clinker factors vary from as low as 0,66 (i.e. 66%) in South America (excl. Brazil) to 0,89 in North America. Europe is somewhere towards the middle of this range with a 0,76 clinker factor. The average European cement would therefore have achieved around 12 points out of 25 for the EU Ecolabel clinker factor criterion.

Future trends in the clinker factor in Europe

In terms of future prospects, CEMBUREAU estimate that the European cement sector could achieve a sectorial average clinker factor of 0,70 by 2050 (CEMBUREAU, 2013) (i.e. only minor and incremental progress from today). Two particularly important SCMs are blast furnace slag (from steel production) and coal fly ash (from coal combustion). Any decreases in European steel production will make it more costly for European cement producers to obtain blast furnace slag. Coal combustion is likely to decrease in Europe due to efforts to decarbonize the energy sector, resulting in less fly ash being available for EU cement production. Furthermore, NO_x emission abatement from coal combustion plants by treatment via selective reduction with ammonia dosing may pose a threat to the consistency of fly ash quality when ammonia slip occurs. The projected decreases in availability of these coal fly ash and blast furnace slag will need to be compensated by increased use of other SCMs such as limestone and calcined clays.

Ambition level in proposed approach

Even though the weighted average clinker factor in European Portland cement is already 0,76, no mandatory threshold was set for the clinker factor. This is in recognition that a low clinker factor is just one way (albeit a very important one) to reduce the environmental impact of Portland cement. It is also possible to produce high clinker factor cements with low emissions to air, and these higher clinker factor cements may deliver certain technical properties that lower clinker factor cements cannot meet (e.g. brightness of white cements) or that would require a larger quantity of low clinker factor cement to be met (e.g. minimum early age strength development of concrete).

There is also the possibility that the concrete producer has their own supply of SCMs and wishes to blend them onsite with CEM I prior to concrete production. The criteria have been set up so that even if a concrete producer loses points by using cement with a high clinker factor, he can obtain extra points by demonstrating a higher use of secondary or recycled materials in his concrete mix (see criterion 5.4).

For these reasons, it is considered necessary to allow for higher clinker factor cements but to reward those cements which achieve lower clinker factors towards an arbitrary best practice benchmark of 0,60.

Dosing and blending systems in cement production

For EU Ecolabel, a similar formula to that used in the GNR database described above can be used to calculate the clinker factor, although it is unimportant whether any distinction is made between own produced and bought clinker.

It must be appreciated that a single cement factory may produce multiple different cement products, even if it would only produce one clinker - the distinction in cement products comes from blending of the clinker with other materials in different combinations after the clinker has cooled. Consequently, the clinker factor must be calculated at the level of individual cement products rather than the entire facility.

The cement blending process may be simple or complex, depending on how many materials are to be blended and at what point. In any case, it is always possible to make a reasonable estimate of the clinker factor by monitoring the mass flows of clinker in and cement out. Accurate monitoring of the mass flows of key non-clinker materials is fundamental to ensuring predictable performance of each cement batch.

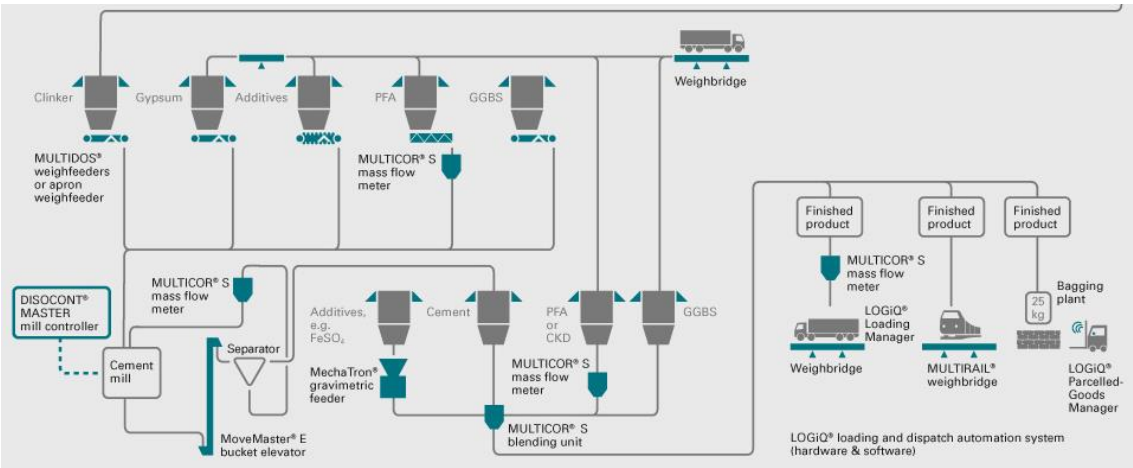

*Figure 37. Cement blending process diagram (Source: **SchenkProcess**).*

The process diagram in Figure 37 shows that the combination of cement clinker with other materials may be carried out prior to milling with gypsum, which results in a homogenous material, or that it may be blended later with SCMs of sufficient fineness in a simple blending unit. The return of fines from the milling operation to the system may complicate the mass balance process if these returns are not metered.

Alternative verification via EN 197-1 cement class

There may be cases where a concrete manufacturer is unable obtain information about the clinker factor of the cement they use. The precise clinker factor is generally considered as commercially sensitive information by cement producers. In such cases, an alternative means of estimating the clinker factor is provided via the code that should be displayed on packaging of any CE marked Portland cement.

The codes listed in the criterion indicate which type or types of SCM have been used and the range of SCM content that is present in accordance with table 1 of EN 197-1. The estimated clinker factor is simply based on the medium point of the range of added SCM covered by that code. For example, if code CEM II/A-S corresponds to clinker blended with 6-20% of blast furnace slag. If the middle percentage is taken (i.e. 13%) this would correspond to an estimated clinker factor of 0,87. Adding in the assumed average gypsum content of 4% (this same assumption applies to all Portland cement classes with more than 50% clinker) would result in a final clinker factor of 0,83.

Due to the fact that gypsum is added to regulate the setting behaviour of one of the clinker constituents (i.e. C3A) for cements with clinker factors less than 0,60, a slightly lower gypsum addition of 3% has been assumed (i.e. for CEM III/A, B and C, for CEM IV/B and CEM V/B).

Verification of clinker factor via testing of the cement product?

Standard procedures (EN 196-4) have been developed for quantifying the content of certain SCMs in blended cement via a selective dissolution procedure and could be used as a last recourse in cases where the cement clinker factor is disputed for almost all cement classes defined in EN 197-1 (except CEM II/A-T and B-T or calcareous fly ash (CEM II/A-W and B-W).

Table 25. Different classes of Portland cement according to EN 197-1

Type	Code	From kiln	From other sources (supplementary cementitious materials (SCMs))									Other minor constituents
		Clinker	Blast furnace slag	Silica fume	Pozzolana		Fly ash		Burnt shale	Limestone		
					natural	natural calcined	siliceous	calcareous				
		K	S	D	P	Q	V	W	T	L	LL	
CEM I	CEMI I	95-100	-	-	-	-	-	-	-	-	-	0-5
CEM II	CEM II/A-S	80-94	6-20	-	-	-	-	-	-	-	-	0-5
	CEM II/B-S	65-79	21-35	-	-	-	-	-	-	-	-	0-5
	CEM II/A-D	90-94	-	6-10	-	-	-	-	-	-	-	0-5
	CEM II/A-P	80-94	-	-	6-20	-	-	-	-	-	-	0-5
	CEM II/B-P	65-79	-	-	21-35	-	-	-	-	-	-	0-5
	CEM II/A-Q	80-94	-	-	-	6-20	-	-	-	-	-	0-5
	CEM II/B-Q	65-79	-	-	-	21-35	-	-	-	-	-	0-5
	CEM II/A-V	80-94	-	-	-	-	6-20	-	-	-	-	0-5
	CEM II/B-V	65-79	-	-	-	-	21-35	-	-	-	-	0-5
	CEM II/A-W	80-94	-	-	-	-	-	6-20	-	-	-	0-5
	CEM II/B-W	65-79	-	-	-	-	-	21-35	-	-	-	0-5
	CEM II/A-T	80-94	-	-	-	-	-	-	6-20	-	-	0-5
	CEM II/B-T	65-79	-	-	-	-	-	-	21-35	-	-	0-5
	CEM II/A-L	80-94	-	-	-	-	-	-	-	6-20	-	0-5
	CEM II/B-L	65-79	-	-	-	-	-	-	-	21-35	-	0-5

	CEM II/A-LL	80-94	-	-	-	-	-	-	-	-	6-20	0-5
	CEM II/B-LL	65-79	-	-	-	-	-	-	-	-	21-35	0-5
	CEM II/A-M	80-88	< ----------12-20---------- >									0-5
	CEM II/B-M	65-79	< ----------21-35---------- >									0-5
CEM III	CEM III/A	35-64	36-65	-	-	-	-	-	-	-	-	0-5
	CEM III/B	20-34	66-80	-	-	-	-	-	-	-	-	0-5
	CEM III/C	5-19	81-95	-	-	-	-	-	-	-	-	0-5
CEM IV	CEM IV/A	65-89	-	< ----------11-35---------- >					-	-	-	0-5
	CEM IV/B	45-64	-	< ----------36-55---------- >					-	-	-	0-5
CEM V	CEM V/A	40-64	18-30	-	< ----------18-30---------- >			-	-	-	-	0-5
	CEM V/B	20-38	31-49	-	< ----------31-49---------- >			-	-	-	-	0-5

Criterion 5.2. CO2 emissions

Criterion 5.2. CO2 emissions

The CO2 emissions associated with the production of Portland cement clinker, lime or alternative cements shall not exceed the relevant mandatory limits defined in the table below, when calculated using the relevant calculation method, also defined in the table below.

Product type	Mandatory limit	Threshold of environmental excellence	CO2 calculation method
Grey Portland cement clinker	816 $kgCO_2$/t clinker	751 $kgCO_2$/t clinker	According to Regulation (EU) 2019/331 or Regulation (EU) No 601/2012, as appropriate
Lime	1028 kgCO2/t hydraulic lime	775 kg/CO2/t hydraulic lime	
White Portland cement clinker	1063 $kgCO_2$/t clinker	835 $kgCO_2$/t clinker	
Alternative cements	571 $kgCO_2$/t cement	526 $kgCO_2$/t cement	ISO 14067 carbon footprint for A1-A3 life cycle stages

In addition, up to 20 points shall be awarded in proportion to how much the CO2 emissions are reduced towards the relevant threshold of environmental excellence indicated in the table above (e.g. for grey Portland cement clinker: from 0 points for 816 $kgCO_2$/t clinker, up to 20 points for 751 $kgCO_2$/t clinker).

Assessment and verification: *The applicant shall provide a declaration of compliance with the mandatory requirement of this criterion, supported by a statement of the calculated specific CO2 emission in accordance with the relevant methodology defined in the table above.*

For products from installations within the scope of Directive 2003/87/EC of the European Parliament and of the Council[34], the calculation of specific emissions per tonne of product shall be based on the emissions level and activity levels as per the monitoring methodology plan established under Article 6 of Regulation (EU) 2019/331 of the European Parliament and of the Council[35] on free allocation rules.

For products from installations not within the scope of Directive 2003/87/EC, results shall be declared in accordance with the relevant calculation methodology defined in Commission Regulation (EU) No 601/2012[36].

In all cases, the specific CO2 emission value shall be estimated at the level of the EU Ecolabel product(s) covered by the EU Ecolabel license. In cases where installations produce more than one type of product, the data shall be based on the actual production lines and processes used to manufacture the product to be licensed as far as is practical. In cases of emissions due to processes common to multiple products at the same installation, the emissions shall be allocated on a mass basis.

