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Complementary Product Category Rules for Bituminous Mixtures (c-PCR Bituminous Mixtures)

DN-PAV-03077
January 2024

DN Design

Standards

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This document has been authorised by the Director of Professional Services, Transport Infrastructure Ireland. For any further guidance on the TII Publications system, please contact the following:

Contact: Standards and Research Section, Transport Infrastructure Ireland
Postal Address: Parkgate Business Centre, Parkgate Street, Dublin 8, D08 DK10
Telephone: +353 1 646 3600
Email: infoPUBS@tii.ie

TII Publications

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Contents

Updates to TII Publications resulting in changes to

Complementary Product Category Rules for Bituminous Mixtures (c-PCR Bituminous Mixtures) DN-PAV-03077

Date:	January 2024
Page No:	52, 60 and 61
Section No:	Tables C1 and C4 of Appendix C

Amendment Details:

In Table C1, the values for the environmental impact indicator “Climate Change” for the six unit processes have been corrected from Ecoinvent version 3.6 data to Ecoinvent version 3.8 data.

In Table C4, the values for all of the environmental impact indicators of the four unit processes have been corrected from Ecoinvent version 3.6 data to Ecoinvent version 3.8 data.

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Introduction

General

European standard IS EN 15804:2012+A2:2019+AC 2021, referred to as ‘EN 15804’ in this document, provides core Product Category Rules (PCR) for Type III environmental declarations for any construction product and services. It provides a structure to ensure that all Environmental Product Declarations (EPD) of construction products, construction services and construction processes are derived, verified and presented in a harmonised way.

This document provides additional rules for Life Cycle Assessments (LCA) and EPDs, specifically for bituminous mixtures. It complements the core product category rules for all construction products and services as established in EN 15804. This document is to be referred as “c-PCR for Bituminous Mixtures” with “c-PCR” standing for “complementary Product Category Rules”.

An EPD communicates verifiable, accurate, non-misleading environmental information for products and their applications, thereby supporting scientifically based, fair choices and stimulating the potential for market-driven continuous environmental improvement.

The standardisation process has taken place in accordance with ISO 14025. All common issues are covered horizontally for all product types in order to minimise vertical (branch specific) deviations.

All common issues are covered horizontally for all bituminous mixtures in order to minimise intra-sectoral deviations.

EPD information is expressed in information modules as defined in EN 15804, which allow easy organisation and expression of data packages throughout the life cycle of bituminous mixtures. The approach requires that the underlying data should be consistent, reproductible and comparable.

In line with EN 15804, the EPD is expressed in a form that allows aggregation (addition) to provide complete information for construction works. This document does not deal with aggregation at the construction level nor does this document describe the rules for applying EPD in a construction assessment.

The document deals with a limited number of quantifiable parameters as predefined in EN 15804. Future revisions of EN 15804 as well as the possible publication of a European Standard, may lead to the incorporation in this document of additional predetermined parameters.

c-PCR for Bituminous Mixtures Review Statement

A review of DN-PAV-03077 – Complementary Product Category Rules for Bituminous Mixtures (c-PCR for Bituminous Mixtures) as per ISO 14025:2010 has been conducted. The draft c-PCR was revised to address issues raised by members of the review panel. The review panel confirms that this final version (Version October 2023) is aligned with EN 15804:2012+A2:2019+AC:2021, EPD Ireland's General Programme Instructions and Product Category Rules without significant deviation and is suitable for adoption as a sub-PCR within the EPD Ireland Programme.

1. Scope

This document, the c-PCR for Bituminous Mixtures, provides core product category rules for type III environmental declaration of bituminous mixtures for civil engineering according to EN 13108-1, EN 13108-4, EN 13108-5, EN 13108-7, EN 13108-8 and EN 13108-31. The classification code for bituminous mixtures is 3794 as per CPC version 2.1 (Central Product Classification from the United Nation Statistics Division - https://unstats.un.org).

This document specifies the parameters to be reported, the life cycle stages to be covered, what rules to be followed in order to generate Life Cycle Inventories (LCI) and conduct Life Cycle Impact Assessment (LCIA) and the data quality to be used in the development of EPDs.

The c-PCR for Bituminous Mixtures shall be used for either of the following two purposes and associated rules:

- Declaring the environmental performances of a specific bituminous mixture to be used on the Irish market – more details are provided in Clauses 3 and 5.6 under the term “Producer-Specific LCA”; or
- Declaring the environmental performances of a specific bituminous mixture to be used on a defined project – more details are provided in Clauses 3 and 5.6 under the term “Project-Specific LCA ”.

For each life-cycle stage and associated modules included in the scope of the c-PCR for Bituminous Mixtures, general references that need to be used for calculation are being prescribed. These general references are considered to be a worst-case baseline that must be used if no specific information is available. The c-PCR for Bituminous Mixtures also describes the requirements for deviating from these baseline references. These specific requirements are reported under the set of rules specific to each life cycle module. Deviation from baseline references can either be through the use of verified industry calibrated default references or by means of verified EPDs.

This document provides a c-PCR that shall be applied for a particular bituminous mixture, from a specific asphalt plant with a specific declared production temperature.

The c-PCR for Bituminous Mixtures is expected to be used by:

- Bituminous mixture producers;
- LCA consultants and EPD generator developers;
- EPD verifiers;
- Contractors;
- Designers; and
- Clients.

In addition to the common parts of EN 15804, this document for bituminous mixtures:

- Defines the system boundaries;
- Defines allocation procedures for multi-output processes along the production chain; and
- Includes the rules for calculating the LCI (Life Cycle Inventory analysis) and the LCIA (Life Cycle Impact Assessment) underlying the EPD.

2. References

2.1 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14025:2006, Environmental labels and declarations — Type III environmental declarations - Principles and procedures

ISO 14040, *Environmental management – Life cycle assessment – Principles and framework*

ISO 14044, *Environmental management – Life cycle assessment – Requirements and guidelines*

IS EN 15804:2012+A2:2019+AC 2021, *Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products*

IS EN 13108-1 – Bituminous Mixtures – Material Specifications – Part 1: Asphalt Concrete

IS EN 13108-4 – Bituminous Mixtures – Material Specifications – Part 4: Hot Rolled Asphalt

IS EN 13108-5 – Bituminous Mixtures – Material Specifications – Part 5: Stone Mastic Asphalt

IS EN 13108-7 – Bituminous Mixtures – Material Specifications – Part 7: Porous Asphalt

IS EN 13108-8 – Bituminous Mixtures – Material Specifications – Part 8: Reclaimed Asphalt

IS EN 13108-20 – Bituminous Mixtures – Material Specifications – Part 20: Type Testing

IS EN 13108-31 – Bituminous Mixtures – Material Specifications – Part 31: Asphalt Concrete with Bituminous Emulsion

2.2 Other References

[1] T. van der Kruk and L. Overmars, "Product Category Rules voor bitumineuze materialmen in verkeersdragers en waterwerken in Nederland" ("PCR Asfalt"), Vakgroep Bitumineuze Werken (VBW), The Netherlands, version 2.0, 2022, available: https://milieudatabase.nl

[2] S. de Vos-Effting, E. Keijzer, B. Jansen, A. Zwamborn, J. Mos, T. Beentjes, N. Jonkers, P. Leendertse; "LCA-Achtergrondrapport voor Nederlandse Asfaltmengsels. Rapport voor opname brancherepresentatieve asfaltmengsels in de Nationale Milieudatabase", Vakgroep Bitumineuze Werken (VBW), The Netherlands, version 2.1, 2018, available: https://www.asfaltblij.nl/

[3] Eco Platform, "Audit and Verification Guidelines for ECO EPD Programme Operators", https://www.eco-platform.org/

3. Terms and Definitions

As per or in complement to the terms and definitions available in ISO 14040, ISO 14044 and EN 15804.

Term	Definition [source]
Average EPD	An Average EPD is developed by an industry association and declares the environmental performances of the product of multiple companies in a clearly defined sector and/or geographical area. Products covered in an Average EPD shall follow the same PCR and the same functional/ declared unit shall be applied. Any communication of the results from an Average EPD should contain the information that the results are based on averages obtained from the sector or industry as defined in the EPD. The communication shall not claim that the Average EPD results are representative for a certain manufacturer or its product. As that, a single EPD cannot represent several products and several manufacturers. In the context of EN 15804, an Average EPD is sometimes referred to as a "Sector EPD". Elsewhere, they could be referred to as "Industry-wide EPD" or "Generic EPD". [EPD International AB - https://www.environdec.com/]
Group EPD	Similar products made by the same manufacturer can be included in a Group EPD. Similar products from a single or several manufacturing sites covered by the same PCR and manufactured by the same company, with the same major steps in the core processes may be included in the same EPD if the differences between the declared environmental performance indicators do not differ by more than 10% between the included products. One set of results shall be declared for one representative product. The choice of representative product shall be justified in the EPD, using, where applicable, statistical parameters. [EPD International AB - https://www.environdec.com/]
Single-company, product-specific EPD	The single-company, product-specific EPD is the most common type of EPD. It is based on a valid PCR and describing the life cycle environmental impact of one product from one single manufacturer. Single-company EPDs provide data on one product made by one manufacturer but can encompass several factories. When a manufacturer produces a product in several plants throughout the world, but all plants use the same processes, they can be covered by a single EPD. [EPD International AB - https://www.environdec.com/]
Life cycle stage	One of the 5 steps making up the life cycle of a product. These are Product stage, Construction stage, Use stage, End of Life stage, and the Benefits and loads beyond the system boundaries as per Figure 1 of EN 15804.
Life cycle module	Sub-steps to each life cycle stage. The product's life cycle is split into 17 modules, A1 to A5, B1 to B7, C1 to C4 and D.
Process or activity	Set of interrelated or interacting activities that transforms inputs into outputs. [ISO 9000:2005, definition 3.4.1 without notes]
Producer-Specific LCA	Life cycle assessment (LCA) for a bituminous mixture defined by its Type Test Report. The outcome of the LCA is a verified EPD as per Clause 9. The EPD can be used for any project across the Republic of Ireland. And as defined under clause 5.6.1 of this document.

Term	Definition [source]
Programme Operator	Body or bodies that conduct a Type III environmental declaration programme. [EN 15804:2012+A2:2019&AC1:2021] Note: A programme operator can be a company, or a group of companies, industrial sector or trade association, public authorities or agencies, or an independent scientific body or organisation.
Project-Specific LCA	LCA for a bituminous mixture defined by its Type Test Report and the exact location of the project site. Life cycle modules A4 and C2-C4 are dependent on the project location. The outcome of the LCA is a LCA report only applicable to a specific project of which the content and the verification requirements are stated by the Client. And as defined under clause 5.6.2 of this document.
Reclaimed Asphalt	The processed site-won asphalt, suitable and ready to be used as constituent material for asphalt, after being tested, assessed and classified according to EN 13108-8. [EN 13108-8:2016] Note: Processing can include one or more of: milling, crushing, sieving (screening), blending, etc.
Site-won asphalt	The material to be recycled, in the form of milled asphalt road layers or as slabs ripped up from asphalt pavements, or being asphalt from reject, surplus or failing production. [EN 13108-8:2016] Note: These materials will require assessment and often processing before being suitable as a constituent material.
Unit Process of activity	Smallest element considered in the life cycle inventory analysis for which input and output data are required. [EN ISO 14040:2006+A1:2020, EN ISO 14044:2006+A2:2020]

4. Abbreviations

As per or in complement to the abbreviations available in ISO 14040, ISO 14044 and EN 15804.

Abbreviation	Description [source]
c-PCR	complementary Product Category Rules – product group specific or horizontal PCR, which provide additional compliant and non-contradictory requirements to EN 15804. [CEN/TR 16970:2016] Note: c-PCR are meant to be used together with EN 15804.
EA	Energy Allocation model – model developed to simulate the energy consumption in the production of asphalt. This model is based on the Energy Balance Analysis (EBA) model, which was originally developed by Ernst and Young (EY) on behalf of the Netherlands Enterprise Agency (RVO) in 2009.
EF 3.0	Environmental Footprint version 3.0. This refers to the Life Cycle Impact Assessment method and associated characterisation factors.
EPD	Environmental Product Declaration – type III environmental declaration providing quantified environmental data using predetermined parameters and, where relevant, additional environmental information. [EN ISO 14025:2010] Note 1: The predetermined parameters are based on the ISO 14040 series of standards, which is made up of ISO 14040 and ISO 14044. Note 2: The additional environmental information may be quantitative or qualitative.
LCA	Life Cycle Assessment – compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle. [EN ISO 14040:2006+A1:2020, EN ISO 14044:2006+A2:2020]
LCI	Life Cycle Inventory analysis – phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle. [EN ISO 14040:2006+A1:2020, EN ISO 14044:2006+A2:2020]
LCIA	Life Cycle Impact Assessment – phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product. [EN ISO 14040:2006+A1:2020, EN ISO 14044:2006+A2:2020]
PCR	Product Category Rules – set of specific rules, requirements and guidelines for developing Type III environmental declarations for one or more product categories. [EN ISO 14025:2010]
RA	Reclaimed Asphalt – the processed site-won asphalt, suitable and ready to be used as constituent material for asphalt, after being tested, assessed and classified according to EN 13108-8:2016. [EN 13108-8:2016] Note: Processing can include one or more of: milling, crushing, sieving (screening), blending, etc.
RVO	Rijksdienst voor Ondernemend Nederland – Netherlands Enterprise Agency
TTR	Type Test Report to comply with the Construction Products Regulation (CPR), Regulation (EU) No 305/2011.

5. General Aspects

5.1 Objective of the c-PCR

In addition to EN 15804, the objective of the c-PCR for Bituminous Mixtures is to provide additional rules for bituminous mixtures that are specific to the Republic of Ireland.

5.2 Type of EPD with Respect to Life Cycle Stages Covered

Whether the c-PCR for Bituminous Mixtures is being used to produce a Producer Specific LCA or a Project Specific LCA, the LCA shall declare at least against modules A1 to A5, C1 to C4 and module D. This version of the c-PCR is limited to the LCA of bituminous mixtures as a material and not as an integral part of a pavement structure. As such, life cycle stage B – Use stage is not covered by this version of the c-PCR. Life cycle stage B – Use stage will be included in a subsequent version of this c-PCR.

Figure 5.1 below illustrates this requirement.

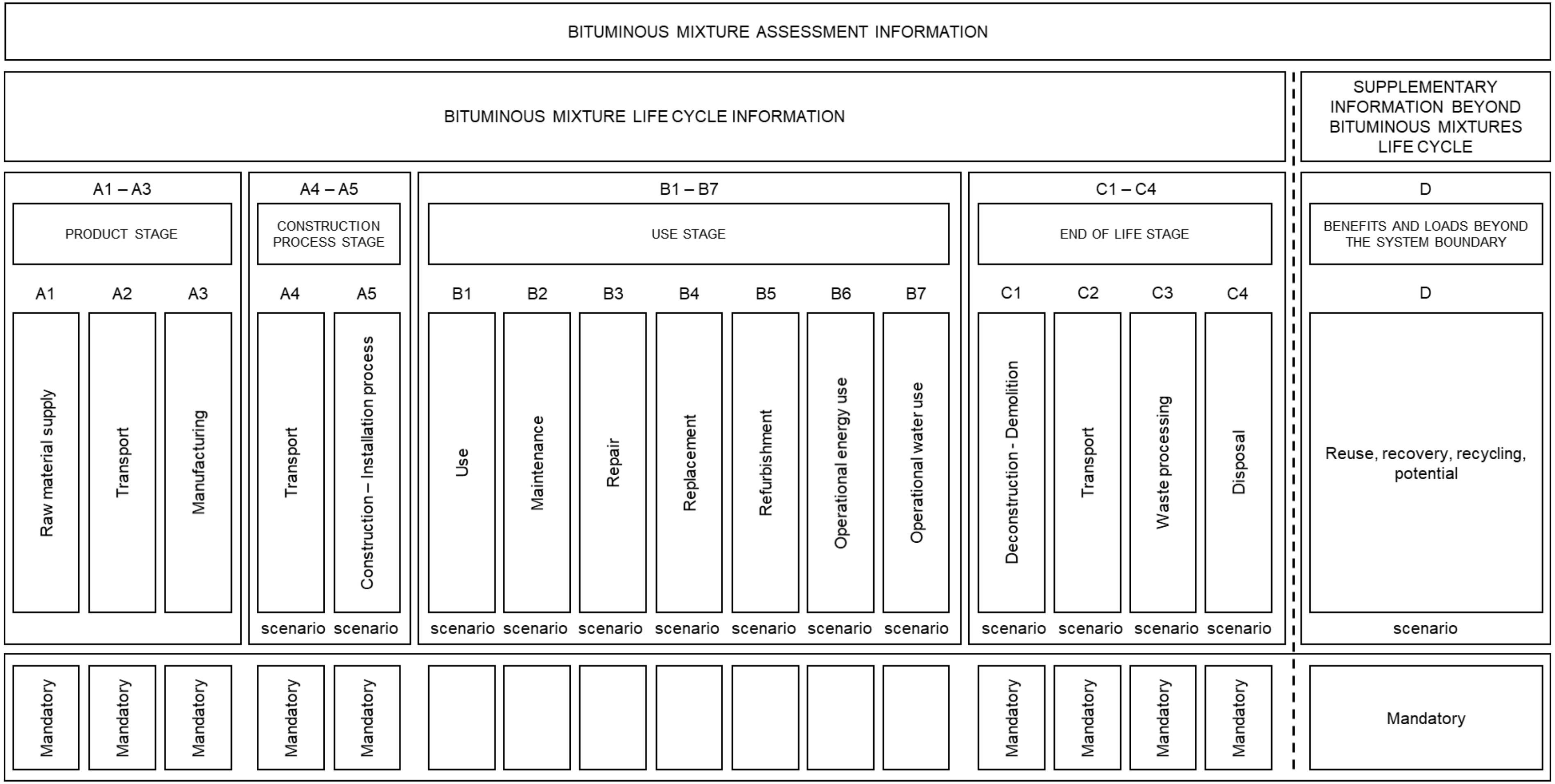

Figure 5.1 Type of EPD with respect to life cycle stages covered and life cycle stages and modules for the assessment of bituminous mixtures

5.3 Comparability of EPD of Construction Products

In principle, the comparison of products on the basis of their EPD is defined by the contribution they make to the environmental performance of the pavement structure. Consequently, comparison of the environmental performance of bituminous mixtures using the EPD information shall be based on the product's use in and its impacts on the pavement structure and shall consider the complete life cycle (all information modules).

In addition, a Producer-Specific LCA is not comparable to a Project-Specific LCA as the scope of the LCA is different.

Note 1: EPD that are not used in a pavement structure context are not tools to compare bituminous mixtures.

Note 2: For the interpretation of a comparison, benchmarks or reference values are needed. This standard does not set benchmarks or reference values.

This c-PCR for Bituminous Mixtures shall only be deemed valid if the adopting Programme Operator complies with the "Audit and Verification Guidelines for ECO EPD Programme Operators" from Eco Platform (References [3]) or similar.

5.4 Additional Environmental Information

5.4.1 General

EN 15804 shall apply.

5.4.2 Additional Impact Indicators

EN 15804 shall apply.

5.4.3 Additional Information on Carbon Offset, Carbon Storage and Delayed Emissions

EN 15804 shall apply.

5.4.4 Additional Information not Derived from LCA

EN 15804 shall apply.

5.5 Ownership, Responsibility and Liability for the EPD

For Producer-Specific LCAs, a producer is the sole owner and has the liability and responsibility, this includes the resulting EPD.

For Project-Specific LCAs, a producer is the sole owner and has the liability and responsibility.

5.6 Implementation

Producer-Specific LCAs (EPD) are mandatory on all TII projects.

Project-Specific LCAs are only required at Client's request.

Both Producer-Specific LCA and Project-Specific LCA are explained below.

5.6.1 Producer Specific LCA (EPD)

Description: LCA for a bituminous mixture defined by its Type Test Report. The outcome of the LCA is a verified EPD as per Clause 9. The EPD can be used for any project across the Republic of Ireland. The LCA of a Producer-Specific bituminous mixture shall meet the following requirements:

i. The bituminous mixture is produced by a specific producer as reported in the product's associated Type Test Report;

ii. The bituminous mixture is produced at a specific asphalt plant as reported in the product's associated Type Test Report;

iii. The bituminous mixture's composition and constituents are as per the product's Type Test Report;

iv. The bituminous mixture is produced at a specific declared production temperature as reported in the product's associated Type Test Report;

v. Data sets shall be based on 1-year averaged data, any deviation shall be justified;

vi. Data sets used for calculations shall be valid for the current year. The reference year shall be the previous calendar year, any deviation shall be justified, and the data used shall be as current as possible; and

vii. LCAs based on a Type Test Report where the family approach was taken, as defined under EN 13108-20, Clause 4.1, are permitted, providing:

   a) items 'i.' to 'vi.' above are still adhered to, and

   b) none of the declared environmental performance indicator results differ by more than ±10% between any of the included products (in line with EN 15804, Clause 9).

Intended use: The Producer-Specific LCA communicates the environmental performances of a specific bituminous mixture and is independent of any project. This makes it possible to sell bituminous mixtures on public road projects.

Calculation rules: The producer of the bituminous mixture shall conduct the Producer-Specific LCA following the Producer-Specific sections from this c-PCR for modules A1-A3 and D (see clauses 6.3.5.2.1 to 6.3.5.2.3 and 6.3.5.6). The other modules (A4, A5, C1-C4) are fixed and a default scenario is provided.

5.6.2 Project Specific LCA

Description: LCA for a bituminous mixture defined by its Type Test Report and the exact location of the project site. The outcome of the LCA is a LCA report of which the content, further reporting format and the verification requirements are stated by the Client. The LCA of a Project-Specific bituminous mixture shall meet the following requirements:

i. The bituminous mixture is produced by a specific producer as reported in the product's associated Type Test Report;

ii. The bituminous mixture is produced at a specific asphalt plant as reported in the product's associated Type Test Report;

iii. The bituminous mixture's composition and constituents are as per the product's Type Test Report;

iv. The bituminous mixture is produced at a specific declared production temperature as reported in the product's associated Type Test Report;

v. The bituminous mixture is installed at a specific location.

vi. The calculation of the environmental impact is based on the specifics of the project, both in terms of input data and unit processes;

vii. Data sets shall be based on 1-year averaged data, any deviation shall be justified; and

viii. Data sets used for calculations shall be valid for the current year. The reference year shall be the previous calendar year, any deviation shall be justified, and the data used shall be as current as possible.

Intended use: The Project-Specific LCA communicates the environmental performances of a specific bituminous mixture and is specific to a project. This LCA shall be submitted following the Client's instructions.

Calculation rules: The producer of the bituminous mixture shall conduct the Project-Specific LCA following the rules and requirements given by the Client as well as the Project-Specific sections from this c-PCR for modules A1-A4, C2-C4 and D (see clauses 6.3.5.2.1 to 6.3.5.3.1, 6.3.5.5.2 to 6.3.5.5.4 and 6.3.5.6). There is no difference for A1-A3+D between project-specific and producer-specific LCA. The other modules (A5 and C1) are fixed, and a default scenario is provided.

5.7 Communication Formats

The communication format of the EPD shall be in accordance with EN 15942, *Sustainability of construction works — Environmental product declarations — Communication formats: business to business*.

6. Product Category Rules for LCA

6.1 Product Category

The product category referred to in this standard includes all bituminous mixtures conforming to EN 13108-1, EN 13108-4, EN 13108-5, EN 13108-7, EN 13108-8 and EN 13108-31.

6.2 Life Cycle Stages and their Information Modules to be included

6.2.1 General

The environmental information of an EPD covering all life cycle stages and module D (cradle to grave and module D) shall be subdivided into the modules A1–A3, A4–A5, B1–B7, C1–C4 and module D.

Only the declaration of the modules A1-A3, A4-A5, C1-C4 and D is required for compliance with this document.

Depending on the type of project, the type of LCA required varies as per clause 5.6. Different rules apply for Producer-Specific LCAs and Project-Specific LCAs.

Clauses 6.2.2 to 6.2.6 below provide a graphical representation of a non-exhaustive list of processes included in each module of the life cycle of a bituminous mixture. These clauses are informative. In clauses 6.2.3 and 6.2.5, the preceding module from the previous life cycle stage is included in a shaded version to illustrate continuity in the overall life cycle.

6.2.2 A1-A3, Product Stage, Information Modules

EN 15804 shall apply.

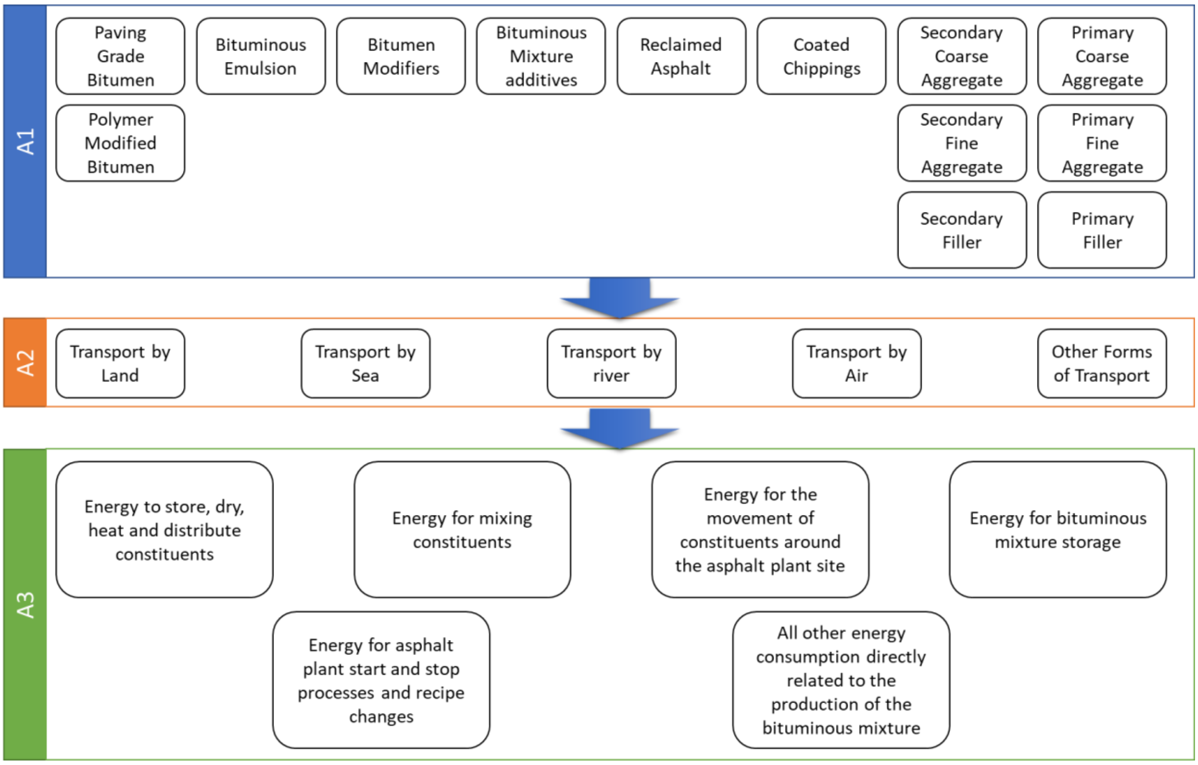

Figure 6.1 Informative and non-exhaustive graphical representation of the Product Stage processes

6.2.3 A4-A5, Construction Process Stage, Information Modules

EN 15804 shall apply.