In cases where an alternative cement is used, the applicant shall provide a copy of the carbon footprint analysis, which shall be in accordance with ISO 14067 and have been verified by an accredited third party. The footprint analysis must cover production of all of the main raw materials used and all chemical activators for life cycle stages A1-A3. In the absence of specific data from material suppliers, the generic emission factors from a life cycle inventory database should be used.

In cases where more than one hydraulic binder or alternative cement is used in the hard covering product (e.g. dual layered terrazzo tiles), the applicant shall calculate the points that would apply to each hydraulic binder or alternative cement as if it was the only one used, then calculate a weighted average points total based on the relative addition of each hydraulic binder or alternative cement to the product.

[34] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (OJ L 275, 25.10.2003, p.32).

[35] Commission Delegated Regulation (EU) 2019/331 of 19 December 2018 determining transitional Union-wide rules for harmonised free allocation of emission allowances pursuant to Article 10a of Directive 2003/87/EC of the European Parliament and of the Council (OJ L 59, 27.2.2019, p. 8).

[36] Commission Regulation (EU) No 601/2012 of 21 June 2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council OJ L 181, 12.7.2012, p. 30.

Rationale:

The CO2 footprint of concrete is dominated by its cement content, despite the fact that cement only accounts for some 10-15% by weight of concrete. For example, Flower and Sanjayan (2007) found that cement was responsible for 74-81% of the CO2 footprint of concrete. The cement content in concrete cannot be varied very much due to requirements for minimum early strength and workability of the fresh mix. However, the composition of the cement can be altered with a view to lowering its CO2 footprint. For these reasons, the criteria on CO2 emissions is focused directly on cement rather than on concrete.

The need to align with an existing calculation method

Emissions of CO2 are at the very top of the scientific and political agenda for climate change (EC, 2018b). The cement industry is commonly cited as being responsible for some 5-8% of global anthropogenic CO2 emissions. This has resulted in a variety of different mandatory and voluntary policies being applied to the cement sector (and other energy intensive sectors) to manage CO2 emissions.

With the EU Ecolabel, it is important to avoid creating yet another way to calculate CO2 emissions. The two main methods for the cement sector are the Emissions Trading Scheme (ETS) and the Getting the Numbers Right (GNR) database.

Reporting of CO2 emissions from cement kilns above a certain capacity (500 tonnes/day for rotary kilns or 50 tonnes/day for other kilns) is mandatory for the ETS. Due to the large economies of scale with cement production, ETS reporting covers almost 100% of the EU cement production. Only emissions from the site are included (i.e. not those from grid electricity).

The approach to calculating CO2 emissions for the GNR database was also considered as potentially relevant for identifying benchmarks since around 90% of EU cement production capacity is already reporting to this database and it is possible to analyse the data for the purpose of setting benchmarks. One major advantage of the GNR database is that it does not include grid electricity, which would lead to further stakeholder debate regarding assumptions for grid factors.

In the end, it was decided to set benchmarks according to the ETS data – and consequently, the calculation method used by EU Ecolabel applicants must follow the ETS methodology.

White cement specificities

Compared to grey cement, white cement is a relatively niche market, with some 3 Mt of production (Saunders, 2014) in EU28 countries compared to 121 Mt of grey cement clinker (GNR, 2018). In fact, significant white cement production is only noted in Spain, Denmark, Portugal and Germany.

White cement can be considered as a value added product that is used when concrete with a high surface reflectivity is required. Although the production process for white cement is generally the same as that for grey cement, there are strict requirements on the iron content of raw materials (each 0,1% increase in iron oxide can reduce cement reflectivity by 2,5%). In order to minimize any potential oxidation of iron impurities, higher kiln temperatures and more rapid clinker cooling techniques tend to be used, which decrease the energy efficiency of the process and lead to higher specific CO2 emissions. This is well reflected by the higher specific thermal energy consumption required for white cement production shown below.

Table 26. Comparison of specific thermal energy consumption for grey clinker and white cement production (Source: GNR, 2018)

Year	Thermal energy consumption - Weighted average | excluding drying of fuels		% difference for white cement versus grey clinker
	MJ/t grey clinker (25aAG)	MJ/t white cement (25 aAWK)	
1990	4,078	6,163	51.2%
2000	3,727	6,160	65.3%
2005	3,695	6,011	62.7%
2006	3,686	5,665	53.7%
2007	3,728	5,961	59.9%
2008	3,725	5,582	49.8%
2009	3,713	5,866	58.0%
2010	3,714	6,084	63.8%
2011	3,731	6,239	67.2%
2012	3,740	6,694	79.0%
2013	3,716	6,214	67.2%
2014	3,704	6,363	71.8%
2015	3,687	6,326	71.6%
2016	3,685	6,352	72.4%

The data in Table 26 show that the thermal energy requirements for white cement production are substantially higher (+50 to +75%) than those for grey clinker production. This difference has remained relatively constant during the last 30 years in Europe.

White cement is important for aesthetic purposes in certain hard covering products, especially in terrazzo tile facing layers, and also important due to potential indirect environmental benefits depending on how and where they are installed: for example, higher albedo (more reflective) surfaces could lower interior or exterior lighting requirements for a fixed luminance level or reduce in the urban heat island effect in warm climates.

For the aforementioned reasons, it is considered acceptable to set a separate ambition level for white cement in the EU Ecolabel criteria.

Hydraulic lime specificities

In the BREF document for lime production (BREF, 2013b) estimated that around 15-20% of commercial lime used in the EU27 in 2004 went to construction materials and clay soil stabilization. There are six main kiln technologies that can be used for lime production, which are as follows:

- Long Rotary Kiln (LRK), n=26 in EU27 in 2004
- Rotary Kiln with Preheater (PRK), n=20 in EU27 in 2004
- Parallel Flow Regenerative Kiln (PFRK), n=158 in EU27 in 2004
- Annular Shaft Kiln (ASK), n=74 in EU27 in 2004
- Mixed-feed Shaft Kiln (MFSK), n=116 in EU27 in 2004
- Other Shaft Kiln (OSK), n=203 in EU27 in 2004.

In table 2.17 of BREF (2013b), it is shown that the hydraulic lime used for building materials has a t60 of > 3 minutes and a CL 70, CL 80, DL80 or DL85 (corresponding to CaO+MgO contents of >65%, >75%, >75% and >80%, respectively). All of the building material grades need to be low in sulfur.

Cross-checking this with table 2.16 of BREF (2013b), it is clear that the hydraulic limes produced for building materials come from either LRK, PRK or OSK-based production processes. Since OSK is by far the most common of these 3 kiln types (n=203 compared to n=46 for LRK+PRK combined), the relevant emission data has been consulted for OSK-based production only.

Ambition levels

The choice of ambition level has been based on discussions with Commission colleagues in DG CLIMA and specifically about anonymized data submitted by relevant installations under ETS reporting requirements.

The mandatory requirement aims to reflect the top 50% of relevant installations while the threshold of environmental excellence aims to reflect the top 10% of installations. This logic was applied for grey cement clinker, white cement clinker and lime production.

The assessment and verification methodology for estimating the process CO2 emissions of these materials is exactly matched to that defined in the ETS legislation.

The ETS does not apply to alternative cements, because they are made simply by combining virgin or secondary materials together with small amounts of clinker and/or chemical activators. Consequently, a different methodology is applied that looks at embodied carbon, since in many alternative cement formulations, the carbon footprint is heavily influenced by the choice of raw material mixes and chemical activators.

The ETS values for lime were still under discussion so the numbers were cross-checked against BREF (2013b) data. In table 2.25 of BREF (2013b), a range of CO2 emission from 1009 to 1419 kgCO2/t lime were reported for OSK technology. The ranges for LRK (1150-1975 kgCO2/t) and PRK (1054-1530 kgCO2/t) were even higher. Consequently, it would be necessary for the hydraulic lime to be blended with pozzolans to some extent in order to meet the EU Ecolabel requirements.

Alternative cements

It was not possible to compile a sufficient amount of data on embodied carbon in alternative cements, so a general rule has been applied that their embodied carbon should be at least 30% lower than that used to produce the same mass as grey cement clinker.

Embodied CO2 is much more comprehensive than looking simply at process emissions, because other sources of CO2 are considered as well, such as transport and raw material extraction. Some of the main ingredients to consider for embodied carbon are: sodium hydroxide, sodium silicate, sodium sulphate and metakaolin. A review of existing life cycle inventories (LCIs) of the main LCA tools that are currently available is recommended for the user manual. Some initial values are included below.

Table 27. Carbon footprints for commonly used activators/raw materials in alternative cements

Substance	Product category and production method	Database and impact category	Impact category and value
Sodium hydroxide	50% in H2O, mercury cell, at plant	Ecoinvent ReCiPe 1.08 Midpoint (H) - Climate change, default, excl biogenic carbon [kg CO2-Equiv.]	1,08 [kg CO2-Equiv.]
	50% in H2O, diaphragm cell, at plant		1,22 [kg CO2-Equiv.]
	from chlorine-alkali electrolysis, diaphragm	Gabi ReCiPe 1.08 Midpoint (H) - Climate change, default, excl biogenic carbon [kg CO2-Equiv.]	1,41 [kg CO2-Equiv.]
Sodium silicate	sodium silicate, furnace process, pieces, at plant	Ecoinvent ReCiPe 1.08 Midpoint (H) - Climate change, default, excl biogenic carbon	0,842 [kg CO2-Equiv.]
	sodium silicate, furnace liquor, 37% in H2O, at plant		1,1 [kg CO2-Equiv.]
	hydrothermal liquor, 48% in H2O, at plant		0,747 [kg CO2-Equiv.]
	spray powder 80%, at plant		1,59 [kg CO2-Equiv.]
Sodium sulphate	from Mannheim process, at plant	Ecoinvent ReCiPe 1.08 Midpoint (H) - Climate change, default, excl biogenic carbon	0,472 [kg CO2-Equiv.]
	from natural sources, at plant		0,132 [kg CO2-Equiv.]
Metakoalin	As described by Dumani and Mapiravana, 2018	ReCiPe 1.08 Midpoint (H) - Climate change, default, excl biogenic carbon	0,313 to 0,423 [kg CO2-Equiv.]

Main discussion points with stakeholders

Ideally, CO2 emissions should be assessed at the level of the precast concrete product and different ambition levels could be set linked to the performance class of the product (because this affects the required cement content). However, the JRC did not receive sufficient data to be able to suggest any way forward with this approach. The data is simply not out there yet in sufficient detail and is a long way from being able to cover even just a part of all the different precast concrete products included in the scope for EU Ecolabel hard coverings (e.g. roof tile, paver, slab, panel etc.) and the different geometries and performance classes that exist within each specific type of product.

Concerns were expressed that the cement industry will not publicly disclose the CO2 emissions associated with individual cement products and that the preferred means of communicating such information would be to use EPDs. While EPDs can be considered as a viable means of communicating environmental information about a product, it could significantly add to the costs of complying with EU Ecolabel criteria for applicants if a new EPD is required for this purpose. There is also a risk that a sectorial EPD (or a multi-site EPD for a given company) will be provided, which would not provide sufficiently specific information for the concrete producer to make an informed choice about the cement they are purchasing.

As per chapter 2 of this report, it must be understood that there is the possibility for cement producers to send their data directly to the Competent Body that is assessing the license application for the precast concrete product(s) without the concrete producer seeing the information.

There is also the possibility that the cement producer applies directly for an EU Ecolabel license, so that they simply need to communicate the total number of points to their customer and no further details.

Criterion 5.3. Emissions of dust, NOx and SOx to air

Criterion 5.3. Emissions of dust, NOx and SOx to air

This criterion applies to hydraulic binders, but not to alternative cements if their clinker content is ≤ 30% w/w.