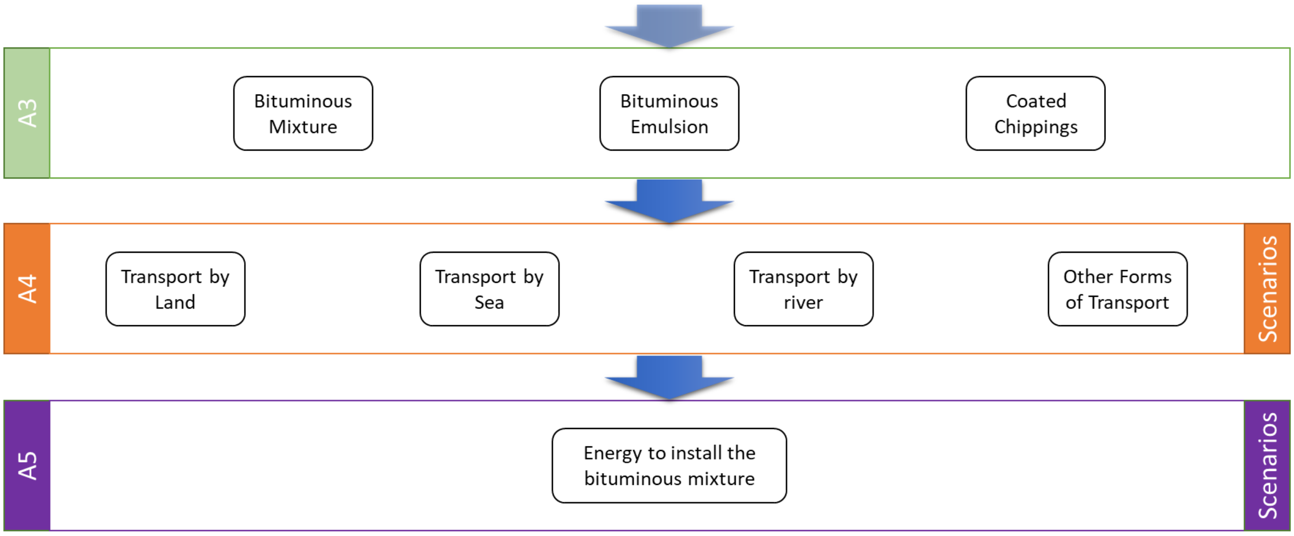

Figure 6.2 Informative and non-exhaustive graphical representation of the Construction Stage processes

6.2.4 B1-B7, Use Stage, Information Modules

Not covered by the scope of this standard.

6.2.5 C1-C4, End-of-Life Stage, Information Modules

EN 15804 shall apply.

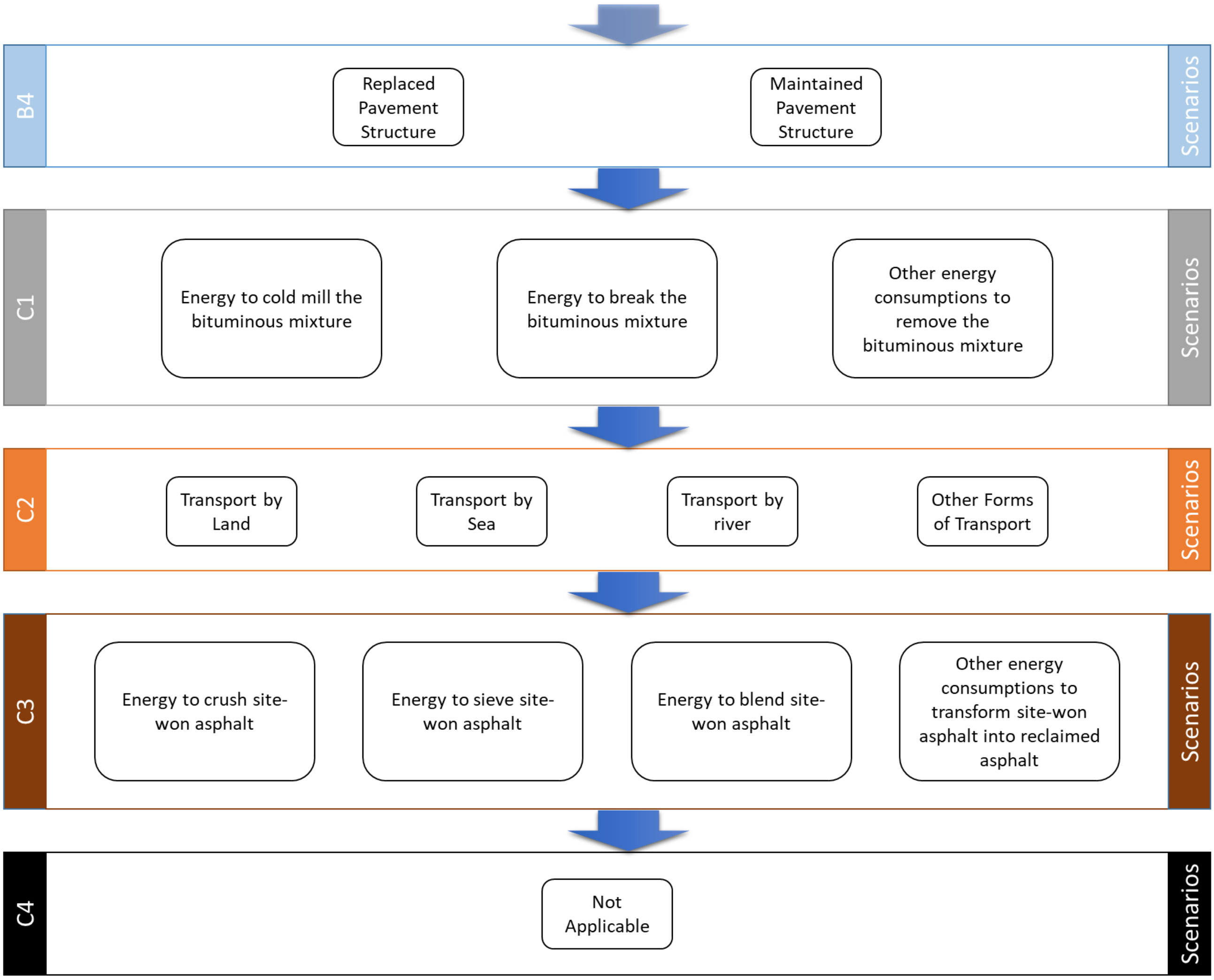

Figure 6.3 Informative and non-exhaustive graphical representation of the End-of-life Stage processes

6.2.6 D, Benefits and Loads Beyond the System Boundary, Information Module

EN 15804 shall apply.

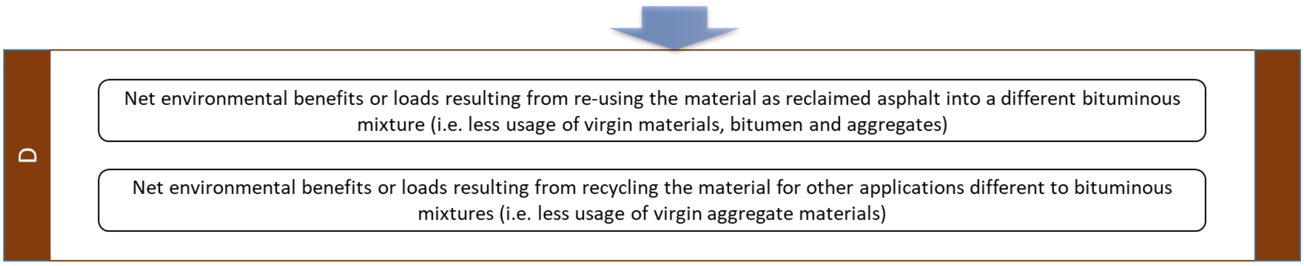

Figure 6.4 Informative and non-exhaustive graphical representation of the Benefits and loads beyond the system boundary

6.3 Calculation Rules for the LCA

6.3.1 Functional or Declared Unit

In addition to EN 15804, the EPD shall be based on the declared unit defined under Clause 6.3.3, functional units shall not be applied in the scope of this standard.

6.3.2 Functional Unit

Functional units shall not be applied in the scope of this standard.

6.3.3 Declared Unit

The declared unit shall be the production, construction, demolition and waste processing (phases A, C and D) of 1 metric tonne of bituminous mixture. The following additional information shall be provided:

i. whether it concerns a Producer-Specific LCA or a Project-Specific LCA environmental profile.
ii. the mixture designation as reported in the Type Test Report.
iii. the density of the compacted bituminous mixture calculated using Formula (1) or Formula (2) below:

Formula (1):

$$\text{density of the compacted bituminous mixture } = [1030 \times B + \rho_a \times (1 - B)] \times (1 - V_a)$$

Or Formula (2):

$$\text{density of the compacted bituminous mixture } = \rho_m \times (1 - V_a)$$

Where,

B is the input/output binder content in % by mass;

$\boldsymbol{\rho_a}$ is the apparent particle density of the aggregate mixture in Mg/m^3;

$\mathbf{V_a}$ is the air void content of the bituminous mixture as defined in IS EN 12697-8; and

$\boldsymbol{\rho_m}$ is the maximum density of the bituminous mixture as defined in IS EN 12697-5.

6.3.4 Reference Service Life

Reference service life (RSL) shall not be applied in the scope of this standard.

6.3.5 System Boundaries and Data Selection

6.3.5.1 General

LCA is conducted by defining product systems as models describing the key elements of physical systems. The system boundary defines the unit processes to be included in the system model.

This clause specifies the boundary of the product system under study and in particular the boundary with any previous or subsequent product systems in the life of a bituminous mixture. It also specifies the processes that are to be included in each of the life cycle stages listed in clause 6.2 (according to Figure 5.1).

The modular set up of the LCA underlying an EPD (see Figure 5.1) allows easy organisation and expression of data packages throughout the life cycle of the product. This approach requires that the system boundaries for the life cycle stages and the information modules included are transparent, well defined and applicable to any bituminous mixture.

The setting of the system boundaries follows the two principles:

- The “modularity principle”: Where processes influence the product’s environmental performance during its life cycle, they shall be assigned to the module of the life cycle where they occur; all environmental aspects and impacts are declared in the life cycle stage where they appear; and
- The “polluter pays principle”: Processes of waste processing shall be assigned to the product system that generates the waste until the end-of-waste state is reached.

These principles are used in the following clauses and are reflected in the formulae in Annex D of EN 15804. These formulae may be used as support while making calculations. No other formulae shall be used for the implementation of the principles in this clause.

6.3.5.2 Product stage

6.3.5.2.1 A1 – Raw Material Supply

In addition to EN 15804, the following is applicable to module A1 – raw material supply:

LCA calculations shall be based on the following rules:

i. all the constituents of the bituminous mixture shall be included in the LCA;
ii. the constituents included in the LCA shall be the ones specifically used to produce the bituminous mixture under assessment;
iii. the composition of the bituminous mixture shall be based on the one declared in the Type Test Report;
iv. for reclaimed asphalt, the end-of-waste status is established from the moment the site-won asphalt has been removed and the processing steps for crushing, mixing and/or sieving have been completed. This is explained in more detail at the end of this clause and on Figure 6.5. Reclaimed asphalt that has reached end-of-waste status is free of environmental impact in module A1;
v. the calculation rules for biogenic materials are specified under clause 6.4.4.

Both for Producer-Specific and Project-Specific LCAs, unit processes and activities shall be selected in accordance with the order of preference stated under clause 6.3.7 and the following principles:

i. Producer specific unit processes or activities data should be used if available from verified EPDs that are in accordance with clause 6.3.8, with the exceptions given in the next item. The greater representativeness of a producer specific unit process or activity data over the one available in Table 6.1 shall be substantiated to comply with clause 6.3.8 of EN 15804;
ii. in the case of paving grade bitumen and polymer modified bitumen, the unit processes from Table 6.1 are fixed and shall be used. It is not permitted to use an alternative unit process;
iii. the default processes and activities listed in Table 6.1 shall be used if there is no specific EPD data or alternative unit processes from Ecoinvent as per order of preference stated under clause 6.3.7;

iv. if the bituminous mixture contains a constituent not included in Table 6.1, a suitable unit process or activity shall be sourced from the Ecoinvent database (version and system model as per clause 6.3.8).
The greater representativeness of the selected unit process or activity shall be substantiated to comply with clause 6.3.8 of EN 15804;

v. if no Ecoinvent unit process or activity, or specific unit process or activity data covered by a verified EPD is available for a constituent, one of the following Ecoinvent unit processes shall be used, depending on the nature of the material to be modelled:

a) Chemical, organic {GLO}| production | Cut off, U

b) Chemical, inorganic {GLO}| production | Cut off, U

c) If this process contributes more than 5% to the total environmental impact of phase A1, information from the producer shall be used to determine the environmental impact.

d) the maximum percentage of materials that can be assigned to these unit processes is 5% of the total mass.

Table 6.1 Default unit processes or activities for life cycle module A1 – Raw materials supply from the Ecoinvent database and Appendix C (version and system model as per clause 6.3.8).

Raw material supply Process or Activity	Corresponding Unit Process or Activity from Ecoinvent or other source
Cellulose-fibre binder drainage inhibitor	Cellulose fibre {RoW}| cellulose fibre production | Cut-off, U (Aluminium Hydroxide and Boric acid put to 0) [1]
Aramid Fibre	Nylon 6 {RoW}| production | Cut-off, U
Reclaimed Asphalt	Free of burden[2]
Bitumen (any Paving Grade)	Bitumen adhesive compound, hot {RER}| production | Cut-off, U
Sand from river or pond	Sand {RoW}| sand quarry operation, extraction from river bed | Cut-off, U
Sand	Sand {RoW}| gravel and sand quarry operation | Cut-off, U
Crushed Stone	Crushed stone, quarry, excl. transport EU quarry-IE [1]
Crushed Limestone	Limestone, crushed, for mill {RoW}| production | Cut-off, U
Recycled filler	Crushed stone, quarry, excl. transport EU quarry-IE [1]
SBS (styrene-butadiene-styrene) Modified Bitumen	SBS modified bitumen from Europe, max 10% modified [1]
EVA (ethylene-vinyl-acetate) Modified Bitumen	EVA modified bitumen from Europe, max 10% modified [1]
Colour pigment (except white from TiO_2)	Chemical, inorganic {GLO}| production | Cut-off, U
Unknown inorganic additive	Chemical, inorganic {GLO}| production | Cut-off, U
Unknown organic additive	Chemical, organic {GLO}| production | Cut-off, U
Polyacrylonitrile	Acrylonitrile {RER}| Sohio process | Cut-off, U
Filler	Combination of: 30% Lime, hydrated, packed {RoW}| lime production, hydrated, packed | Cut-off, U, 70% Lime {Europe without Switzerland}| lime production, milled, loose | Cut-off, U
Very weak Filler	Lime {Europe without Switzerland}| lime production, milled, loose | Cut-off, U

Raw material supply Process or Activity	**Corresponding Unit Process or Activity from Ecoinvent or other source**
Weak Filler	Combination of: 10% Lime, hydrated, packed {RoW}| lime production, hydrated, packed | Cut-off, U, and 90% Lime {Europe without Switzerland}| lime production, milled, loose | Cut-off, U
Weak Filler with, limestone, fly ash and chalk hydrate	Combination of : x% Lime {Europe without Switzerland}| lime production, milled, loose | Cut-off, U y% Fly ash and scrubber sludge {Europe without Switzerland}| treatment of fly ash and scrubber sludge, hazardous waste incineration | Cut-off, U z% Lime, hydrated, packed {RoW}| lime production, hydrated, packed | Cut-off, U
White Pigment	Titanium dioxide {RER}| production, chloride process | Cut-off, U
Bituminous emulsions	Bitumen, emulsifier, and water, including A3 production processes [1]
Coated chippings	Bitumen and crushed stone, including A3 production processes [1]
Cements	Cement, unspecified {Europe without Switzerland}| production | Cut-off, U
Cement CEM II	Cement, alternative constituents 6-20% {Europe without Switzerland}| production | Cut-off, U
Ground Granulated Blast furnace Slag (GGBS)	Ground granulated blast furnace slag {RoW}| production | Cut-off, U

Note:

[1] Unit processes based on LCA reports for Dutch PCR Asphalt, details of unit process or activity available under Appendix C.