The specific dust, NOx and SOx emissions to air from the cement kiln or lime kiln shall not exceed the relevant mandatory limits defined in the table below:

Parameter	Mandatory specific emission limit	Threshold of environmental excellence	Test method	Points available
Dust	≤ 34,5 g/t clinker or hydraulic lime	≤ 11,5 g/t clinker or hydraulic lime	EN 13284	Up to 5
NOx (as NO2)	≤ 1472 g/t clinker or hydraulic lime	≤ 920 g/t clinker or hydraulic lime	EN 14791	Up to 5
SOx (as SO2)	≤ 460 g/t clinker or hydraulic lime	≤ 115 g/t clinker or hydraulic lime	EN 14792	Up to 5

In addition, up to 15 points can be awarded in proportion to how much the actual specific emissions (expressed as g/t clinker or g/t hydraulic lime) of dust, NOx and SOx are reduced towards the relevant thresholds for environmental excellence indicated in the table above (e.g. 0 points for 34,5 g/t clinker dust emissions, 5 points for 11,5 g/t clinker dust emissions).

Assessment and verification: *The applicant shall provide a declaration of compliance with the mandatory requirements of this criterion, supported by site data for emissions from the cement kiln or lime kiln, in mg/Nm^3 and expressed as an annual average value calculated from daily average values. The site data shall have been generated via continuous monitoring according to relevant EN or ISO standards.*

To convert exhaust gas monitoring results from mg/Nm^3 (at 10% O_2 content) into g/t of clinker, it is necessary to multiply by the specific kiln gas flow volume (Nm^3/t clinker). The specific gas flow volumes for cement kilns typically range from 1700 to 2500 Nm^3/t clinker. The cement producer must clearly state the specific airflow rate in the calculations of dust, NOx and SOx emissions. One Nm^3 refers to one m^3 of dry gas under standard conditions of 273K and 101,3 kPa.

To convert exhaust gas monitoring results from mg/Nm^3 (at 11% O2 content) into g/t of lime, it is necessary to multiply by the specific kiln gas flow volume (Nm^3/t lime). The specific gas flow volumes for lime kilns can generally range from 3000 to 5000 Nm^3/t lime, depending on the kiln type used. The lime producer must clearly state the specific airflow rate in the calculations of dust, NOx and SOx emissions. One Nm^3 refers to one m^3 of dry gas under standard conditions of 273K and 101,3 kPa.

For continuous production campaigns, data should be representative of a 12 month period prior to the date of award of the EU Ecolabel license. For shorter production campaigns, the actual production period(s) shall be stated and site data should represent at least 80% of the production campaign.

In case it is not possible to provide specific data for a production line or product, the applicant shall refer to data for the entire plant

In cases where more than one hydraulic binder is used in the production of EU Ecolabel certified hard covering products (e.g. dual layered terrazzo tiles), the applicant shall calculate the points that would apply to each hydraulic binder as if it was the only one used, then calculate a weighted average points total based on the relative use of each hydraulic binder in the EU Ecolabel hard covering product production line.

Rationale:

When making this new criterion proposal, the existing emission to air limit values set out in Decision 2009/607/EC have been considered in the context of data from the following sources.

Table 28. Data sources examined for criterion 5.3.

Data source	Comments
BAT Conclusions (Decision 2013/163/EU)	Defines upper AELs for the emission of dust, SOx and NOx (plus other emissions not addressed by the EU Ecolabel criteria. Where relevant, exceptions and nuances are provided to the limits.
Anonymised data published by CEMBUREAU in 2017.	Data for approximately 250 kilns was published in the CEMBUREAU annual report of 2017. The data is presented in random order and raw data was not provided, so it was not possible to accurately identify any percentiles of the data spread.

The rationale for this particular criterion proposal is presented in the following structure: (i) technical considerations relating to emissions and (ii) existing data to put the EU Ecolabel ambition level in context.

Technical considerations relating to emissions of dust, NOx and SOx

Cement kilns operating in compliance with the BAT Conclusions (Decision 2013/163/EU) are required to continuously monitor emissions of dust, NOx and SOx (as SO2) from the kilns (specifically in BAT 5d). Upper emission limits to comply with are defined in units of mg/Nm^3.

Dust: For cement production, BAT 17 states the following:

> *"In order to reduce dust emissions from the flue-gases of cooling and milling processes, BAT is to use dry flue-gas cleaning with a filter.*
>
> *The BAT-AEL for dust emissions from flue-gases of kiln firing processes is < 10–20 mg/Nm^3, as the daily average value. When applying fabric filters or new or upgraded ESPs, the lower level is achieved."*

BAT 17 basically states that any cement plant that has installed fabric filters or new or upgraded electrostatic precipitators should be able to comply with the lower limit of 10 mg/Nm^3. The EU industry data reported below show the actual values being reported.

Dust: For lime production, BAT 43 states the following limits:

> *< 10 mg/Nm^3 for all kiln processes using a fabric filter*
>
> *< 20 mg/Nm^3 for all kiln processes using ESP or other filters (possible up to 30 mg/Nm^3 in cases of high resistivity dust.*

NOx: for cement production, BAT 19 states the following:

> *"In order to reduce the emissions of NOx from the flue-gases of kiln firing and/or preheating/precalcining processes, BAT is to use one or a combination of the following techniques:...flame cooling; low NOx burners; mid-kiln firing; addition of mineralisers to improve burnability of the raw meal or process optimisation..."*

Process optimization can be achieved by a number of different ways, such as by staging combustion (especially with a precalciner) and using selective catalytic or non-catalytic reduction (SCR and SCNR) to reduce NOx to N2.

Techniques are either primary ones (i.e. reduce the formation of NOx in the first place) or secondary ones (i.e. remove NOx from the exhaust gas). Table 2 of BAT 19 sets the following limits for NOx emissions:

> *< 200 to 450 mg/Nm^3 for preheater kilns (daily average values)*[37,38]

[37] The upper level of the BAT-AEL range is 500 mg/Nm3, if the initial NOx level after primary techniques is > 1 000 mg/Nm3.

400 to 800 mg/Nm^3 for lepol and long rotary kilns (daily average values)[39]

Apart from the primary and secondary NOx reduction techniques mentioned above in the BAT Conclusions, other factors such as the maximum kiln temperature needed (higher for white cement) and the N content of the fuel(s) used will affect NOx emissions.

NOx: For lime production, BAT 45 states the following limits (daily average values):

100 to 350 mg/Nm^3 (1),(3) for PFRK, ASK, MFSK and OSK processes

<200 to 500 mg/Nm^3 (1),(2) for LRK and PRK processes,

Where (1) means that the higher ends of the ranges relate to the production of dolime and hard burned lime. Higher levels than the upper range may be associated with the production of sintered dolime.

Where (2) means that the upper limit can be up to 800 mg/Nm3 for LRK and PRK production of hard burned lime.

Where (3) means that upper limit may actually 500 mg/Nm3 in some particular cases where hard-burned lime is produced and where biomass is used as a fuel.

SOx: for cement production, BAT 21 states the following:

"In order to reduce/minimise the emissions of SOx from the flue-gases of kiln firing and/or preheating/precalcining processes, BAT is to use one of the following techniques: absorbent addition or wet scrubber."

Absorbent addition generally refers to slaked lime (which will react with SOx to form calcium sulphate compounds). The absorbent can either be injected into the flue-gas or added to the kiln feed. The former case tends to be less efficient than the latter, but the latter can cause problems in Lepol kilns with granule quality. Wet scrubbing can be applied to all kiln types and is advantageous when there is sufficient SOx in the gas to form flue-gas desulphurisation gypsum.

BAT 21 sets the following BET AEL range:

<50 to 400 mg/Nm3 (daily average values expressed as SO2).

In cases where sulphur emissions are due to burning of certain alternative fuels, sulphur emissions are simply transferred from either the landfill (where they would arise as sulphides) or waste incinerators (where an inorganic air pollution control residue would be produced that requires disposal). Incinerating such waste in a cement kiln effectively prevents ash generation because any mineral content is incorporated into the clinker or into flue gas desulphurization residue, which can be used as a partial gypsum substitute in cement blending at the same site where it is produced.

SOx: for lime production, BAT 47 states the following limits:

50 to 200 mg/Nm$^{3(1),(2)}$ for PFRK, ASK, MFSK, OSK and PRK processes

<50 to 400 mg/Nm$^{3(1),(2)}$ for LRK processes,

Where (1) means that the level depends on the initial SOx in the flue gas and the reduction technique used.

Where (2) means that for the production of sintered dolime using the double pass process, SOx emissions may exceed the upper limits.

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38 Existing kiln system design, fuel mix properties including waste and raw material burnability (e.g. special cement or white cement clinker) can influence the ability to be within the range. Levels below 350 mg/Nm3 are achieved at kilns with favourable conditions when using SNCR. In 2008, the lower value of 200 mg/Nm3 has been reported as a monthly average for three plants (easy burning mix used) using SNCR.

39 Depending on initial levels and NH3 slip.

Context for setting ambition levels

The CEMBUREAU data is presented below for emissions of dust, NOx and SOx and horizontal lines are inserted that indicate: (i) the upper AEL indicated by the BAT Conclusions (Decision 2013/163/EU); (ii) the mandatory requirement for the new EU Ecolabel criteria and (iii) the threshold for environmental excellence for the new EU Ecolabel criteria where maximum points can be awarded.

In principle, the same logic is applied to the ambition level for dust, NOx and SO2 emissions as has been applied to the CO2 emissions, that is to say:

- that the mandatory requirement will be to fall within the top 75% of the reporting kilns (or within 75% of the upper AEL defined in BAT Conclusions).
- that maximum points can be achieved by complying with the top 25% of reporting kilns.

In cases where it is not possible to accurately identify 3rd quartile values, the mandatory EU Ecolabel requirement will be set to align with 75% of the upper AEL defined in the BAT Conclusions.

Dust: emission data for dust is presented below.

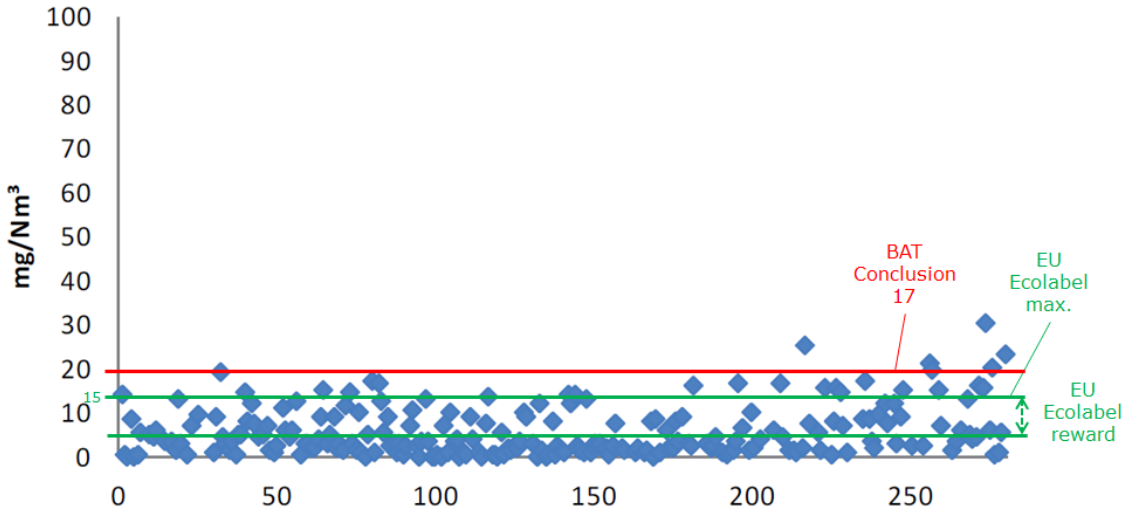

Figure 38. Comparison of EU Ecolabel and BAT ambition levels with 2015 industry data for dust emissions (Source: CEMBUREAU 2017 Activity Report).

The data in Figure 38 show that all but 5 of the 250+ cement production facilities covered (ca. 2%) exceeded the upper AEL for BAT Conclusion 17 in 2015 (20 mg/Nm³).

With the more stringent upper limit (15 mg/Nm³) proposed for EU Ecolabel cement criteria, an additional 28 mills (ca. 13%) would have problems meeting the limit, at least based on this data presented from 2015.

Many mills seem to be achieving near zero dust emissions. However, due to the difficulty to distinguish between the points on the graph, it was considered reasonable to set the requirements as a function of the upper BAT AEL of 20 mg/Nm³. So this would mean the following:

- Mandatory requirement of dust emissions being ≤ 15 mg/Nm³
- Maximum points when dust emissions are ≤ 5 mg/Nm³
- Points awarded in proportion to where site specific emissions lie between 5 and 15 mg/Nm³

NOx: emission data for NOx is presented below.

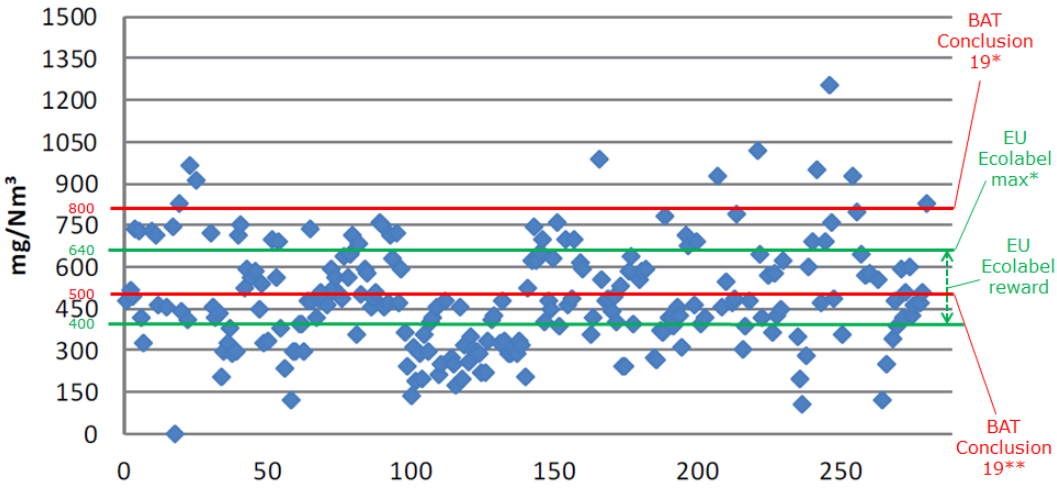

*Figure 39. Comparison of EU Ecolabel and BAT ambition levels with 2015 industry data for NOx emissions (*denotes BAT upper limits for Lepol kilns and long kilns, **denotes upper limits for all other kilns and normal cements).*

The data for NOx emissions is more complicated because the BAT Conclusions set two upper AELs, with a higher limit allowed for Lepol kilns and long rotary kilns (800 mg/Nm³) and another limit for all other kilns (450-500 mg/Nm³). The data presented in Figure 39 unfortunately does not identify which points correspond to Lepol and long dry kilns, to those producing white cement or those burning alternative fuels with a notable N content.

Consequently, it was decided to set the EU Ecolabel ambition level by treating the data in Figure 39 as a single data set. Approximately 42 of the kilns (ca. 17%) would not meet the proposed mandatory EU Ecolabel limit of 640 mg/Nm3. An environmental excellence limit of 400 mg/Nm3 is proposed to distinguish kilns that have made particular efforts to reduce NOx emissions. Any kiln that has emissions equal to or below 400 mg/Nm3 would therefore achieve maximum points. According to the data in Figure 39, approximately 64 of the kilns (ca. 26%) would be able to meet this definition of environmental excellence with regards to NOx emissions. Any plants with NOx emission data lying within the range of 400 to 640 mg/Nm3 would receive EU Ecolabel points in proportion to where the lie within that range. So this would mean the following:

- Mandatory requirement of NOx emissions being ≤ 640 mg/Nm³.
- Maximum points when NOx emissions are ≤ 400 mg/Nm³.
- Points awarded in proportion to where site specific emissions lie between 400 and 640 mg/Nm³.

SOx: emission data for NOx is presented below.

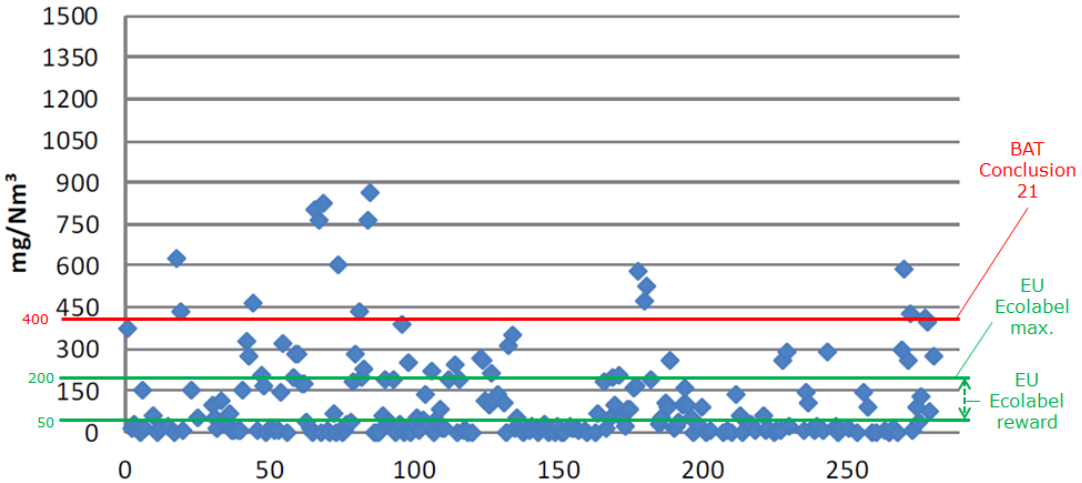

Figure 40. Comparison of EU Ecolabel and BAT ambition levels with 2015 industry data for SO2 emissions.

The data in Figure 40 show that all but 15 of the 250+ kilns covered (ca. 6%) exceeded the upper AEL for BAT Conclusion 21 in 2015 (400 mg/Nm^3). If the mandatory EU Ecolabel limit for SO2 emissions was lowered to 75% of the upper AEL (i.e. to 300 mg/Nm3), an additional 5 mills (ca. 2%) would be cut off, at least based on this data presented from 2015.

In order to better align the mandatory EU Ecolabel limit with the 3rd quartile performance for SO2 emissions, it is now proposed to lower the limit for SO2 to 200 mg/Nm3, which would cut off approximately 50 of the 250+ kilns (i.e. 20%).

Looking at the data, it is clear that there are many mills able to achieve very low SO2 emissions, which will most likely be due to the use of very low sulphur content fuels. Consequently the environmental excellence threshold, where maximum points can be attained, is set at 50 mg/Nm3. Due to the scale of the graph and the size of the data points, it is difficult to see how many kilns fall below 50 mg/Nm3 but it is estimated that at least 25% of the kilns could meet this level.

Overall comparison of dust, NOx and SOx limits:

Table 29. Comparison of existing and proposed mandatory limits for dust, NOx and SO2 emissions from cement lime production.

	BAT conclusions (upper AELs)		**Old EU Ecolabel criteria (Decision 2009/607/EC)**	**New EU Ecolabel criteria (Decision (EU) 2021/476)**
	mg/Nm3	**g/t clinker****	**g/t***	**g/t clinker**
Dust	<10-20	<23-46	65	34,5 (max. points if ≤11,5)
NOx	<200-450	<460-1035	900	1472 (max. points if ≤920)
	400-800‡	920-1840		
SOx	<50-400	<115-920	350	460 (max. points if ≤115)
	BAT conclusions (upper AELs)		**Old EU Ecolabel criteria (Decision 2009/607/EC)**	**New EU Ecolabel criteria (Decision (EU) 2021/476)**
	mg/Nm3	**g/t lime†**	**g/t***	**g/t hydraulic lime**
Dust	<10-20	<30-60	n/a	34,5 (max. points if ≤11,5)
NOx	100-350	300-1050	n/a	1472 (max. points if ≤920)
SOx	<50-200	<150-600	n/a	460 (max. points if ≤115)

** it is not clear if the reference was to g/t cement or g/t clinker*

***converted from mg/Nm3 to g/t by multiplying by 2.3. This was based on an assumed specific airflow rate in the kiln of 2300 Nm3/t clinker (section 1.3.4 of the BREF document states a typical range of 1700 to 2500 Nm3/t).*

†Values are presented that are relevant for Other Shaft Kilns (OSK) with an assumed specific airflow rate of 3 Nm3/kg.

‡For Lepol and long rotary kilns. Depending on initial levels and NH_3 slip.

Any strict comparison with the limits set out in Decision 2009/607/EC should be treated with caution since it was not explicitly stated in that Decision whether or not the g/t related to tonnes of cement product (i.e. clinker plus any blended supplementary cementitious materials) or simply as tonnes of cement clinker. If considered as tonnes of cement, the ambition level of Decision 2009/607/EC could potentially be much lower than is assumed in the table above if the units were meant to be g/t cement (it would depend on the clinker factor).

The dust limits are now significantly more ambitious than the old EU Ecolabel, this is strongly influenced by the new BAT Conclusions and by recent industry data.

The NOx limits in the new proposal are actually less ambitious than the previous criteria published in 2009. Since no licenses have been awarded to precast concrete products, it is probable that the 2009 limits have not been examined by the industry. The new NOx limits are based directly on industry data reported in 2015 (CEMBUREAU, 2017).

The SOx limits are also less ambitious than the criteria published in 2009, but seem relatively ambitious in the context of recent industry data reported in 2015 and are quite ambitious compared to the BAT ranges.

For limits relating to lime, the emission limits are broadly similar to those for cement production, especially after specific airflow rates typical in OSK processes have been accounted for. Limits associated with the other possibly relevant kiln processes (LRK and PRK) would have generated significantly higher numbers in terms of g/t because they had both higher BAT ranges for emissions (in mg/Nm3) and higher specific airflow rates (3,7 Nm3/kg and 5,0 Nm3/kg for PRK and LRK respectively).

When setting limits for the new EU Ecolabel criteria, the functional unit was expressed as g/t hydraulic lime. The main reasons for this were: (i) avoid potential confusion about how the emissions should be allocated (i.e. is it per tonne of CaO+MgO content? Or per tonne of final hydraulic lime product?) and (ii) by focussing on a per tonne of final hydraulic lime product, the environmental benefits of blending with pozzolans after production can also be captured.

Criterion 5.4. Recovery and responsible sourcing of raw materials

Criterion 5.4. Recovery and responsible sourcing of raw materials

The applicant shall assess and document the regional availability of virgin material, recycled material from wastes produced by different production processes and secondary material from by-products of different production processes. The approximate transport distances of the documented material sources shall be stated.

The applicant shall have procedures in place for any batches of returned or rejected concrete in which all returned/rejected material is either:

- Recycled directly into new concrete batches which are cast prior to the returned/rejected concrete hardening; or
- Recycled as aggregate in new batches after returned/rejected concrete hardening: or
- Recycled offsite either prior to or after hardening as part of a contractual arrangement with a third party.

In addition, a maximum total of 25 points may be granted in relation to sourcing of raw materials as follows:

	Cement-based products	**Lime- or alternative cement-based products**
Recycled or secondary material content up to 30%	Up to 20 points	Up to 25 points
Responsibly sourced virgin aggregate content up to 100%	Up to 5 points	Up to 5 points
Responsibly sourced cement	5 points	n/a

Assessment and verification: *The applicant shall provide a declaration of compliance with the mandatory requirements of this criterion, supported by documentation stating the transport distances of potential sources virgin, recycled and secondary materials. Alternatively, compliance with the mandatory aspects of this criterion can be demonstrated via a silver, gold or platinum certificate awarded by the Concrete Sustainability Council (CSC) to the concrete producer in accordance with version 2.0 of the CSC technical manual.*

Recycled or secondary materials shall only be counted as contributing towards the content of recycled/secondary material if they are obtained from sources that are ≤ 2,5 times distant from the precast concrete production site than the main virgin materials used (e.g. coarse and fine aggregates and supplementary cementitious materials). The incorporation of dust and rejects of precast concrete products into new product shall not be considered as recycled content if it is going back into the same process that generated it.