[2] When a waste flow has reached its "end of waste" point, it will enter the new product system as an input without any environmental burden. Therefore, if an asphalt plant uses reclaimed asphalt that has reached its end-of-waste status, the material has no environmental impact in module A1. However, all reprocessing steps, processes and transport that are carried out after reaching the end-of-waste status do belong to modules A1 and A2

System Boundaries and End-of-Waste Status for Reclaimed Asphalt

Reclaimed asphalt is permitted as a constituent in some bituminous mixtures. For the LCA it is important to describe where the waste processing ends (i.e. the end-of-waste status has been reached), and where the reuse of reclaimed asphalt begins.

For reclaimed asphalt, the end-of-waste status is reached when the site-won asphalt has been removed from site and the processing steps for crushing, mixing and/or sieving have been completed. This is illustrated in Figure 6.5.

This means that all processes for removal (e.g. milling), transport to the processing location and the crushing, mixing and/or screening of the asphalt released at the processing location are allocated to the demolition and processing modules (C1-C3).

When a waste flow has reached its “end of waste” point, it will enter the new product system as an input without any environmental burden. If an asphalt plant therefore uses reclaimed asphalt that has reached its end-of-waste status, the material has no environmental impact in module A1. All reprocessing steps, processes and transport that are carried out after reaching the end-of-waste status do belong to modules A1 and A2 of the next product life cycle as per Figure 6.5 below.

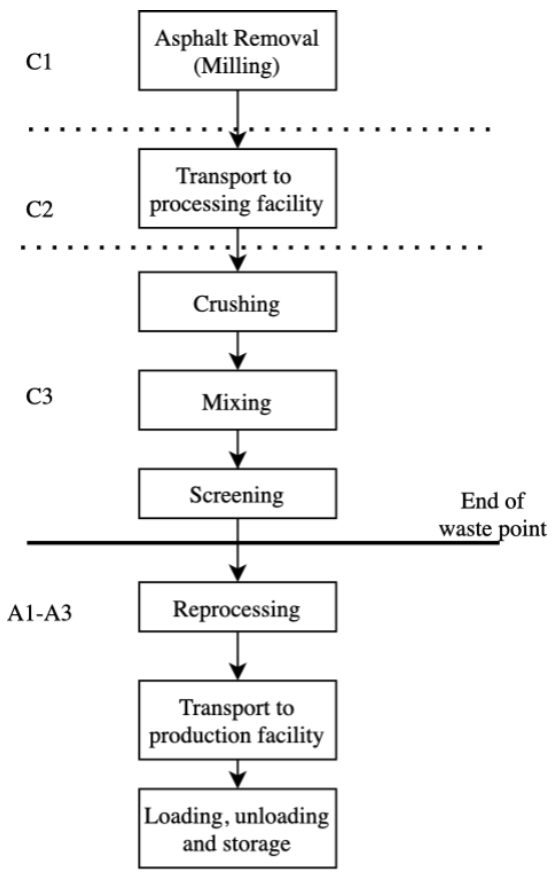

Figure 6.5 System boundaries and end-of-waste determination of reclaimed asphalt

6.3.5.2.2 A2 – Transport of Raw Materials

In addition to EN 15804, the following is applicable to module A2 – transport of raw materials:

LCA calculations shall be based on the following rules:

i. For the transport of raw materials used in the production of the bituminous mixture, the actual transport distance, in kilometres, from the raw material extraction and/or production site to the bituminous mixture production plant shall be used;

ii. the location of raw material extraction and/or production site shall be based on the origin of the materials where the raw material has been extracted or produced. For example, the following shall be selected: quarry location for the coarse aggregate, the production site of bitumen, the production plant for additives, but not the storage location of any supplier;

iii. for any secondary material like reclaimed asphalt or recycled filler, all transport processes shall be modelled in this module, from the location where end-of-waste status was reached to the bituminous mixture production plant.

iv. When several suppliers provide the same raw material, a weighted average of the distance should be calculated according to the quantity purchased from each supplier over the previous calendar year. Any deviation shall be justified, and the data used shall be as current as possible.

Unit processes and activities shall be selected in accordance with the order of preference stated under clause 6.3.7 and the following principles:

i. producer specific transport unit processes or activities data can be used if available from verified EPDs that are in accordance with clause 6.3.8. The greater representativeness of a producer specific unit process or activity data over the one available in Table 6.2 shall be substantiated to comply with clause 6.3.8 of EN 15804;

ii. if the transport process or activity used by the producer is not included in Table 6.2 a suitable unit process or activity shall be sourced from the Ecoinvent database (version and system model as per clauses 6.3.7 and 6.3.8). This could for example be freight transport by lorry with a specific weight and emission standard (e.g. EURO 5) corresponding to the fleet used over the past calendar year (Producer-Specific LCA) or the fleet used for a specific project (Project-Specific LCA). The greater representativeness of the selected unit process or activity shall be substantiated to comply with clause 6.3.8 of EN 15804.

iii. the default unit processes and activities listed in Table 6.2 should be used if there is no specific EPD data or alternative unit processes from Ecoinvent as per order of preference stated under clause 6.3.7;

Table 6.2 Default unit processes or activities for life cycle module A2 – Transport from the Ecoinvent database (version and system model as per clause 6.3.8)

Transport Process or Activity	Corresponding Unit Process or Activity[1] from Ecoinvent	Unit
Transport, lorry	Transport, freight, lorry, unspecified {GLO}| market group for transport, freight, lorry, unspecified | Cut-off, U)	tkm
Transport, barge (Europe)	Transport, freight, inland waterways, barge {GLO}| market group for transport, freight, inland waterways, barge | Cut-off, U)	tkm
Transport, Sea-ship	Transport, freight, sea, container ship {GLO}| market for transport, freight, sea, container ship | Cut-off, U	tkm
Transport, Train	Transport, freight train {Europe without Switzerland}| market for | Cut-off, U)	tkm

Note:

[1] *Unit processes or activities based on an outward journey with a full load and an inward journey with an empty load.*

6.3.5.2.3 A3 – Manufacturing

In addition to EN 15804, the following is applicable to module A3 – manufacturing:

LCA calculations shall be based on the following rules:

i. The energy consumption of the following processes shall be included:
   - movement of materials (e.g. loader, conveyor belts, bucket conveyors…)
   - heating of bitumen and bitumen emulsion,
   - drying and heating of aggregate,
   - drying and heating of reclaimed asphalt,
   - storage and distribution of additives,
   - sieving aggregate,
   - foaming bitumen,
   - mixing all constituents,
   - bituminous mixture storage,
   - asphalt plant start and stop processes as well as bituminous mixture production changes, and
   - all other energy consumption directly related to the production of the bituminous mixture.

ii. The impacts of the following processes shall not be included:
   - The equipment and machinery used for bituminous mixture production, their upkeep and maintenance, including filters, tyres, lubricant, except the energy consumption for the movement of materials,
   - Energy produced on site (e.g. solar energy, biomass energy) not used in the production of the bituminous mixture,
   - Processes linked to general management, office and headquarter operations,
   - Commuting of plant personnel,
   - Laboratory activities.

iii. The modelling of electricity shall adopt the following principles:

– For internally generated electricity (e.g. on-site generated electricity) consumed for the bituminous mixture under study and for which no contractual instruments have been sold to a third party, the life cycle data for that electricity shall be used for that bituminous mixture.

– For electricity from a directly connected supplier, life cycle data representing the consumed electricity obtained from the supplier to facilities within the scope of this module may be used if there is a dedicated transmission line between the organisation and the generation plant from which the emission factor is derived, and no contractual instruments have been sold to a third party for that consumed electricity.

– For electricity from the grid and if the facilities within the scope of this module purchase electricity under a contract in which no specific mix of fuels or generation types is specified, then the residual electricity mix provided in Table 6.3 shall be applied.

– Life cycle data representing a specific electricity product as generated, or purchased, from an electricity supplier may be used instead of the residual mix, provided that the organisation has a commitment to purchase this green electricity for the duration of the EPD's validity, and that the electricity supply contract:

- conveys the information associated with the unit of electricity delivered together with the characteristics of the generator.
- is supported by Guarantees of Origin or equivalent, which
  - is tracked and redeemed, retired or cancelled by or on behalf of the reporting entity correspond as closely as possible in time to the period to which the contractual instrument is applied, and
  - are produced within the country or within Europe in the case of facilities in Ireland or elsewhere in Europe, or within an electricity market interconnected to the market where the facility is located in the case of facilities in other regions.

If the characteristics of the supply mix change during the validity of the EPD and this has a material effect on the indicator values reported in the EPD, then the EPD shall be updated.

iv. For Cold Mix Asphalt (CMA) bituminous mixtures, the energy consumption during the manufacturing module of the bituminous mixture shall be calculated using the following rules:

– The energy consumption of the pieces of plant used to move materials shall be based on the total energy consumption from the previous calendar year, at the CMA plant where the bituminous mixture is being produced. This must be divided by the total annual production tonnage from that same year, all mixtures combined. The energy consumption per tonne of bituminous mixture is therefore the same for all mixtures produced at that specific plant.

– The energy consumption of the CMA plant shall be based on the total energy consumption from the previous calendar year, at the CMA plant where the bituminous mixture is being produced. This must be divided by the total annual production tonnage from that same year, all mixtures combined. The energy consumption per tonne of CMA bituminous mixture is therefore the same for all mixtures produced at that specific plant.

- The energy consumption of the emulsion storage tank shall be based on the total energy consumption from the previous calendar year, at the CMA plant where the bituminous mixture is being produced.

  This must be divided by the total annual production tonnage from that same year, all mixtures combined. The energy consumption per tonne of CMA bituminous mixture is therefore the same for all mixtures produced at that specific plant.

- Any other energy consumptions directly linked to the manufacturing of the CMA bituminous mixture shall be based on the total energy consumption from the previous calendar year, at the CMA plant where the bituminous mixture is being produced. This must be divided by the total annual production tonnage from that same year, all mixtures combined. The energy consumption per tonne of CMA bituminous mixture is therefore the same for all mixtures produced at that specific plant.

v. For Hot Mix Asphalt (HMA) and Warm Mix Asphalt (WMA) bituminous mixtures, the energy consumption during the manufacturing module of the bituminous mixture shall be calculated using an Energy Allocation (EA) model, both for Producer-Specific and Project -Specific LCAs.

- The Irish EA-model 2022 (from now on referred to as “the EA-model") is available via https://www.tiipublications.ie/downloads/,

- a guide for the EA model is provided in Appendix A.

vi. The following rules apply to the EA model:

- The energy consumption of the pieces of plant used to move materials shall be based on the total energy consumption from the previous calendar year, at the asphalt plant where the bituminous mixture is being produced. This must be divided by the total annual production tonnage from that same year, all mixtures combined. The energy consumption per tonne of bituminous mixture is therefore the same for all mixtures produced at that specific plant.

- For other heating processes, at the asphalt plant where the bituminous mixture was produced, the input parameters as shown in Table A2 shall be entered in the EA model. To determine the production quantity per bituminous mixture type, it is necessary to choose which of the bituminous mixture types is the most representative for each mixture. This choice must be substantiated. Input of this data results in a fuel consumption per process. Subsequently, the energy consumption per process must be allocated over the produced mixtures, on the basis of the production quantities, compositions and EA input parameters. These allocation parameters differ per process, the parameters to be selected per process are shown Table A4. The EA parameters are calculated specifically for the power plant that applies; these values should therefore be adhered to. For the EA parameters 'temperature of minerals' and 'temperature of reclaimed asphalt' it is permitted to determine and maintain a value per mixture instead of a value per bituminous mixture type.

- For bitumen heating with electricity, the input parameters as shown in Table A1 should be entered in the EA model. The electricity consumption for bitumen heating must be allocated to the mixtures produced on the basis of the total production quantities and the amount of bitumen contained in the mixtures.

- Other electricity consumption must be determined by subtracting the electricity consumption for bitumen heating from the total electricity consumption for bituminous mixture production in the last calendar year of the asphalt plant where the bituminous mixture is produced. This electricity consumption must then be divided by the total annual production of this asphalt plant of the same calendar year, to determine the electricity consumption per mixture. Allocation is not necessary, the energy consumption per tonne is therefore the same for all mixtures.
- If the mixture was not produced in the previous calendar year, 1 tonne of the mixture must be added to the annual production in order to be able to allocate the energy consumption to this new mixture in the EA-model in the same way as described above. For this mixture, the asphalt type-specific EA parameters of another mixture that is most comparable to the new mixture should be adopted.
- For LCA software in which it is not possible to follow the above-described allocation method, the “consumption bituminous mixtures” part of the EA model (tab ‘results’ row 46 onwards) has to be used.

Unit processes and activities shall be selected in accordance with the order of preference stated under clause 6.3.7 and the following principles:

i. producer specific unit processes or activities data can be used if available from verified EPDs that are in accordance with clause 6.3.8. The greater representativeness of a producer specific unit process or activity over the one available in Table 6.3 shall be substantiated to comply with clause 6.3.8 of EN 15804;

ii. the default unit processes and activities listed in Table 6.3 should be used if there is no specific EPD data or alternative unit processes from Ecoinvent as per order of preference stated in iii above and under clause 6.3.7.

Table 6.3 Default unit processes or activities for life cycle module A3 – Manufacturing from the Ecoinvent database (version and system model as per clause 6.3.8)

Process	Reference	Conversion factor and Net calorific value (NCV) [1]
Electricity	Residual mix based on “Electricity, high voltage {IE}| market for electricity, high voltage | Cut-off, U”	3.60 MJ/kWh
Diesel	Diesel, burned in building machine {GLO}| processing | Cut-off, U	36.61 MJ/L
Natural Gas	Heat, district or industrial, natural gas {Europe without Switzerland} | heat production, natural gas, at industrial furnace >100kW | Cut-off, U	34.8 MJ/m³
LPG	Heat, central or small-scale, natural gas {GLO}| propane extraction, from liquefied petroleum gas | Cut-off, U	47.156 MJ/kg
Kerosene	Kerosene based on: Diesel, burned in building machine {GLO}| processing | Cut-off, U), fuel production adjusted to kerosene and amount adjusted based on NCV	44.196 MJ/kg (density 0,82 kg/l)
Heavy Fuel Oil	Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, heavy fuel oil, at industrial furnace 1MW | Cut-off, U	41.236 MJ/kg [2]

Process	**Reference**	**Conversion factor and Net calorific value (NCV)** [1]
Recovered Fuel Oil	Recover Fuel Oil, based on: "Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, heavy fuel oil, at industrial furnace 1MW | Cut-off, U"" without fuel production	41.236 MJ/kg

Note:

[1] Conversion factors from Conversion Factors | SEAI Statistics | SEAI - https://www.seai.ie/data-and-insights/seai-statistics/conversion-factors/.

[2] NCV for Heavy Fuel Oil taken as the same as for Recovered Fuel Oil.

In addition to the energy consumptions mentioned in Table 6.3, the emissions of polycyclic aromatic hydrocarbons (PAHs) as a result of the heating of materials in the asphalt plant, are particularly relevant to the environmental impact. In the absence of specific information for different asphalt installations, it is prescribed in this c-PCR to include PAH emissions in the same way for all asphalt mixtures (for both Producer-Specific and Project-Specific LCAs). The fixed value is based on the worst-case scenario. Other emissions (including benzene) may be disregarded.

The PAH emissions per tonne of asphalt should be modelled in the LCA software as follows: a total of PAH emissions to air of 17 mg per tonne of asphalt, modelled as:

- 56.7% non-carcinogenic PAH
- 42.9% naphthalene
- 0.4% benzo(a)pyrene.

According to EN 15804, production losses shall be included in modules A1 to A3. However, in accordance with EN 15804, an input can be excluded if it remains below a certain threshold.

Because the production losses are considered to be very small, approximately 0.5% of the total mass input of each unit process, they are not included.

In addition, according to ISO 14040 clause 5.2.3, the unit processes and flows associated to the manufacture, maintenance and decommissioning of capital equipment should be taken into consideration. However, the capital goods of the asphalt plant may be disregarded for bituminous mixtures because they contribute to less than 5% of the overall environmental impact.

6.3.5.3 Construction Process Stage

6.3.5.3.1 A4 – Transport to Construction Site

In addition to EN 15804, the following is applicable to module A4 – transport to construction site:

LCA calculations shall be based on the following rules:

i. because material losses during the transport module are expected and assumed to be very limited (i.e. less than 1% of the total mass input of the associated unit process or activity and less than 5% of the total mass input of this module), material losses shall not be accounted for in this module;

ii. The impacts of the following processes shall not be included:

   a) Commuting of site personnel,

   b) Transportation of construction equipment to the construction site;

iii. for Producer-Specific LCA, the default distance of 100 kilometres shall be used for the transport of bituminous mixtures from the production plant to the construction site.

iv. for Project-Specific LCA only, the actual distance in kilometres from the asphalt plant to the project location shall be used. For large (area) contracts, the average project location specified by the client shall be used. If not defined, the centre of the area should be used to determine the distance.

Unit processes and activities shall be selected in accordance with the order of preference stated under clause 6.3.7 and the following principles:

i. for Producer-Specific LCA, the process or activity listed in Table 6.4 shall be used;

ii. for Project-Specific LCA only, the process or activity listed in Table 6.4 should be used but the actual composition of the fleet that has been or will be deployed for this specific project shall be used. In other words, the default 75/25 split of EURO5/EURO6 emission standard fleet of lorries shall be amended to reflect the specifics of the project. If the project specific split is unknown, the process or activity listed in Table 6.4 shall be used.

iii. for Project-Specific LCA only, producer specific transport unit processes or activities data can be used if available from verified EPDs that are in accordance with clause 6.3.8. The calculation of the effective transport distance shall be clearly stated and justified. The greater representativeness of a producer specific unit process or activity data over the one available in Table 6.4shall be substantiated to comply with clause 6.3.8 of EN 15804;

iv. for Project-Specific LCA only, if the transport unit processes or activities included in Table 6.4 are not representative of what will be used by the producer, suitable unit processes or activities shall be sourced from the Ecoinvent database (version and system model as per clause 6.3.7 and 6.3.8). The calculation of the effective transport distance shall be clearly stated and justified. The greater representativeness of the selected unit process or activity over the ones available in Table 6.4 shall be substantiated to comply with clause 6.3.8 of EN 15804;

v. for Project Specific LCA only, if an alternative fuel is used in the unit process or activity (instead of diesel), the consumption of the vehicle per tkm must be converted from the calorific value of diesel to the calorific value of the alternative fuel. The fuel consumption for the vehicle using the alternative fuel shall be calculated using formula (1):

$$Consumption\ with\ alternative\ fuel = Consumption\ with\ diesel \times \frac{NCV\ of\ diesel}{NCV\ of\ alternative\ fuel}$$

Where:

Fuel consumption is in litres,

NCV is the Net Calorific Value of a fuel in MJ/L as per the SEAI Conversion Factors - https://www.seai.ie/data-and-insights/seai-statistics/conversion-factors/.

Table 6.4 Default unit processes or activities for life cycle module A4 – Transport from the Ecoinvent database (version and system model as per clause 6.3.8)

Transport Process or Activity	Corresponding Unit Process or Activity from Ecoinvent	Effective Transport distance[1]
Transport, lorry	Transport, freight, lorry >32 metric ton, EURO5 {RER}| transport, freight, lorry >32 metric ton, EURO5 | Cut-off, U	66,6 km
	Transport, freight, lorry >32 metric ton, EURO6 {RER}| transport, freight, lorry >32 metric ton, EURO6 | Cut-off, U	22,2 km
-		

Note:

[1] *Based on:*

- *a 70/30 split of empty/fully loaded return journeys,*
- *For return transport, a fixed load factor is used, from which follows an effective transport distance that must be used. The effective transport distance is calculated according to the Dutch Determination Method (References [1]).*
- *The Ecoinvent unit processes or activities mentioned above model both a fully loaded trip to the site and an empty return (load capacity 50%). A proven fully loaded return can therefore model half the distance. However, fully loaded trucks consume 25% more fuel, so for the full returns 0,5 * 1,25 = 62,5% of the distance is used.*
- *Effective transport distance is calculated as follows: (62,5% * 0,3 + 100% * 0,7) * 100km = 88,75 km*
- *a 75/25 split of EURO5/EURO6 emission standard fleet of lorries.*

6.3.5.3.2 A5 – Construction-Installation Process

In addition to EN 15804, the following is applicable to module A5 – construction and installation:

LCA calculations shall be based on the following rules:

i. because material losses during the construction module are expected and assumed to be very limited (i.e. less than 1% of the total mass input of the associated unit process or activity and less than 5% of the total mass input of this module References [2]), material losses shall not be accounted for in this module;

ii. for the installation of the bituminous mixture, the fuel consumption of at least a paver or finisher and a roller shall be included in litres per tonne of produced asphalt;

iii. The impacts of the following processes shall not be included:

   a) Small tools and equipment such as saws or mini-compactors (e.g. wacker plates),

   b) Equipment for collateral activities during installation such as traffic management, traffic control, road marking and studs, vegetation clearance,

   c) Vehicles and equipment used for quality assurance and quality control;

Unit processes and activities shall be selected in accordance with the following principles:

i. the unit processes and activities listed in Table 6.5 shall be used. Two scenarios are available, one with an efficiency of 400 tonnes per day and the other with an efficiency of 1,000 tonnes per day.

ii. The 400 tonnes/day rate shall be used for the installation of surface courses (AC, SMA, HRA and PA), while

iii. The 1,000 tonnes/day rate shall be used for the installation of base and binder courses (AC and SMA).

Table 6.5 Default unit processes or activities for life cycle module A5 – Construction-Installation Process from de Vos et al., 2018 (References [2])

Production volume (tonnes/day)	Applicable to	Reference mixture type	Corresponding Unit Process or Activity[1]
400	Resurfacing	AC surf, SMA surf, HRA surf, PA surf	A5 Emissions + Fuel Stage IIIb/IV Asphalt Construction set– 400 tonnes/day - per tonne of asphalt
1,000	Overlay, Strengthening, Reconstruction	AC bin, AC base, SMA bin	A5 Emissions + Fuel Stage IIIb/IV Asphalt Construction Set – 1000 tonnes/day - per tonne of asphalt

Note:

[1] The unit process for the fuel consumption of the construction pieces of plant is based on the assumption that 75% of the pieces of plant are emission Stage IIIb and 25% are emission Stage IV.

6.3.5.4 B1 to B7 – Use Stage Modules

Modules B1 to B7 are outside the scope of this standard and shall not apply (as per clause 5.2).

6.3.5.5 End of Life Stage

6.3.5.5.1 C1 – Deconstruction-Demolition

In addition to EN 15804, the following is applicable to module C1 – deconstruction and demolition:

LCA calculations for both Producer-Specific LCA and Project-Specific LCA shall be based on the following rules:

i. the fuel consumption of the removal pieces of plant shall account for the removal of 100% of the installed bituminous mixture;

ii. The loss of bitumen through erosion in surface layers during the “use” module B1 results in a limited mass loss and is therefore neglected in the amount of reclaimed asphalt that becomes available in modules C[1].

iii. for the removal of the bituminous mixture, the fuel consumption required for cold milling, breaking, cleaning and sweeping shall be included;

iv. it shall be stated whether the bituminous layer is being removed separately from the rest of the pavement structure or whether more than one layer of bituminous mixture is being removed at the same time. Current practice must be followed, and no claim may be made based on intentions (e.g. “We expect to mill everything separately in the future.”).

Unit processes and activities shall be selected in accordance with the following principles:

i. the unit processes and activities listed in Table 6.6 shall be used. Two scenarios are available, one with an efficiency of 400 tonnes per day and the other with an efficiency of 1,000 tonnes per day.

[1] The loss of bitumen through erosion is 1.3% at a maximum. Such loss has a negligible environmental impact when removing and processing the reclaimed asphalt.

ii. The 400 tonnes/day rate shall be used for the removal of surface courses (AC, SMA, HRA and PA), while

iii. The 1,000 tonnes/day rate shall be used for the removal of base and binder courses (AC and SMA).

Table 6.6 Default unit processes or activities for life cycle module C1 – Deconstruction-Demolition Process from de Vos et al., 2018 (References [2])

Production volume (tonnes/day)	Applicable to	Reference mixture type	Corresponding Unit Process or Activity[1]
400	Resurfacing	AC surf, SMA surf, HRA surf, PA surf	C1 Emissions + fuel Emission Stage Class IIIb/IV Asphalt removal set – 400 ton/day - per tonne of removed asphalt
1,000	Overlay, Strengthening, Reconstruction	AC bin, AC base, SMA bin	C1 Emissions + fuel Emission Stage Class IIIb/IV Asphalt removal set – 1000 ton/day - per tonne of removed asphalt

Note:

[1] The unit process for the fuel consumption of the removal pieces of plant is based on the assumption that 75% of the pieces of plant are emission Stage IIIb and 25% are emission Stage IV.

6.3.5.5.2 C2 – Transport

In addition to EN 15804, the following is applicable to module C2 – transport:

LCA calculations shall be based on the following rules:

i. because material losses during the transport module are expected and assumed to be very limited (i.e. less than 1% of the total mass input of the associated unit process or activity and less than 5% of the total mass input of this module), material losses shall not be accounted for in this module;

ii. for Producer-Specific LCA, the default distance of 100 kilometres shall be used for the transport of site-won asphalt from site to the processing plant.

iii. for Project-Specific LCA only, the actual distance in kilometres from the project location to the processing plant shall be used. For large (area) contracts, the average project location specified by the client shall be used. If not defined, the centre of the area should be used to determine the distance.

iv. Unit processes and activities shall be selected in accordance with the following principles:

v. for Producer-Specific LCA, the unit process or activity listed in Table 6.7 shall be used;

vi. for Project-Specific LCA only, the fleet composition, associated unit processes or activities and the fuel alternative (if applicable) used for module A4 shall be used for this module.

Table 6.7 Default unit processes or activities for life cycle module C2 – Transport from Ecoinvent database (version and system model as per clause 6.3.8)

Transport Process or Activity	Corresponding Unit Process or Activity from Ecoinvent	Effective Transport distance[1]
Transport, lorry	Transport, freight, lorry >32 metric ton, EURO5 {RER}| transport, freight, lorry >32 metric ton, EURO5 | Cut-off, U	66,6 km
	Transport, freight, lorry >32 metric ton, EURO6 {RER}| transport, freight, lorry >32 metric ton, EURO6 | Cut-off, U	22,2 km

Note:

[1] *Based on:*

- *a 70/30 split of empty/fully loaded return journeys,*
- *For return transport, a fixed load factor is used, from which follows an effective transport distance that must be used. The effective transport distance is calculated according to the Dutch Determination Method (References [1]).*
- *The Ecoinvent unit processes or activities mentioned above model both a fully loaded trip to the site and an empty return (load capacity 50%). A proven fully loaded return can therefore model half the distance. However, fully loaded trucks consume 25% more fuel, so for the full returns 0,5 * 1,25 = 62,5% of the distance is used.*
- *Effective transport distance is calculated as follows: (62,5% * 0,3 + 100% * 0,7) * 100km = 88,75 km*
- *a 75/25 split of EURO5/EURO6 emission standard fleet of lorries.*

6.3.5.5.3 C3 – Waste Processing

In addition to EN 15804, the following is applicable to module C3 – waste processing, in particular the processing of site-won asphalt:

LCA calculations shall be based on the following rules:

i. this module is about processing site-won asphalt into reclaimed asphalt according to EN 13108-8;
ii. it is assumed that 100% of the site-won asphalt will be processed into reclaimed asphalt;
iii. for the processing of the site-won asphalt, the fuel consumption required for crushing, mixing and/or screening shall be included;
iv. subsequent processing steps, processes and transport that are carried out after reaching the end-of-waste status, belong to modules A1 and A2 of the next product life cycle as described on Figure 6.5.