Responsibly sourced materials shall have been certified as such by the Concrete Sustainability Council or an equivalent third party certification scheme.

A monthly balance sheet of recycled/secondary materials and responsibly sourced materials shall be presented based on the 12 months of production prior to the date of award of the EU Ecolabel license. The applicant shall commit to maintaining such an inventory up to date during the validity period of the EU Ecolabel license. The balance sheet shall provide the quantities of ingoing recycled/secondary and responsibly sourced materials (justified by delivery notes and invoices) and outgoing recycled/secondary materials and responsibly sourced materials in all sold or ready for sale precast concrete production with recycled/secondary material or responsibly sourced content claims (justified by product quantities and % claims).

Due to the batch nature of the precast concrete production process, recycled/secondary material content claims and claims on the use of responsibly sourced hydraulic binder, alternative cement or aggregates shall be based on mix compositions used at the batch level. Allocation of recycled/secondary/responsibly sourced materials shall not be permitted.

In cases where production data is only available in m³ but needs to be reported in kg, or vice versa, the

value should be converted using a fixed bulk density factor for the relevant material.

Rationale:

The mandatory requirements are largely inspired by criterion E7.04 (Responsible processing of returned concrete) set out in version 2.0 of the Concrete Sustainability Council's (CSCs) technical manual. These mandatory requirements for the EU Ecolabel are prerequisites for any concrete producer that wishes to obtain the silver, gold or platinum CSC certification.

Compliance with these mandatory EU Ecolabel requirements can nonetheless be met independently of CSC certification, and for this reason the underlying requirements are also stated in the assessment and verification text.

What is meant exactly by "recycled aggregate"?

The ISO 14021 definition of the term "recycled content" and related terms are as follows:

- **Recycled content**: Proportion, by mass, of recycled material in a product or packaging. Only pre-consumer and post-consumer materials shall be considered as recycled content, consistent with the following usage of terms.
- **Pre-consumer material**: Material diverted from the waste stream during a manufacturing process. Excluded is reutilization of materials such as rework, regrind or scrap generated in a process and capable of being reclaimed within the same process that generated it.
- **Post-consumer material**: Material generated by households or by commercial, industrial and institutional facilities in their role as end-users of the product which can no longer be used for its intended purpose. This includes returns of material from the distribution chain.
- **Recycled material**: Material that has been reprocessed from recovered [reclaimed] material by means of a manufacturing process and made into a final product or into a component for incorporation into a product.
- **Recovered [reclaimed] material**: Material that would have otherwise been disposed of as waste or used for energy recovery, but has instead been collected and recovered [reclaimed] as a material input, in lieu of new primary material, for a recycling or a manufacturing process.

So unless the concrete has previously been transferred to other actors (and thus other processes or activities) in the distribution chain, it cannot be considered as recycled content when it comes back to the concrete factory. In the case of fresh concrete returns, if it were to be reincorporated directly back into the concrete mix, it should not be considered as recycled content. However, if the concrete was hardened and then crushed into aggregate before going into any new concrete mix, it could be argued that it is recovered material or recycled material, depending on which actors in the supply chain it is handled by.

What is meant by "secondary material"?

The ISO 14021 definition for recycled content and recycled material does seem to cover materials such as blast furnace slag, silica fume and coal fly ash. However, it is possible that they may be considered as industrial by-products rather than waste, which would complicate their recognition as recycled materials.

Consequently, the term "*secondary material*" has also been used in order to avoid any confusion about whether these commonly used materials should be counted as contributing to points in the EU Ecolabel criteria. Potential confusion may stem from Article 5 of the Waste Framework Directive (2008/98/EC) when a "*waste*" is no longer considered as a waste but instead as a "*by-product*" when:

- Further use of the substance or object is certain;
- The substance or object can be used directly without any further processing other than normal industrial practice;
- The substance or object is produced as an integral part of a production process; and
- Further use is lawful, i.e. the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts.

Considering recycled and secondary aggregates from an LCA and LCC perspective

When assessing the environmental impacts of concrete production from an LCA perspective, aggregates are a relatively minor contribution to most impacts. It has also been argued that the normal abiotic depletion LCA impact category is not suitable for considering the impacts of aggregate use because, when global resources are considered, the impact is negligible because sand and gravel reserves are vast.

Furthermore, due to the high bulk mass and low value, transport costs for aggregates are highly significant (truck haul for 30 miles can double the cost of the aggregate to the end user (Robinson and Brown, 2002)) and aggregates do not tend to travel far unless rail or barge transport links are convenient. Consequently, it would be much more relevant to consider abiotic depletion potential at the regional level (Habert et al., 2010), where the impacts would undoubtedly be far more significant.

The benefits of using recycled aggregates are significant when considering the consequential impacts of reduced land use (via avoided landfill and reduced quarrying) (Blengini and Garbarino, 2010) and potentially reduced transport emissions. Another important aspect is that, especially in developed areas, recycled aggregates tend to be available in the local environments where construction activities are taking place and may even be reincorporated into the same project where demolition activity precedes new construction on the same site.

In cases where recycled aggregates are available, but require longer transport distances than natural aggregates, there is a trade-off in environmental impacts. Blengini and Garbarino (2010) estimated that the use of recycled aggregates (when compared to natural aggregates) can remain environmentally beneficial up until the point when the transport distance for recycled aggregates becomes 2-3 times longer than for natural aggregates.

A report by ECRA (ECRA, 2015) considered recycling rates for recycled concrete aggregates (RCA) in different EU Member States and also considered the assumed environmental impacts of different uses. The report showed that recycling rates approached or exceeded 80% in a number of Member States by 2009. The fate of the vast majority (>80%) of RCA was as road base or geotechnical fill. Only minor fractions were actually making it into new concrete or asphalt mixes. The ECRA study concluded that the impact of crushing and grading RCA had higher impacts than doing so for gravel. Taking the examples of road base and structural concrete for the use of RCA, the ECRA study showed that benefits of using RCA could be cancelled if this resulted in an increase in cement content by 10% (from 290 to 320 kg/m3).

EU policy promoting recycled content and secondary aggregates and fillers

Two of the main types of recycled aggregate relevant to concrete production are recycled concrete aggregate (RCA) and crushed brick waste, which is produced by processing waste concrete from construction and demolition waste (CDW). As one of the most voluminous waste streams in the EU, accounting for some 25-30% of all EU waste, the Waste Framework Directive (WFD) has identified the recycling of CDW as a priority area. Specifically under Article 11(2) of the WFD, Member States are required to achieve a minimum of 70% of non-hazardous CDW recycling by 2020.

Although backfilling is permitted to count towards the 70% target, higher value recycling applications possible, such as use in non-structural or structural concrete. Data reported back in 2011 revealed that there was considerable scope to improve the handling of CDW by moving away from backfilling and towards recycling.

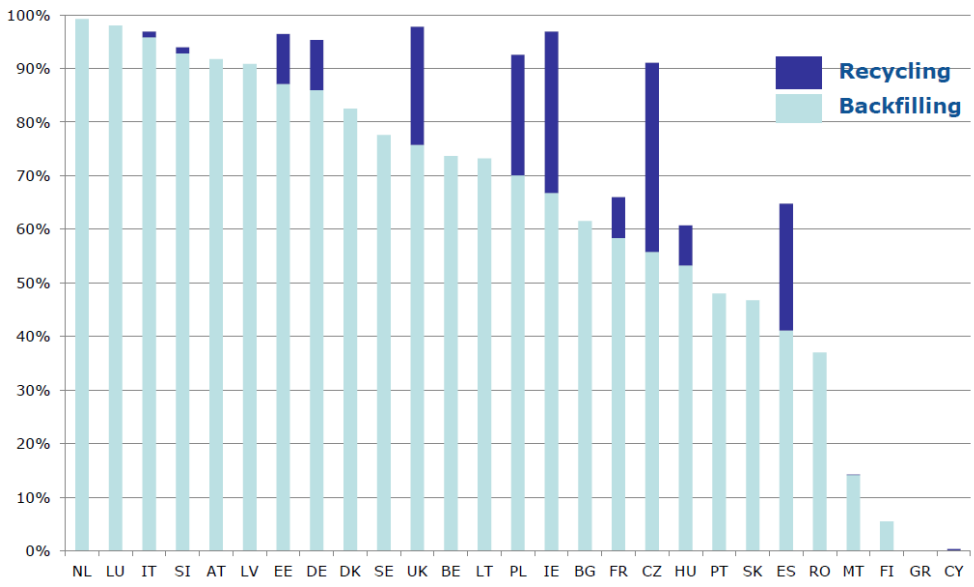

Figure 41. CDW backfilling and recycling in 2011 (Source: DG ENV).

Based on the data above, it is clear that only a handful of Member States were implementing CDW recycling in 2011. The leading Member States in CDW were clearly IE, the UK, the CZ, ES and PO. The Commission has since published an EU CDW protocol (EC, 2016a) and guidelines (EC, 2018a) to encourage better uptake of CDW recycling and increase awareness of higher value reuse and recycling opportunities compared to simple backfilling.

There is no harmonised approach to the regulation of CDW in Member States, which in turn leads to a wide range in performance. It is generally understood that CDW does not travel far, since the materials are generally of low bulk value. Selective demolition of gypsum plasterboard is one sensible approach due to the higher added value of gypsum and the fact that the sulphate present in gypsum is undesirable in any waste that would be sent to landfill (possible anaerobic biodegradation to sulphide gases) or in recycled aggregates used in concrete (as it could adversely affect the Portland cement hydration chemistry).

A large volume of research has been published regarding the use of recycled aggregates in concrete products. Structural engineers are reluctant to use recycled aggregates in structural concrete due to concerns about consistency of technical properties, especially the fact that recycled aggregates tend to be weaker than natural ones and that they will show a higher, and more variable water absorption. Poon et al., (2002) explained that any concerns about recycled aggregate in structural concrete do not extend to mechanically moulded concrete bricks and blocks. The authors demonstrated that up to 100% of the natural aggregate could be replaced by recycled aggregate of a suitable size distribution with only a minor decrease in compressive strength, a minor reduction in density, a minor increase in drying shrinkage and a notable increase in skid resistance. With both brick and paving blocks, the same authors showed that a 50% replacement of natural aggregates by recycled aggregates improved all physical properties.

Recognition of responsible sourcing by GBA schemes

In terms of responsible sourcing, the CSC criteria are now recognized by several Green Building Assessment schemes. BREEAM recognizes bronze, silver and gold certification under its "Mat 03" indicator for responsible sourcing.