Unit processes and activities shall be selected in accordance with the following principles:

i. the following end-of-life scenario is assumed and shall be followed:
   a) 55% of reclaimed asphalt to be recycled into unbound foundation materials; and
   b) 45% of reclaimed asphalt to be recycled into new bituminous mixtures;
ii. both unit processes or activities listed in Table 6.8 should be used;
iii. for Project-Specific LCA only, producer specific unit processes or activities data can be used if available from verified EPDs.

The greater representativeness of a producer specific unit process or activity data over the one available in Table 6.8 shall be substantiated to comply with clause 6.3.8 of EN 15804;

iv. for Project-Specific LCA only, if the processing of site-won asphalt involves a unit process or activity not included in Table 6.8, a suitable unit process or activity shall be sourced from the Ecoinvent database (version and system model as per clause 6.3.8). The representativeness, of the selected unit process or activity shall be substantiated to comply with clause 6.3.8 of EN 15804.

Table 6.8 Default unit processes or activities for life cycle module C3 – waste processing based on the Dutch industry experience (References [1])

Waste processing process or activity	Diesel fuel consumption (L/tonne)	Corresponding Unit Process or Activity [1]
Crane & Digger	0,185	C3 Emissions + fuel Emission Stage IIIb/middle (75-130 kW) - per liter (based on "Diesel, burned in building machine {GLO} | processing | Cut-off, U")
Crusher	0,185	C3 Emissions + fuel Emission Stage IIV/heavy (130-560 kW) - per liter (based on "Diesel, burned in building machine {GLO} | processing | Cut-off, U")

Note:

[1] Details of unit processes or activities available under Appendix C.

6.3.5.5.4 C4 – Disposal

Module C4 is not applicable as 100% of site-won asphalt shall be processed to reclaimed asphalt for reuse.

6.3.5.6 Benefits and Loads Beyond the System Boundary (D)

In addition to EN 15804, the following is applicable to life cycle stage D:

i. the following end-of-life scenario is assumed and shall be followed:

   a) 55% of reclaimed asphalt to be recycled into unbound foundation materials; and

   b) 45% of reclaimed asphalt to be recycled into new bituminous mixtures;

ii. the reclaimed asphalt that becomes available has relatively less bitumen as a result of the erosion and ageing of bitumen during its lifetime. Therefore, fewer environmental benefits can be attributed to the available reclaimed asphalt in module D, as a result of a lower quantity of the net output flow.

Unit processes and activities shall be selected in accordance with the following process as illustrated on Figure 6.6:

i. for consistency purposes, the calculation model provided in Appendix B shall be used to determine mass flows for module D;

ii. reclaimed asphalt is regarded as a secondary raw material in its entirety. Because 100% of the reclaimed asphalt is recycled, the net output flow per tonne of reclaimed asphalt is equal to 1,000 kg minus the mass of reclaimed asphalt in the composition of the mixture in module A1;

iii. the net output flow per tonne of reclaimed asphalt is subsequently divided between two flows as mentioned above:

a) A flow that represents 55% of the net output flow and intended for use in unbound foundation materials; and

b) A flow that represents 45% of the net output flow and intended for recycling in new bituminous mixtures;

iv. both flows described in iii.a. and iii.b. above have designated raw material equivalents, which are further detailed under clauses 6.3.5.6.1 and 6.3.5.6.2;

v. loss of quality factors shall apply to the flow described in iii.b. before applying the designated raw material equivalent, these are further detailed under clause 6.3.5.6.2;

vi. a correction factor shall also be applied to the flow described in iii.b. before applying the designated raw material equivalent, this is further detailed under clause 6.3.5.6.2.

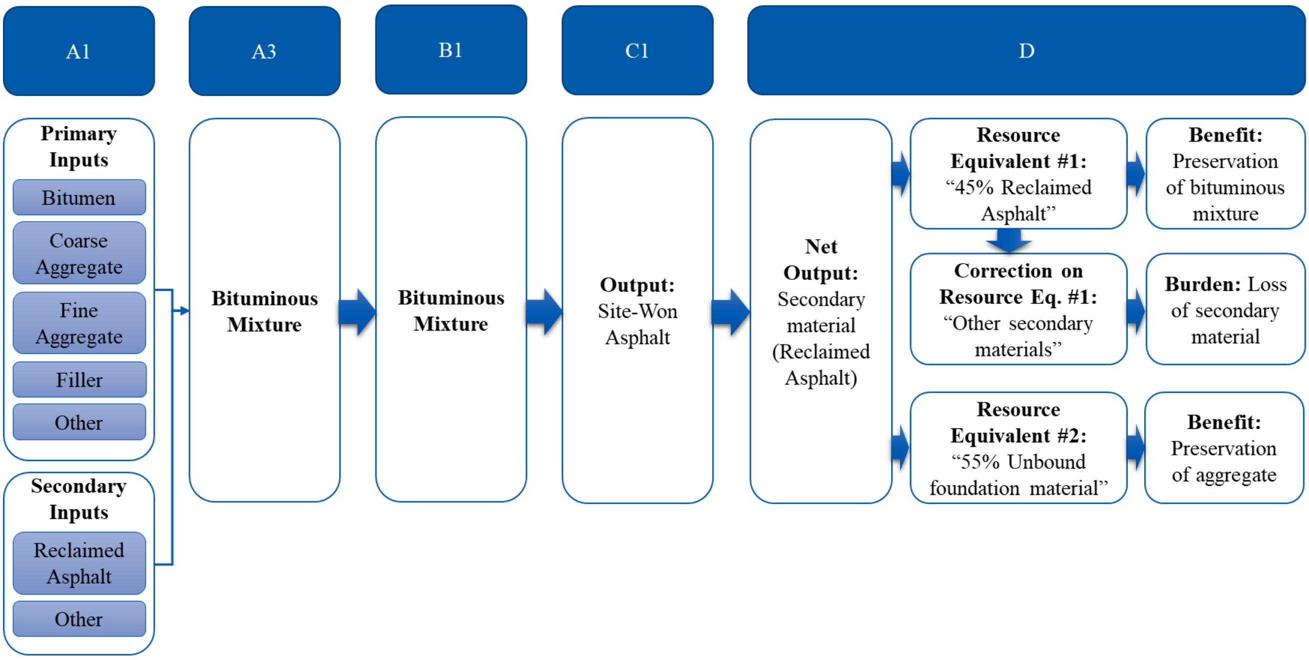

Figure 6.6 Mass balance for bituminous mixtures

6.3.5.6.1 Raw Material Equivalent for Reclaimed Asphalt in Unbound Foundation Materials

The raw material equivalent for reclaimed asphalt recycled in unbound foundation materials is crushed stone. The default unit process is "Crushed stone, quarry, excl. transport EU quarry-IE" as per Table 6.1, details of unit process or activity available under Appendix C.

6.3.5.6.2 Raw Material Equivalent for Reclaimed Asphalt in new Bituminous Mixtures

Reclaimed asphalt is an aged bituminous mixture that has been processed to be used as a secondary material, in new bituminous mixtures in this case. The constituents used in the initial bituminous mixture have lost part or the totality of their performance due to ageing and following the demolition process (module C1). That loss of material quality shall be evaluated in order to best reflect the value of the reclaimed asphalt as a secondary constituent in a new mixture.

The losses in quality that shall be included are:

i. Partial loss of bitumen mass due to erosion during the use stage (B);

ii. Partial loss of performance of the bitumen due to ageing;

iii. Partial loss of coarse aggregate following the demolition processes – C1 (cold milling and/or breaking) and the waste processing – C3 (crushing);

iv. Total loss of performance of any additive.

For the purpose of the c-PCR for bituminous mixtures, the wide variety of sources of reclaimed asphalt has been rationalised to four distinctive types, each with a representative composition as per Table 6.9 below:

Table 6.9 Composition of the four default reclaimed asphalt materials

	Reclaimed asphalt from Base and Binder courses	Reclaimed asphalt from surface layers		
		From AC and SMA	From HRA	From PA
Bitumen	4,4%	5,6%	7,3%	6,0%
Coarse aggregate	58,3%	59,2%	32,1%	78,4%
Fine aggregate	30,4%	28,7%	52,7%	11,1%
Filler	6,9%	6,5%	7,9%	4,5%
Other	0%	0%	0%	0%

Note:

The compositions above are calculated average compositions from the requirements on grading from CC-SPW-00900 (TII Publications).

Therefore, for the declared unit of 1 tonne or 1,000 kilograms of the bituminous mixture, the following rules on losses apply:

i. The set of rules to be selected shall be the one appropriate to the bituminous mixture type declared in the declared unit description (e.g. if the mix designation in the declared unit is SMA 10 surf 40/60 des., then the rules for SMA surface course mixtures apply);

ii. Partial loss of bitumen in the surface course due to erosion during the use stage (B):

a) 17% of mass loss for the bitumen for AC, HRA and SMA surface course mixtures;

b) 21% of mass loss for the bitumen for PA surface course mixtures;

c) No partial loss of bitumen due to erosion is applicable to the binder and base course layers.

iii. Partial loss of performance of the bitumen due to ageing during the use stage (B):

a) 4% of mass loss for the bitumen for any bituminous mixture.

iv. Partial loss of coarse aggregate following the demolition processes the waste processing (C1 and C3):

a) 6% of mass loss for the coarse aggregate for AC, HRA and SMA surface course mixtures;

b) 21% of mass loss for the coarse aggregate for PA surface course mixtures;

c) 5% of mass loss for the coarse aggregate for base and binder course mixtures;

d) No loss of mass for fine aggregate and filler is assumed as the crushing of the coarse aggregate into smaller fractions is greater than the loss that could be observed in the fine and filler fractions.

v. Total loss of performance of any additive:

a) Any additive included in the initial composition of the bituminous mixture is assumed to have lost 100% of its performance.

For the four default reclaimed asphalt materials described in Table 6.9, the application of the above rules results in the raw materials equivalents per declared unit in Table 6.10 below:

Table 6.10 Raw materials equivalents for each of the four default reclaimed asphalt materials per declared unit

Equivalent Raw Materials	Reclaimed asphalt from Base and Binder courses	Reclaimed asphalt from surface layers		
		From AC and SMA	From HRA	From PA
Bitumen	42,24	44,24	57,67	45
Coarse aggregate	553,85	556,48	301,74	619,36
Fine aggregate	304	287	527	111
Filler	69	65	79	45
Other	0	0	0	0

Unit processes and activities are selected in accordance with the following principles:

i. Regardless of the type of bitumen used in the bituminous mixture (paving grade or polymer modified), the performances of this bitumen would have deteriorated during the use and demolition stages in various ways. The contribution of that deteriorated bitumen to the performances of the new bituminous mixture will therefore vary. Rejuvenation products, softer bitumen or even different recycling processes would even have an impact on how the recycled bitumen contributes to the new bituminous mixture. It is for these reasons that the bitumen from the reclaimed asphalt is assumed to be paving grade bitumen, i.e. the effects of any initial enhancement from additives are assumed to have disappeared;

ii. the unit processes and activities listed in Table 6.11 below are used in the resulting unit processes for each reclaimed asphalt type in Table C4 (Appendix C),

Table 6.11 Default unit processes or activities for life cycle module D – Benefits and loads beyond the system boundaries from Ecoinvent database (version and system model as per clause 6.3.8)

Equivalent raw material	Unit Process or Activity
Bitumen (fixed)	Bitumen adhesive compound, hot {RER}| production | Cut-off, U
Modified bitumen (fixed)	Bitumen adhesive compound, hot {RER}| production | Cut-off, U
Coarse aggregate	Crushed stone, quarry, excl. transport EU quarry-IE [1]
Fine aggregate	Sand {RoW}| gravel and sand quarry operation | Cut-off, U
Fillers	Lime {Europe without Switzerland}| lime production, milled, loose | Cut-off, U
Other	N/A, free-of-burden

Note:

[1] Details of unit process or activity available under Appendix C.

The resulting unit processes for the raw material equivalents of the four types of reclaimed asphalt are a combination of Table 6.10 and Table 6.11 and are given in Appendix C, Table C4, The unit processes for the reclaimed asphalt types shall then be allocated to the quantity of reclaimed asphalt resulting from the calculation model in Appendix B.

The allocation should match the mixture type. For example, for a PA mixture, the unit process for PA reclaimed asphalt should be used as raw material equivalent in module D.

Correction for the environmental burden of secondary coarse and/or fine aggregate

If, in addition to reclaimed asphalt, a bituminous mixture also contains secondary coarse and/or fine aggregate, a correction must be made for the benefits calculated for saving coarse and/or fine aggregate via the raw material equivalent for reclaimed asphalt. After all, the secondary input of coarse and/or fine aggregate has not been deducted from the secondary output[2]. This correction must be included in module D as an extra environmental burden. The net load to be calculated on secondary coarse and/or fine aggregate is 45% of the environmental impact of the amount of this material applied in module A1. The process maps used for calculations are equal to the prescribed process maps for coarse and/or fine aggregate from Table 6.11.

6.3.6 Criteria for the Exclusion of Inputs and Outputs

In addition to EN 15804:

i. All raw materials at module A1 shall be included, even if the raw material contributes less than 1% of the total mass or less than 5% of the impact on one or more of the environmental impact indicators within this module.

ii. For processes or activities outside Module A1, the exclusion rules of EN 15804 shall be followed.

6.3.7 General Data Selection

Requirements in terms of selection of data are set in clause 6.3.5. These are more specific than the ones given in EN 15804.

[2] This conflicts with EN 15804, because no environmental benefits can be calculated in module D for secondary raw materials that are free of environmental burden in module A1.

Depending on each life cycle module and the type of LCA (Producer- or Project-Specific), alternative unit processes are permitted, the order of preference is as follows:

i. Unit process based on data from a verified EPD. This shall be a single-company, product-specific EPD. Neither data from group EPDs nor sector or industry average EPDs are permitted. This verified EPD shall be based on an LCA using any version of the Ecoinvent database, deviation from Ecoinvent is not permitted. [3]

ii. Alternative unit process from Ecoinvent v.3.8. [4]

iii. Default unit process from Ecoinvent v.3.8 and from this c-PCR.

Unit process for bitumen shall be sourced from Ecoinvent 3.8 (applicable to bitumen, bituminous emulsion, coated chippings).

The loss of material in the form of construction waste (supply, storage, production) shall not be included because it is expected and assumed to be less than 1% of the total mass input of each corresponding unit process or activity and less than 5% of the total mass input of each corresponding module.

6.3.8 Data Quality

In addition to EN 15804:

The source of default unit processes or activities is the Ecoinvent database version 3.8, system model “Allocation, cut-off by classification”.

Some unit processes or activities prescribed in the c-PCR Bituminous Mixtures are not available in the Ecoinvent database at the time of publication. This applies, among other things, to raw materials, transport, and machinery profiles. The detail of these unit processes or activities is available in Appendix C.

Alternative unit processes or activities may be sourced from the same source as the one used for default unit processes or activities. (see clause 6.3.7 for the order of preference). The requirement on greater representativeness still applies.

Producer specific unit processes or activities data shall comply with ISO 14025 and EN 15804 (EF 3.0).

6.3.9 Developing Product Level Scenarios

All required scenarios for the c-PCR for Bituminous Mixtures are described under the relevant sub-clauses of clause 6.3.5.

6.3.10 Units

EN 15804 shall apply.

[3] Any producer specific unit processes or activities from verified EPDs shall comply with ISO 14025 and EN 15804.

[4] Any alternative unit processes or activities from the Ecoinvent database shall all comply with ISO 14025 and EN 15804.

6.4 Inventory Analysis

6.4.1 Collecting Data

EN 15804 shall apply.

6.4.2 Calculation Procedures

EN 15804 shall apply.

6.4.3 Allocation of Input Flows and Output Emissions

EN 15804 and clause 6.3.5 shall apply.

6.4.4 Information on Biogenic Carbon Content

EN 15804 shall apply.

6.5 Impact Assessment

EN 15804 shall apply.

7. Content of the EPD

EN 15804 shall apply.

8. Project Report

EN 15804 shall apply.

9. Verification and Validity of an EPD

EN 15804 shall apply.

This c-PCR for Bituminous Mixtures shall only be adopted by programme operators complying with the “Audit and Verification Guidelines for ECO EPD Programme Operators” from Eco Platform (References [3]) or similar.

Appendix A:

EA Model Description

A model has been developed to simulate the energy consumption in the production of asphalt: the Irish Energy Allocation model (Irish EA model 2022). This model is based on the Energy Balance Analysis (EBA) model, which was originally developed by Ernst and Young (EY) on behalf of the Netherlands Enterprise Agency (RVO) in 2009. This was part of the multi-year agreements (MJA) asphalt, to support asphalt producers when setting up energy balance analyses. The EBA was subsequently further developed by Ecochain and can now be used as an EA model to determine the energy consumption of a specific bituminous mixture at a specific asphalt plant. Clause 6.3.5.2.3 describes when and how this model should be applied.

To use the EA model, the following data about the asphalt plant for a specific production year must be entered:

1. Total fuel and electricity consumption.
2. Characteristics of the bitumen heating system, such as the throughput time of bitumen.
3. Main features of the asphalt plant such as type of mixing plant, types of drum and their level of insulation.
4. Moisture content of the coarse aggregate, fine aggregate and reclaimed asphalt fractions.
5. Total production quantities per bituminous mixture product.
6. Total amount of processed reclaimed asphalt per bituminous mixture product.
7. Dryer and parallel drum temperatures per bituminous mixture product.

Table A1 and Table A2 show the input data for the EA-model, with some examples given. After entering the input data, the EA model provides the consumptions per process (Table A3) and asphalt plant-specific EA factors (Table A5, Table A6). The consumptions per process are allocated to the different mixtures on the basis of production quantities, compositions and EA factors. Clause 6.3.5.2.3, in combination with Table A4, describe exactly how this allocation should be carried out.

For LCA software in which it is not possible to follow the described allocation method, the "consumption bituminous mixtures" part of the EA model (tab 'results' row 46 onwards) shall be used. The EA model can be found on the following webpage: Downloads (tiipublications.ie) .

Table A1 Input data held in the EA model for determining the bitumen heating energy consumption.

Parameters	Example of input value
Energy source for bitumen heating system	Electricity
Location of tanks	Indoor
Other items connected to heating system	>5
Supply temperature (°C)	>175
Lead time (weeks)	0.7-1.3
Quality of insulation bitumen infrastructure	Good
Estimate energy consumption bitumen infrastructure (kWh electricity)	523,843

Table A2 Input data held in the EA model for determining the natural gas consumption of the other heating processes.

General parameters	Example of input value
Main fuel used for heating of the Dryer (and PR) drum (amount in MJ)	61,811,534
Main fuel used for heating of the Dryer (and PR) drum (type)	Natural gas
Fuel used for internal transport (amount in MJ)	864.000
Fuel used for internal transport (type)	Diesel
Total electricity consumption (MJ)	1,048,065
Installation type	Charge-mixing plant
Fuel type for dryer and parallel (RA) drums	Natural Gas
Parallel (RA) drum for reclaimed asphalt available?	Yes
Average flue gas temperature dryer Drum HMA (°C)	110
Average flue gas temperature dryer Drum WMA (°C)	105
Average flue gas temperature parallel (RA) drum (°C)	120
Insulation dryer drum	Insulated and encased
Insulation parallel (RA) drum	Insulated and encased
Temperature drop from dryer drum to mixer for HMA (°C)	10
Temperature drop from dryer drum to mixer for WMA (°C)	5
Temperature drop from parallel (RA) drum to mixer (°C)	0
Number of annual starts of dryer drum	400
Number of bituminous mixture production changes per year	2,000
Energy consumption during recipe change for Dryer drum (MJ/product change)	1,500
Moisture content of materials	
Coarse and crushed stone	
Crushed sand	
Sand	
Reclaimed Asphalt	

Total bituminous mixtures production quantities & quantity of reclaimed asphalt

Bituminous mixture type	Total bituminous mixtures production (tonnes/year)	Production quantity of bituminous mixtures in which RA is processed (tonnes/year)	Amount of RA processed (tonnes/year)
HMA AC Bin/Base			
HMA AC Surf			
HMA SMA			
PA			
HRA			
WMA AC Bin/Base			
WMA AC Surf			
WMA SMA			
Total			

Dryer and parallel (RA) drum temperatures

Type	Average final temperature of bituminous mixture in mixer (°C)	Temperature RA at exit of parallel drum (°C)
HMA AC Bin/Base		
HMA AC Surf		
HMA SMA		
PA		
HRA		
WMA AC Bin/Base		
WMA AC Surf		
WMA SMA		

Table A3 Fuel consumption per process of the other heating processes as calculated with the EA model based on the input data.

EA process	Fuel consumption (MJ)	Electricity consumption (MJ)	Diesel consumption (MJ)
Warming of minerals dryer drum			
Warming of parallel (RA) drum			
Evaporating moisture in minerals dryer drum			
Evaporating moisture in parallel (RA) drum			
Heating of combustion air, excess and leaking air			
Radiation dryer drum and parallel (RA) drum			
Bitumen heating			
Bituminous mixture production changes			
Starts and stops			
Electricity (other)			
Overheating minerals for asphalt mixtures containing RA			
Internal transport			
Total			

Table A4 Parameters on the basis of which fuel consumption per other heating process is allocated to bituminous mixtures.

Process	Input parameters[5]			
	General parameters		EA-specific parameters	
	Parameter 1	Parameter 2	Parameter 3	Parameter 4
Heating of minerals dryer drum	Production quantity	Amount of minerals in mixture	Temperature of Minerals	
Heating of RA parallel drum	Production quantity	Amount of reclaimed asphalt in mixture	Temperature Reclaimed Asphalt	
Evaporating moisture in minerals dryer drum	Production quantity	Amount of minerals in mixture	Moisture in Minerals	Evaporation factor
Evaporating moisture in RA parallel drum	Production quantity	Amount of reclaimed asphalt in mixture	Moisture in RA	Evaporation factor
Heating of combustion air, excess and leaking air	Production quantity		Heating of combustion air	

[5] These input parameters are provided to illustrate how the calculation model for A3 (Appendix A EA-model) works. These input parameters define which processes/factors are allocated in the calculation model for A3 (Appendix A EA-model) to the various processes.

Process	**Input parameters[5]**			
	General parameters		**EA-specific parameters**	
	Parameter 1	**Parameter 2**	**Parameter 3**	**Parameter 4**
Radiation dryer drum and parallel drum	Production quantity		Radiation of drums	
Overheating minerals for mixtures containing RA	Production quantity	Amount of reclaimed asphalt in mixture	overheating	
Mixture Recipe Changes	Production quantity			
Starts and stops	Production quantity			

Table A5 Bituminous mixture type specific EA factors for the reference mixtures

Indicator	**unit**	**HMA AC Bin/Base**	**HMA AC Surf**	**HMA SMA**	**HRA**	**PA**
Temperature minerals[6]	°C	165	165	170	165	160
Temperature Reclaimed Asphalt [7]	°C	110	110	110	110	110
Evaporation Factor	factor	2,66	2,66	2,66	2,66	2,66
Heating of Combustion air	factor	35,4	34,9	35,0	36,5	33,0
Radiation of drums	factor	2,74	2,71	2,72	2,82	2,57

Indicator	**unit**	**WMA AC Bin/Base**	**WMA AC Surf**	**WMA SMA**
Temperature minerals[8]	°C	140	140	140
Temperature Reclaimed Asphalt [9]	°C	110	110	110
Evaporation Factor	factor	2,65	2,65	2,65
Heating of Combustion air	factor	30,8	30,4	30,0
Radiation of drums	factor	2,50	2,47	2,44

[6] This is the average final temperature in the mixer plus the temperature drop between dryer drum and mixer minus the average outside temperature in Ireland (°C).

[7] This is the temperature of RA just after parallel (RA) drum plus the temperature drop between parallel drum and mixer minus the average outside temperature in Ireland (°C).

[8] This is the average final temperature in the mixer plus the temperature drop between dryer drum and mixer minus the average outside temperature in Ireland (°C).

[9] This is the temperature of RA just after parallel (RA) drum plus the temperature drop between parallel drum and mixer minus the average outside temperature in Ireland (°C).

Table A6 Bituminous mixture specific EA factors.

Moisture content of aggregates (kg/tonnes aggregates)	The amount of moisture in aggregates is determined per bituminous mixture, based on: $$\frac{\sum Quantity_i * moisture\ \%_i}{Total\ quantity\ of\ aggregates} * 1000$$ In which i represents a fraction of aggregate (e.g. “4/10 aggregate”).
Moisture in RA (kg/tonnes RA)	The amount of moisture in reclaimed asphalt per bituminous mixture is based on: $$\frac{\sum Quantity_j * moisture\ \%_j}{Total\ quantity\ of\ reclaimed\ asphalt} * 1000$$ In which j represents a single source of reclaimed asphalt.
Overheating	This factor has a value of 0 if the mixture does not contain RA. If the mixture contains RA, the overheating factor is automatically calculated.

Appendix B:

Calculation Model for Module D

The excel spreadsheet which is based on the spreadsheet in the Dutch c-PCR (References [1]) and can be found on the following webpage: https://www.tiipublications.ie/downloads/

Appendix C:

Additional Unit Processes to Ecoinvent

Table C1 References for module A1, EN 15804+A2, EF 3.0

Module A1	**Unit**	**1 tonne**	**1 tonne**	**1 tonne**	**1 tonne**	**1 tonne**	**1 tonne**
Impact category / Parameter		Cellulose fibre, inclusive blowing in {RoW}| production | Cut-off, U (Aluminium hydroxide and Boric acid put to 0)	SBS modified bitumen from Europe, max 10% modified1	EVA modified bitumen from Europe, max 10% modified1	Bitumen, emulsifier and water, including A3 production processes	Coated Chippings: Crushed stone and 1,5% bitumen, including 10% surcharge for A3 production processes.	Crushed stone, quarry, excl. transport EU quarry-IE2
Climate change	kg CO_2 eq	1,82E+02	7,88E+02	7,68E+02	4,04E+02	1,85E+01	9,23E+00
Ozone depletion	kg CFC11 eq	1,16E-05	7,84E-04	7,30E-04	6,03E-04	1,44E-05	1,25E-06
Ionising radiation	kBq U-235 eq	8,19E+00	2,13E+02	1,92E+02	1,55E+02	4,22E+00	8,05E-01
Photochemical ozone formation	kg NMVOC eq	6,64E-01	5,36E+00	5,00E+00	3,49E+00	1,92E-01	1,09E-01
Particulate matter	disease inc.	1,19E-05	4,40E-05	3,52E-05	2,14E-05	2,40E-06	1,80E-06
Human toxicity, non-cancer	CTUh	1,89E-06	8,90E-06	7,73E-06	4,63E-06	2,34E-07	1,26E-07
Human toxicity, cancer	CTUh	1,39E-07	3,71E-07	2,91E-07	1,89E-07	1,35E-08	8,94E-09
Acidification	mol H+ eq	8,06E-01	6,51E+00	6,00E+00	4,21E+00	2,11E-01	1,11E-01
Eutrophication, freshwater	kg P eq	5,89E-03	1,31E-02	8,13E-03	3,22E-03	4,53E-04	3,59E-04
Eutrophication, marine	kg N eq	1,98E-01	8,44E-01	8,17E-01	5,07E-01	4,93E-02	3,55E-02
Eutrophication, terrestrial	mol N eq	2,16E+00	9,36E+00	8,99E+00	5,58E+00	6,31E-01	4,73E-01
Ecotoxicity, freshwater	CTUe	8,24E+03	2,70E+04	2,41E+04	1,86E+04	3,02E+03	2,42E+03
Land use	Pt	4,22E+02	6,66E+03	5,72E+03	4,32E+03	9,52E+02	7,93E+02
Water use	m3 depriv.	1,98E+01	1,85E+02	1,58E+02	2,56E+01	1,70E+00	1,49E+00
Resource use, fossils	MJ	1,92E+03	5,20E+04	5,15E+04	3,69E+04	9,40E+02	1,39E+02