Table 1: BREEAM recognised RSCS, EMS and their associated summary scores levels

RSCS/EMS Scheme (or other recognised source)	Label(s)/Version(s) of the scheme	Additional requirement to be specified[4]	RSCS summary score level for use in BREEAM assessments
BES 6001 Framework Standard for Responsible Sourcing	All	n/a	5 (Baseline score[3])
CARES Sustainable Constructional Steel Scheme	All	n/a	5
Concrete Sustainability Council (CSC)	Certified concrete (bronze, silver, gold and platinum levels)	n/a	5
Eco Reinforcement Responsible Sourcing Standard, Steel Products for the Reinforcement of Concrete	All	n/a	5
FSC	'FSC 100%'	n/a	7
	'FSC Mix' 'FSC Recycled'	n/a	5
PEFC	'PEFC Certified' 'PEFC Recycled'	n/a	5
SFI	'SFI Certified Chain of Custody, Promoting Sustainable Forestry'	Certified forest content = 100% of total	6
	'SFI Certified Chain of Custody, Promoting Sustainable Forestry'	Recycled timber/fibre content = 0% of total	5
Construction products/materials reused in-situ or within the same construction site, with only minor processing that does not alter the nature of the construction product/material (e.g. cleaning, cutting, fixing to other construction products).	n/a	n/a	10
Environmental Management Systems (EMS) (certified)	Key Process[1] and supply chain[2] extraction process. See Table 2 below.	n/a	2
	Key Process[1]. See Table 2 below.	n/a	1

Figure 42. Recognition of CSC certification by BREEAM (snapshot from BREEAM guidance note GN18, v3.1).

It can be seen that BREEAM recognizes the CSC certification for concrete on a similar level as it does for FSC and PEFC with wood.

The CSC is also currently recognized by the DGNB scheme based in Germany, specifically under criterion ENV 1.3 (sustainable resource extraction) and in the US, the CSC has been recognized by the infrastructure certification system, Envision (specifically under credit RA 1.2 "sustainable procurement practices").

Criterion 5.5. Energy consumption

Criterion 5.5. Energy consumption
The applicant shall have established a program to systematically monitor, record and reduce energy consumption and specific CO2 emissions in the precast concrete plant to optimal levels. The applicant shall report energy consumption as a function of energy source (e.g. electricity and diesel) and purpose (e.g. use of onsite buildings, lighting, cutting equipment operation, pumps and vehicle operation). The applicant shall report on energy consumption for the site both on an absolute basis (in units of kWh or MJ) and on a specific production basis (in units of kWh or MJ per m^3, m^2 or t of material sold/produced and ready for sale) for a given calendar year. A plan to reduce specific energy consumption and CO2 emissions shall describe measures already taken or planned to be taken (e.g. more efficient use of existing equipment, investment in more efficient equipment, improved transportation and logistics etc.). In addition, a total of 20 points may be granted as follows: – Up to 10 points shall be awarded in proportion to how much of the energy consumed (fuel plus electricity) is from renewable sources (from 0 points for 0% renewable energy up to 10 points for 100% renewable energy). – Up to 5 points shall be awarded depending on the manner in which any renewable electricity is purchased as follows: via private energy service agreements for on-site or near-site renewables (5 points); corporate power purchase agreements for on-site or near-site renewables (5 points); long term corporate power purchase agreements for grid-connected or remote grid renewables[40] (4 points); green electricity certifications[41] (3 points); purchase of renewable energy guarantees of origin certificates for the full electricity supply or green tariff from utility supplier[42] (2 points). – 3 points shall be awarded where a carbon footprint analysis has been carried out for the product in accordance with ISO 14067 or 5 points if the Product Environmental Footprint method's elements[43] related to greenhouse gas emissions has been used. ***Assessment and verification:*** *The applicant shall provide an energy inventory for the precast concrete plant for a period of at least 12 months prior to the date of award of the EU Ecolabel license and shall commit to maintaining such an inventory during the validity period of the EU Ecolabel license. The energy inventory shall distinguish the different types of fuel consumed, highlighting any renewable fuels or renewable content of mixed fuels. As a minimum, the specific-energy consumption and specific CO2 emission reduction plan must define the baseline situation with energy consumption at the precast concrete plant when the plan was established, identify and clearly quantify the different sources of energy consumption at the plant, identify and justify actions to reduce specific energy consumption and to report results on a yearly basis.* *The applicant shall provide details of the electricity purchasing agreement in place and highlight the share of renewables that applies to the electricity being purchased. If necessary, a declaration from the electricity provider shall clarify (i) the share of renewables in the electricity supplied, (ii) the nature of the purchasing agreement in place (i.e. private energy service agreement, corporate power purchase agreement, independent green energy certified or green tariff) and (iii) whether the purchased electricity is from on-site or near-site renewables.* *In cases where guarantee of origin certificates are purchased by the applicant to increase the renewables share, the applicant shall provide appropriate documentation to ensure that the guarantee*

[40] According to art. 15.8 of Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast) (OJ L 328, 21.12.2018, p. 82).

[41] Based on guarantees of origin with independent 3rd party verification of additional requirements according to art. 19 of Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast) (OJ L 328, 21.12.2018, p. 82).

[42] Renewable energy sources disclosed according to art. 19.8 of Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast) (OJ L 328, 21.12.2018, p. 82) and Annex I, paragraph 5 of Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast) (OJ L 158, 14.6.2019 p. 125).

[43] https://eplca.jrc.ec.europa.eu/permalink/PEF_method.pdf

of origin certificates have been purchased in accordance with the principles and rules of operation of the European Energy Certificate System.

In cases where points are claimed for a carbon footprint analysis, the applicant shall provide a copy of the analysis, which shall be in accordance with ISO 14067 or the Product Environmental Footprint method and have been verified by an accredited third party. The footprint analysis must cover all manufacturing processes directly related to hydraulic binder or alternative cement production, onsite and offsite transportation of raw materials to the precast concrete plant, precast concrete production, emissions relating to administrative processes (e.g. operation of onsite buildings) and transport of the sold product to the precast concrete plant gate or local transportation hub (e.g. train station or port).

Rationale:

Why focus on energy consumption at the concrete plant?

Although the energy footprint of concrete is dominated by cement manufacture, it is necessary that the EU Ecolabel criteria focus on some aspects that can be directly controlled by the potential EU Ecolabel applicant, i.e. the pre-cast or dry-cast concrete producer.

The type of information would fit well with any environmental management system which the applicant may have implemented and which could obtain points under the optional criterion 1.7.

Why promote higher renewable energy?

The Renewable Energy Directive has recently been recast and sets a target of an average renewable energy share of 27% by 2030. A criterion on renewable energy is appropriate since the applicant has a much better control over their fuel choice and especially their electricity supply.

An industry representative stated that EU precast concrete producers were beginning to install onsite renewables at their factories and that this should be promoted and recognized by the EU Ecolabel.

The potential of CHP in the precast concrete factory

The installation of onsite CHP brings clear environmental benefits for any industry where the waste heat from the CHP unit can be beneficially reused. As a general rule of thumb, grid electricity can be considered to represent no more than a 40% efficient conversion of primary energy into useful energy (i.e. electricity) due to losses of heat and transmission losses across the grid. However, CHP can generally be considered as an 80% efficient conversion of primary energy into useful energy (i.e. electricity plus heat) because the demand for the heat is located near the CHP unit.

The potential for CHP is maximised when onsite heat demand exceeds onsite electricity demand onsite by at least a factor of 2. Some typical operating data for concrete production plants by Marceau et al., (2007) is presented below.

Data presented in the study by Marceau et al., (2007) for the production of ready mix concrete, precast concrete and concrete masonry units (see table below) suggested that the ratio of heat energy to electrical energy required would make CHP an interesting option to improve energy efficiency.

Table 30. A look at the significance of concrete plant energy consumption.

		Masonry (data from 13 plants)	**Pre-cast (data from 15 plants)**	**Ready mix 3**
		Unspecified class	**50 MPa class**	**20 MPa class**
Unit weight		2380 kg/m3	2290 kg/m3	2320 kg/m3
Representative mix (kg/100 units† or kg/m3 concrete)	Cement	159 kg/100 units	504 kg/m3 concrete	223 kg/m3 concrete
	Water	109 kg/100 units	178 kg/m3 concrete	141 kg/m3 concrete
	Coarse aggregate	473 kg/100 units	1050 kg/m3 concrete	1127 kg/m3 concrete
	Fine aggregate	1081 kg/100 units	555 kg/m3 concrete	831 kg/m3 concrete

		Masonry (data from 13 plants)	Pre-cast (data from 15 plants)	Ready mix 3
		Unspecified class	**50 MPa class**	**20 MPa class**
Concrete plant energy (GJ/100 units† or GJ/m3 concrete) (% of total plant energy)	Vehicles (fuel)	0.0793 GJ/100 units 24.4 %	0.2648 GJ/m3 32.3%	0.0067 GJ/m3 15.6%
	Curing (fuel)	0.2019 GJ/100 units 62.2%	0.3584 GJ/m3 43.7%	0.0213 GJ/m3 49.8%
	Heating + other (fuel)		0.0590 GJ/m3 7.2%	
	Plant (electricity)	0.0433 GJ/100 units 13.3%	0.1371 GJ/m3 16.7%	0.01481 GJ/m3 34.6%
	Plant total	**0.3245 GJ/100 units 100%**	**0.8193 GJ/m3 100%**	**0.0428 GJ/m3 100%**
	Fuel : elec. ratio	86.7 : 13.3 (6.5 : 1)	83.3 : 16.7 (5 : 1)	65.4 : 34.6 (1.9 : 1)
Embodied energy* (GJ/100 units† or m3 concrete)	Cement	0.691 GJ/100 units	2.19 GJ/m3	Not specified
	Aggregates	0.038 GJ/100 units	0.04 GJ/m3	
Sum of embodied energy and plant energy		**1.01 GJ/100 units**	**3.15 GJ/m3**	**1.13 GJ/m3**
Plant energy as % of total embodied energy		**32.1%††**	**26.0%††**	**3.8%**

**Ignoring transportation of materials to concrete plant.*

†100 units refers to 100 concrete masonry units of 200x200x400mm. Typically 131 such units would be produced from 1m3 of concrete.

††Number not explicitly stated in the report, but deduced by calculation using values in the table above.

The ratio of fuel to electricity use in the precast concrete plants was around 5:1. Focussing on fuel used for heat only, the ratio of heat to electricity is around 3:1, suggesting that CHP could a very relevant technology to implement onsite. However, an industry representative stated that they were not aware of any use of onsite CHP in the EU precast concrete sector.

Criterion 5.6. Environmentally innovative product designs (optional)

Criterion 5.6. Environmentally innovative product designs (optional)
Precast concrete or compressed earth products that bring direct or indirect environmental benefits via one or more of the design features described below shall be awarded points in accordance with the design features they exhibit. The total number of points granted under this criterion cannot exceed 15 points (for lime-based products) or 10 points (for all other precast concrete or compressed earth products). A total of up to 10 or 15 points, as appropriate, may be granted as follows: - Up to 10 points shall be awarded in proportion to how the precast or pervious concrete floor tile, floor slab or paver product exceeds a minimum infiltration rate of 400 mm/h and approaches the threshold of environmental excellence of ≥2000 mm/h (from 0 points for 400 mm/h, up to 10 points for 2000 mm/h). - Up to 10 points shall be awarded in proportion to how much the block, slab or panel product exceeds a minimum void space of 20% and approaches the threshold of environmental excellence of ≥80% void space (from 0 points for 20% void space, up to 10 points for ≥80% void space). - Up to 15 points shall be awarded in proportion to how much the block, slab or panel product is below a maximum upper thermal conductivity limit of 0,45 W/m.K and approaches the threshold of environmental excellence of ≤0,15 W/m.K (from 0 points for ≥0,45 W/m.K, up to 15 points for ≤0,15 W/m.K). - Up to 15 points shall be awarded in proportion to how much the hydraulic binder or alternative cement content has been reduced below a maximum upper limit of 10% (expressed as % of total product weight) and approaches the threshold of environmental excellence of ≤5% (from 0 points for ≥10%, up to 15 points for ≤5%). - 10 points shall be awarded to paving units that are designed with void spaces to be filled with topsoil/sand/gravel and be seeded with grass and that can fit into permeable paving design solutions (commonly referred to a grass or turf pavers). ***Assessment and verification:*** *The applicant shall provide a declaration stating whether or not this criterion is relevant to the product(s) subject to the EU Ecolabel application.* *In cases where points are claimed due to infiltration rates of precast or pervious concrete floor tile, floor slab or paver products, the applicant shall provide test reports according to BS 7533-13, BS DD 229:1996 or similar standards.* *In cases where the material efficient block, slab or panel criterion is relevant, the applicant shall provide a declaration of the % void content of the form by providing the dimensions of the product form in such detail that the total volume and the void volume can be calculated.* *In cases where points are claimed due to highly insulating products with a low thermal conductivity, the applicant shall provide test reports according to EN 12667 or similar standards.* *In cases where points are claimed due to a low hydraulic binder or alternative cement content, the applicant shall declare the specific binder content or at least a maximum upper binder content used.* *In cases where the grass/turf open paver criterion is relevant, the applicant shall provide technical drawings of the concrete forms, images of real-life installations complete with vegetated surfaces and detailed installation instructions about how the products should be filled and seeded.*

Rationale:

Why are freely draining concrete paving units worth recognising?

Paved surfaces are beneficial in the sense that they provide flat and solid surfaces that facilitate the continued optimum movement of pedestrians and vehicles and which are designed to drain well during and

after rainfall. The classical design of paving systems is to be impermeable to water and to be sloped in order to quickly divert rainwater to drainage systems. As urbanisation has increased, so too has the extent of impermeable paving. During storm events in any particular river catchment, water that hits an impermeable area is rapidly conveyed via the drainage system to the river whereas storm water hitting a greenfield site infiltrates into the ground and, only once the ground is saturated, it would flow across the vegetated surface towards the river or be trapped in natural depressions in the surface topography. The result is that for a given storm event, there is a higher and more concentrated peak flow in watercourses fed by impermeable areas compared to those fed by greenfield areas.

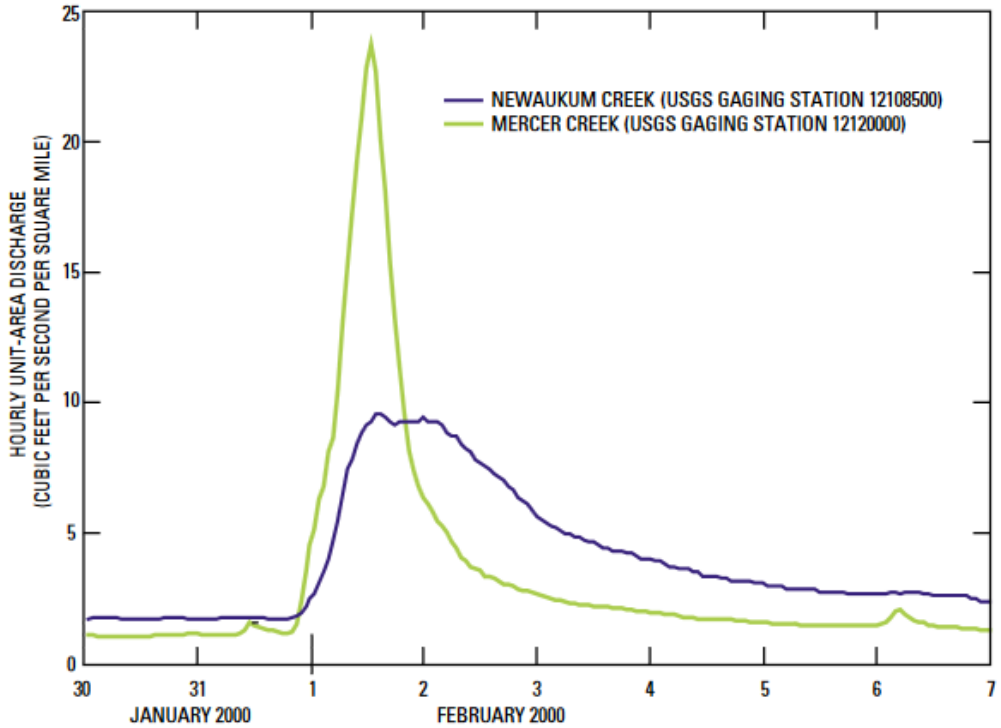

Figure 43. Specific runoff rates in an urban stream (green) and a rural stream (purple) that are located in the same area (Konrad, 2003).

Even though the rainfall event on the 1st February shown in Figure 43 was essentially the same for both stream catchments, the urban stream shows a much higher (x2,5) peak runoff rate. Furthermore, almost all of the storm runoff has passed from the urban area to the stream within one day whereas this process takes more than 5 days in the rural area. The two runoff behaviours indicate that watercourses in urban areas are much more susceptible to the phenomenon of flash flooding simply due to the increase in speed with which stormwater reaches the watercourse.

So it is clear that impermeable pavements play an important role in the rapid conveyance of stormwater to watercourses. To design and construct paved areas that deliver more gradual runoff in a similar (or better) manner when compared to a greenfield site, permeable paving is one of a number of options possible, all of which fall under the concept of sustainable (urban) drainage systems (SUDS for short).

Apart from elevated risks of flash flooding, impermeable paving reduces the possibility of recharging of groundwater aquifers. Permeable pavements can be designed for full, partial or zero infiltration, depending on what is most appropriate for the local area, by adjusting the broader paving system design and underlying base layers that are installed.

Focusing purely on the top paving layer, there are two broad types of permeable paving:

i. impermeable blocks with larger joints or large void spaces that are to be filled with aggregates of a well-defined granulometry, and

ii. concrete blocks that are permeable on the surface of the block itself (i.e. pervious concrete).

With the first option, in order to ensure the permeability of the filled joints, it is necessary to fill joints with aggregates with a very low fines content, to ensure that voids between coarse aggregates are not filled by small aggregates. Larger joint areas between blocks will also enhance permeability.

With the second option, for pervious concrete, it is also important to restrict the fines content in aggregates as well as the cement content. Ranges of mix compositions (aggregate, cement and water) that have been used in academic research have been summarised by Chandrappa and Biligiri, (2016). With correct compositional control, pervious concrete with an interconnected void content of 15-35% can be produced (Kia et al., 2017).

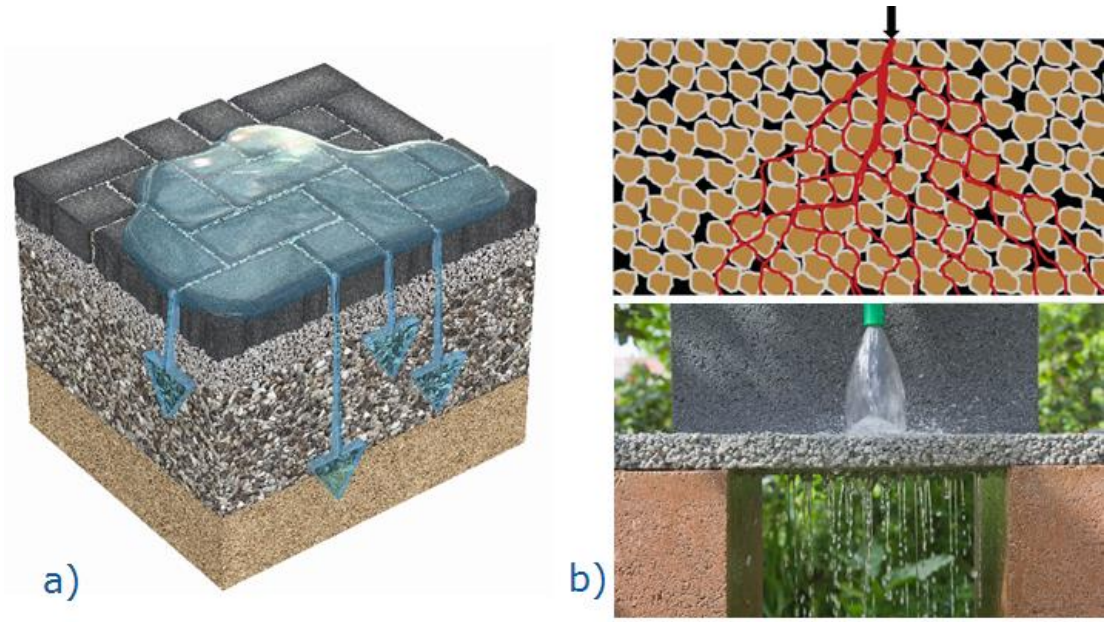

*Figure 44. Drainage mechanisms in a) paving with permeable joints and b) pervious concrete blocks (Source of image a) **Marshalls**, image b) Kia et al., 2017).*

It is worth noting that permeable paving is recognised by a number of green building assessment schemes. Points can be awarded under credit 6 (Stormwater Management) of LEED for reducing the runoff rate by at least 25% (credit 6.1) and removing at least 80% of total suspended solids and 40% of total phosphorus (credit 6.2). The BREEAM scheme has a requirement related to surface runoff rates (Pol. 03), HQE rewards building plot designs with fewer impermeable areas (criterion 5.2.1) and that limit rainwater discharge into combined sewers (criterion 5.3.3).

If claims for permeable paving are to be recognised, it is important to consider exactly how the claims should be assessed and verified. Although results will also depend on the correct specification of joint filler and underlying base materials, one simple and reproducible test is to measure the infiltration rate of water (in mm/h) under standard conditions. It is unclear if there is a harmonised European standard for this type of test but one example used in the UK is BS DD 229:1996 (Method for determination of the relative hydraulic conductivity of permeable surfacings). With impermeable pavers that are interlocked with permeable joints and spacings, a simple specification would be to specify the permeable area as a fraction of the total area.

Why are material efficient precast concrete blocks worth recognising?

The compressive strength of concrete tends to greatly exceed its minimum requirement when used in structural applications. So in applications which are not part of loadbearing building structures, which is where the scope for EU Ecolabel hard coverings becomes relevant, the safety margin is even wider.

This wide safety margin has led to innovation in the design of precast concrete forms, by introducing large void spaces that do not compromise on compressive strength requirements but which do increase the material efficiency of the product and reduce raw material costs. These forms with incorporated voids allow for blocks to be larger while still remaining light enough for manual placement onsite.

The void content in the form (clearly visible when looking at a block and measurable with a pair of calipers) should not be confused with pore volume within the concrete material itself (not clearly visible and only possible to estimate in a laboratory) caused by entrapped air bubbles or evaporated pockets of water.

The direct environmental benefits associated with material efficient precast concrete units include less consumption of aggregates and cement per unit volume. Indirect environmental benefits could relate to lower loads on foundations/floor slabs or, depending on how the blocks are placed together and incorporated into the broader design, the potential for passive ventilation in the wall.

Why are grass/turf open paving concrete paving units worth recognising?

These types of products have found particular interest in areas such as driveways and car parks, where a stable ground surface is needed for vehicle traction and ride-ability on a continual or periodic basis. These products have some significant environmental advantages, the importance of each varying depending on the site-specific situation:

- Help reduce soil erosion due to both the vegetation cover.
- Help reduce soil erosion by winds even in cases when vegetation cover is minimal.
- Help reduce soil erosion by wind and rain especially on sloping surfaces.
- Help reduce erosion, rutting and soil compaction by the concrete surface supporting vehicle loads and transferring them over broader areas.
- Permit the free drainage of the surface towards greenfield site levels.
- Permit the establishment of a vegetation cover for aesthetic benefits.
- Save on concrete for a given m^2 of ground surface area covered.
- When vegetated, help reduce urban heat island effects.

In wetter climates, these products offer an optimal compromise between green space and outdoor paved areas in cases where soil erosion, drainage or the need for occasional or permanent heavy use of the area applies. The more occasional the use, or the lighter the use volume in general, the more suitable the vegetated option becomes. Non-vegetated options are also possible in cases of heavy and permanent vehicle use and/or insufficient moisture. As a general rule of thumb, a surface will need to receive at least 5 hours of sunlight a day for grass to flourish (ICPI, 2006). Some images of the grass/turf pavers are provided below.

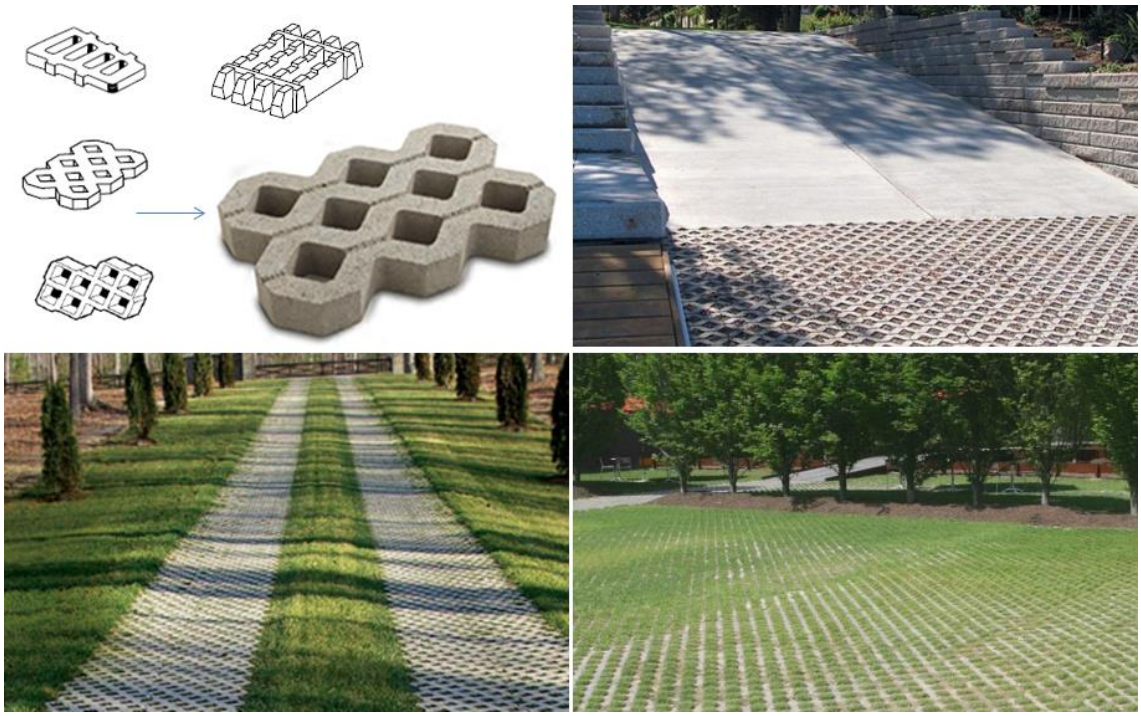

*Figure 45. Examples of grass/turf open pavers (Sources: ICPI, 2006; **Eagle Bay Pavers** and **Unilock**)*

The possible uses of these products include: parking lots (especially overspill parking), emergency and fire lane access, driveways, access roads to remote infrastructure, drainage channels, erosion control, riverbank stabilization, walkways, flooring for barns and picnic areas.

According to the ICPI, these types of products can potentially be recognised by LEED under the criteria summarised below.

Table 31. Potential recognition of grass/turf open pavers by LEED (Source: ICPI, 2014)

LEED Credit Category	Available	Potential Points Using Segmental Concrete Pavement
Integrative Process	1-5	1-5
Sustainable Sites	10	
Open Space		1
Rainwater Management		3
Heat Island Reduction		2
Water Efficiency	11	
Outdoor water use		Prerequisite (no points)
Materials & Resources	13	
Building Product Disclosure and Optimization– Environmental Product Declarations		1
Building Product Disclosure and Optimization– Sourcing of Raw Materials		1
Building Product Disclosure and Optimization– Material Ingredients		3
Construction and Demolition Waste Management		2
Innovation	6	6
Regional priority	4	4
Range of potential points	45 – 50	25 – 30

From the table above it is clear that the rainwater management and heat island reduction benefits are recognised. Although LEED does not recognise the grass grown in grass paver voids as a vegetated area, it is still possible to obtain one credit for the open space category by potentially providing surfaces for outdoor social activities and recreation.

The potential credits relating to materials and resources are more related to producer management systems and the choice of whether or not to incorporate recycled aggregates into the products.

4 Main changes to criteria compared to Decision 2009/607/EC

Comparison of old criteria and revised criteria

A direct comparison between the criteria is not straightforward because of the restructuring that has been carried out. Furthermore, where some old criteria applied to multiple sub-products, they are repeated in cases where they compare to more than one sub-product in the new criteria set.

Table 32. Comparison of the old criteria in Decision 209/607/EC and the new revised criteria

EU Ecolabel criteria for hard coverings in Decision 2009/607/EC	New revised EU Ecolabel criteria for hard covering products
Horizontal criteria	
1.2. Extraction management.	1.1. Industrial and construction mineral extraction
2.1. Absence of risk phrases in raw materials. 2.3. Limitation of asbestos in the materials.	1.2. Restricted substances
	1.3. VOC emissions
8. Fitness for use	1.4. Fitness for use
9. Consumer information	1.5. User information
10. Information appearing on the eco-label	1.6. Information appearing on the EU Ecolabel
	1.7. Environmental Management System (optional)
Criteria specifically for natural stone products	
	2.1. Energy consumption at the quarry
I3. Natural resource waste 5.1. Waste management (for natural products only)	2.2. Material efficiency at the quarry
I1. Water recycling ratio I5. Water quality	2.3. Water and wastewater management at the quarry
I4. Air quality	2.4. Dust control at the quarry
I6. Noise	2.5. Personnel safety and working conditions at the quarry
I2. Quarry impact ratio.	2.6. Quarry landscape impact ratios (optional)
	2.7. Energy consumption at the transformation plant
3. Finishing operations (SS, Cd, Cr(VI), Fe, Pb and water recycling ratio)	2.8. Water and wastewater management in the transformation plant
3. Finishing operations (dust, styrene).	2.9. Dust control at the transformation plant
5.1. Waste management (for natural products only)	2.10. Reuse of process waste from the transformation plant
	2.11. Regionally integrated production at the transformation plant (optional)
Criteria specifically for agglomerated stone products based on resin binders	
4.1.(a) Process energy requirement (PER)	3.1. Energy consumption
4.3.Emissions to air (a) agglomerated stone	3.2. Dust control and air quality
	3.3. Recycled/secondary material content
2.3. Limitation of polyester resins in the materials.	3.4. Resin binder content
5.2. Recovery of waste (for processed products only)	3.5. Reuse of process waste
Criteria specifically for ceramic or fired clay products	
4.1.(b) Energy requirement for firing (ERF)	4.1. Fuel consumption for drying and firing
	4.2. CO2 emissions (from drying and firing)
4.2. Water consumption and use.(a+b)	4.3. Process water consumption
4,3, Emissions to air: (b) ceramic tiles; (c) clay tiles	4.4. Emissions of dust, HF, NOx and SOx to air
4.4. Emissions to water	4.5. Wastewater management

EU Ecolabel criteria for hard coverings in Decision 2009/607/EC	New revised EU Ecolabel criteria for hard covering products
5.2. Recovery of waste (for processed products only)	4.6. Reuse of process waste
2.2. Limitation of the presence of some substances in the additives (Pb, Cd, Sb) 6.1. Release of dangerous substances - glazed tiles only)	4.7. Glazes and inks
Criteria specifically for precast concrete products based on hydraulic binders or alternative cements (including autoclaved aerated concrete, calcium silicate and compressed earth)	
	5.1. Clinker factor
4.5. Cement (energy not CO2)	5.2. CO2 emissions (from cement or lime kiln)
4.5. Cement	5.3. Emissions of dust, NOx and SOx to air *(from cement or lime kiln).*
5.2. Recovery of waste (for processed products only)	5.4. Recovery and responsible sourcing of raw materials
	5.5.Energy consumption (at the precast concrete plant)
	5.6. Environmentally innovative product designs (optional)
4.3. Emissions to air: (d) terrazzo tiles and concrete paving units	
7. Packaging	

From the table above, it is clear that there is a high degree of overlap in the criteria areas. The table shows that most old criteria have been accommodated within the new criteria structure. However, it must be highlighted that the wording of the criteria text has been completely reworked and some of the main changes will be described in the next sub-sections.

Main changes introduced in criteria revision

- In relation to the **scope,** the main change is the enlargement of the scope to include kitchen-worktops, vanity tops, table-tops and roofing tiles – the markets for these products are worth billions of euros per year in sold production at the EU level and open the EU Ecolabel to many new companies specializing in these newly included products.
- The criteria are set up now to also **allow for the EU Ecolabel to be awarded to intermediary products** from suppliers in the production chain (specifically dimension stone blocks and hydraulic binders or alternative cements). Such allowance has been made because these intermediate products account for significant portions of the total environmental impacts of the final product. Now these important intermediate actors have a direct marketing opportunity and incentive to provide data as well.
- The criteria set now includes both mandatory requirements and optional requirements. Points can be awarded where mandatory requirements are exceeded (for some criteria), and when optional requirements are met. The criteria are consequently **more flexible** than before and **maximise the steerability** for applicants and license holders. Such an approach also **encourages continuous improvement** towards the maximum score possible.
- To further promote **circular economy aspects**, the incorporation of **recycled and secondary materials** into the sub-products that are made by batch processes (i.e. agglomerated stone and precast concrete) is now rewarded.
- Now there are criteria relating to **carbon emissions**, reflecting the important political priority of achieving climate neutrality and a much more comprehensive approach is taken to **energy consumption** for all sub-products, which is closely related to carbon emissions.

Natural stone products

The natural stone criteria have been adapted to focus much more on good practice at the quarry and the transformation plant, especially on energy consumption, material efficiency and water reuse. The criteria have

moved away from mandatory approaches to quantitative emissions, which sound good in theory but are not so meaningful in practice (e.g. measuring diffuse emissions of dust at a point source). Care has been taken not to discriminate between quarries in mountainous regions and those in flatter sites by removing mandatory requirements on quarry footprint ratios. The criteria have been heavily influenced by other initiatives such as the National Stone Council in the US and Fair Stone in Germany.

Agglomerated stone products based on resin binders

The agglomerated stone criteria have been developed following active engagement with interested industry representatives and focus on energy efficient production, the promotion of renewable energy and the promotion of recycled/secondary materials in particular.

Ceramic and fired clay products

The ceramic criteria have been re-evaluated following an exhaustive analysis of the BREF document published in 2007, the latest draft ISO 17889-1 standard published in 2018 and anonymous data from existing license holders. The ambition level of thresholds of environmental excellence is much better justified although further data input would have been welcomed. In particular, the NOx data merited further investigation. A major gap in the previous criteria for ceramic and fired clay products (i.e. specific CO2 emissions), has now been addressed. The scope for limits on fuel consumption has now been expanded from the kiln only to the dryer plus kiln, also including spray dryers where relevant for ceramic tiles. Overall, the approach to energy consumption is now more holistic and the CO2 emission reporting is well aligned with ETS reporting practices.

Precast concrete products based on hydraulic binders or alternative cements (including autoclaved aerated concrete, calcium silicate and compressed earth blocks)

For cement criteria, the first point to highlight is that non-Portland cement binders are also considered in the scope (i.e. hydraulic limes and alternative cements). Two new criteria that are highly relevant to the environmental impact of the hydraulic binders or alternative cements have been introduced: (i) clinker factor (especially relevant to hydraulic cements and alternative cements) and (ii) CO2 emissions (relevant to all binders, with an ETS-based approach for Portland cement and hydraulic lime and a carbon footprint approach for alternative cements).

Renewable energy is strongly promoted at the precast concrete plant and products that meet defined criteria for delivering environmental benefits during their use stage are also recognised.

For all types of material covered by the product group scope, greater emphasis has been placed on the reuse of process waste and process by-products as well as the potential recognition of recycled content, in line with recognising products that help contribute to a more circular economy.

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