Module A1	Unit	1 tonne	1 tonne	1 tonne	1 tonne	1 tonne	1 tonne
Resource use, minerals and metals	kg Sb eq	6,39E-04	6,39E-03	3,40E-03	1,29E-03	1,17E-04	8,34E-05
Climate change - Fossil	kg CO_2 eq	1,56E+02	7,87E+02	7,68E+02	4,04E+02	1,84E+01	9,17E+00
Climate change - Biogenic	kg CO_2 eq	3,58E+01	-9,46E-01	1,17E+00	7,12E-01	1,82E-01	1,54E-01
Climate change - Land use and LU change	kg CO_2 eq	2,16E-01	4,68E-01	2,31E-01	1,01E-01	1,80E-02	1,47E-02
Human toxicity, non-cancer - organics	CTUh	8,67E-08	5,15E-07	6,56E-07	2,77E-07	9,76E-09	3,67E-09
Human toxicity, non-cancer - inorganics	CTUh	4,68E-07	2,28E-06	2,21E-06	1,52E-06	7,66E-08	4,10E-08
Human toxicity, non-cancer - metals	CTUh	1,35E-06	6,20E-06	4,98E-06	2,89E-06	1,49E-07	8,16E-08
Human toxicity, cancer - organics	CTUh	7,24E-08	1,36E-07	1,11E-07	8,39E-08	5,82E-09	3,90E-09
Human toxicity, cancer - inorganics	CTUh	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Human toxicity, cancer - metals	CTUh	6,63E-08	2,35E-07	1,80E-07	1,05E-07	7,66E-09	5,04E-09
Ecotoxicity, freshwater - organics	CTUe	3,99E+01	3,03E+03	3,12E+03	2,35E+03	5,58E+01	4,77E+00
Ecotoxicity, freshwater - inorganics	CTUe	2,73E+02	8,43E+03	7,50E+03	6,14E+03	1,54E+02	2,01E+01
Ecotoxicity, freshwater - metals	CTUe	7,93E+03	1,55E+04	1,35E+04	1,01E+04	2,81E+03	2,39E+03

[1] *Based on data from Dutch industry average LCA for EVA and SBS modified bitumen (https://www.bouwendnederland.nl/media/13790/lca-achtergrondrapport-sbs-eva-gemodificeerde-bitumen-cat-3_def.pdf), modelled using Ecoinvent 3.8.*

[2] *Based on industry average data from LCA report used for Dutch PCR Asphalt (https://www.bouwendnederland.nl/media/13789/lca-achtergrondrapport-steenslag-uit-groeve-cat-3_def.pdf).*

Table C2 References for Module A3, EN 15804+A2, EF 3.0

Module A3	Unit	1 MJ	1 MJ	1 kWh
Impact category / Parameter		Kerosene combustion, based on: Diesel, burned in building machine {GLO}| processing | Cut-off, U	Recovered Fuel Oil, no fuel production, based on: Heat, district or industrial, other than natural gas {Europe without Switzerland}| heat production, heavy fuel oil, at industrial furnace 1MW | Cut-off, U	Residual Mix, grey only, based on: Electricity, high voltage {IE}| market for | Cut-off, U
Climate change	kg CO_2 eq	9,20E-02	8,40E-02	6,05E-01
Ozone depletion	kg CFC11 eq	2,04E-08	2,20E-11	3,20E-08
Ionising radiation	kBq U-235 eq	5,41E-03	6,75E-05	3,01E-02
Photochemical ozone formation	kg NMVOC eq	1,28E-03	1,42E-04	9,07E-04
Particulate matter	disease inc.	2,56E-08	5,68E-09	3,49E-09
Human toxicity, non-cancer	CTUh	5,38E-10	3,49E-10	2,48E-09
Human toxicity, cancer	CTUh	2,87E-11	2,54E-11	5,97E-11
Acidification	mol H+ eq	9,60E-04	6,24E-04	1,77E-03
Eutrophication, freshwater	kg P eq	3,09E-07	4,27E-08	8,47E-06
Eutrophication, marine	kg N eq	4,23E-04	4,13E-05	3,03E-04

Eutrophication, terrestrial	mol N eq	4,64E-03	4,53E-04	3,37E-03
Ecotoxicity, freshwater	CTUe	7,55E-01	1,76E-02	2,80E+00
Land use	Pt	1,62E-01	1,80E-03	2,89E-01
Water use	m3 depriv.	1,62E-03	1,16E-04	7,53E-02
Resource use, fossils	MJ	1,27E+00	8,32E-03	9,26E+00
Resource use, minerals and metals	kg Sb eq	4,78E-08	1,50E-08	2,10E-07
Climate change - Fossil	kg CO_2 eq	9,19E-02	8,40E-02	6,05E-01
Climate change - Biogenic	kg CO_2 eq	3,79E-05	1,07E-05	-1,63E-04
Climate change - Land use and LU change	kg CO_2 eq	8,35E-06	1,32E-06	4,04E-05
Human toxicity, non-cancer - organics	CTUh	1,71E-11	2,19E-12	3,19E-11
Human toxicity, non-cancer - inorganics	CTUh	3,78E-10	9,94E-12	1,74E-10

Human toxicity, non-cancer - metals	CTUh	1,45E-10	3,37E-10	2,29E-09
Human toxicity, cancer - organics	CTUh	1,52E-11	1,24E-11	1,37E-11
Human toxicity, cancer - inorganics	CTUh	0,00E+00	0,00E+00	0,00E+00
Human toxicity, cancer - metals	CTUh	1,35E-11	1,30E-11	4,60E-11
Ecotoxicity, freshwater - organics	CTUe	8,10E-02	2,08E-04	1,63E-02
Ecotoxicity, freshwater - inorganics	CTUe	2,13E-01	6,56E-04	1,76E-01
Ecotoxicity, freshwater - metals	CTUe	4,61E-01	1,67E-02	2,61E+00

Table C3 References for modules A5, C1 and C3, EN 15804+A2, EF 3.0 (Based on Dutch industry average machinery used for Asphalt installation reported in References [1]).

Modules		**A5**		**C1**		**C3**	
	Unit	**1 tonne**	**1 tonne**	**1 tonne**	**1 tonne**	**1 litre**	**1 litre**
Impact category / Parameter		A5 Emissions + Fuel Stage IIIb/IV Asphalt Construction Set– 400 tonnes/day - per tonne of asphalt (AC surf, SMA surf, HRA surf, PA surf)	A5 Emissions + Fuel Stage IIIb/IV Asphalt Construction Set – 1000 tonnes/day - per tonne of asphalt (AC bin and AC base)	C1 Emissions + fuel Emission Stage Class IIIb/IV Asphalt removal set – 400 tonnes/day - per tonne of removed asphalt (AC surf, SMA surf, HRA surf, PA surf)	C1 Emissions + fuel Emission Stage Class IIIb/IV Asphalt removal set – 1000 tonnes/day - per tonne of removed asphalt (AC bin and AC base)	C3 Emissions + fuel Emission Stage Class IIIb/middle (75-130 kW) - per liter (based on ""Diesel, burned in building machine {GLO} | processing | Cut-off, U"")	C3 Emissions + fuel Emission Stage Class IV/heavy (130-560 kW) - per liter (based on ""Diesel, burned in building machine {GLO} | processing | Cut-off, U"")
Climate change	kg CO_2 eq	2,56E+00	1,41E+00	1,45E+00	3,39E+00	4,41E+00	4,40E+00
Ozone depletion	kg CFC11 eq	4,09E-07	2,26E-07	2,33E-07	5,44E-07	7,06E-07	7,06E-07
Ionising radiation	kBq U-235 eq	1,12E-01	6,18E-02	6,38E-02	1,49E-01	1,93E-01	1,93E-01
Photochemical ozone formation	kg NMVOC eq	1,77E-02	9,31E-03	6,29E-03	1,46E-02	3,85E-02	1,19E-02
Particulate matter	disease inc.	5,50E-08	2,97E-08	2,34E-08	5,45E-08	1,08E-07	5,95E-08
Human toxicity, non-cancer	CTUh	1,08E-08	6,10E-09	4,91E-09	1,14E-08	2,11E-08	1,13E-08
Human toxicity, cancer	CTUh	5,94E-10	3,28E-10	3,38E-10	7,89E-10	1,02E-09	1,02E-09
Acidification	mol H+ eq	1,46E-02	7,72E-03	5,55E-03	1,29E-02	3,10E-02	1,16E-02
Eutrophication, freshwater	kg P eq	6,35E-06	3,51E-06	3,62E-06	8,44E-06	1,10E-05	1,10E-05

Modules		**A5**		**C1**		**C3**	
	Unit	**1 tonne**	**1 tonne**	**1 tonne**	**1 tonne**	**1 litre**	**1 litre**
Eutrophication, marine	kg N eq	6,36E-03	3,33E-03	2,17E-03	5,04E-03	1,40E-02	3,84E-03
Eutrophication, terrestrial	mol N eq	6,97E-02	3,65E-02	2,38E-02	5,54E-02	1,54E-01	4,23E-02
Ecotoxicity, freshwater	CTUe	1,53E+01	8,44E+00	8,70E+00	2,03E+01	2,64E+01	2,64E+01
Land use	Pt	3,34E+00	1,85E+00	1,90E+00	4,44E+00	5,77E+00	5,77E+00
Water use	m3 depriv.	4,09E-02	2,26E-02	2,33E-02	5,43E-02	7,05E-02	7,05E-02
Resource use, fossils	MJ	2,63E+01	1,45E+01	1,49E+01	3,49E+01	4,53E+01	4,53E+01
Resource use, minerals and metals	kg Sb eq	9,84E-07	5,43E-07	5,60E-07	1,31E-06	1,70E-06	1,70E-06
Climate change - Fossil	kg CO_2 eq	2,56E+00	1,41E+00	1,45E+00	3,39E+00	4,41E+00	4,39E+00
Climate change - Biogenic	kg CO_2 eq	7,22E-04	3,98E-04	4,11E-04	9,58E-04	1,24E-03	1,24E-03
Climate change - Land use and LU change	kg CO_2 eq	1,89E-04	1,04E-04	1,07E-04	2,50E-04	3,25E-04	3,25E-04
Human toxicity, non-cancer - organics	CTUh	1,95E-10	1,07E-10	1,11E-10	2,59E-10	3,36E-10	3,36E-10
Human toxicity, non-cancer - inorganics	CTUh	7,64E-09	4,37E-09	3,13E-09	7,29E-09	1,57E-08	5,91E-09

Modules		A5		C1		C3	
	Unit	1 tonne	1 tonne	1 tonne	1 tonne	1 litre	1 litre
Human toxicity, non-cancer - metals	CTUh	2,98E-09	1,65E-09	1,70E-09	3,96E-09	5,14E-09	5,14E-09
Human toxicity, cancer - organics	CTUh	3,14E-10	1,73E-10	1,79E-10	4,17E-10	5,42E-10	5,42E-10
Human toxicity, cancer - inorganics	CTUh	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Human toxicity, cancer - metals	CTUh	2,80E-10	1,54E-10	1,59E-10	3,72E-10	4,83E-10	4,83E-10
Ecotoxicity, freshwater - organics	CTUe	1,60E+00	8,85E-01	9,13E-01	2,13E+00	2,77E+00	2,77E+00
Ecotoxicity, freshwater - inorganics	CTUe	4,29E+00	2,37E+00	2,44E+00	5,70E+00	7,40E+00	7,40E+00
Ecotoxicity, freshwater - metals	CTUe	9,40E+00	5,18E+00	5,35E+00	1,25E+01	1,62E+01	1,62E+01

Table C4 References for Module D – result of the combination of Table 6.10 and Table 6.11, EN 15804+A2, EF 3.0

Module D	Unit	1 tonne	1 tonne	1 tonne	1 tonne
Impact category / Parameter		**D, Reclaimed Asphalt from Base and Binder courses**	**D, Reclaimed asphalt from surface layers, AC Surf and SMA Surf**	**D, Reclaimed asphalt from surface layers, HRA**	**D, Reclaimed asphalt from surface layers, PA**
Climate change	kg CO_2 eq	2,96E+01	2,95E+01	3,64E+01	3,03E+01
Ozone depletion	kg CFC11 eq	3,42E-05	3,42E-05	4,61E-05	3,63E-05
Ionising radiation	kBq U-235 eq	9,26E+00	9,25E+00	1,23E+01	9,77E+00
Photochemical ozone formation	kg NMVOC eq	2,67E-01	2,66E-01	3,16E-01	2,78E-01
Particulate matter	disease inc.	2,42E-06	2,41E-06	2,53E-06	2,47E-06
Human toxicity, non-cancer	CTUh	3,62E-07	3,60E-07	4,41E-07	3,65E-07
Human toxicity, cancer	CTUh	1,65E-08	1,64E-08	1,86E-08	1,68E-08
Acidification	mol H+ eq	3,13E-01	3,13E-01	3,78E-01	3,26E-01
Eutrophication, freshwater	kg P eq	5,20E-04	5,12E-04	5,38E-04	4,87E-04
Eutrophication, marine	kg N eq	5,23E-02	5,21E-02	5,57E-02	5,39E-02
Eutrophication, terrestrial	mol N eq	6,27E-01	6,25E-01	6,46E-01	6,48E-01
Ecotoxicity, freshwater	CTUe	2,56E+03	2,55E+03	2,36E+03	2,71E+03
Land use	Pt	7,05E+02	7,06E+02	6,08E+02	7,57E+02
Water use	m3 depriv.	2,23E+01	2,11E+01	3,58E+01	9,73E+00
Resource use, fossils	MJ	2,14E+03	2,14E+03	2,86E+03	2,26E+03
Resource use, minerals and metals	kg Sb eq	1,30E-04	1,30E-04	1,42E-04	1,31E-04
Climate change - Fossil	kg CO_2 eq	2,96E+01	2,94E+01	3,63E+01	3,03E+01
Climate change - Biogenic	kg CO_2 eq	4,77E-02	4,74E-02	4,28E-02	4,79E-02

Module D	**Unit**	**1 tonne**	**1 tonne**	**1 tonne**	**1 tonne**
Impact category / Parameter		**D, Reclaimed Asphalt from Base and Binder courses**	**D, Reclaimed asphalt from surface layers, AC Surf and SMA Surf**	**D, Reclaimed asphalt from surface layers, HRA**	**D, Reclaimed asphalt from surface layers, PA**
Climate change - Land use and LU change	kg CO_2 eq	1,72E-02	1,70E-02	1,67E-02	1,68E-02
Human toxicity, non-cancer - organics	CTUh	1,76E-08	1,76E-08	2,25E-08	1,84E-08
Human toxicity, non-cancer - inorganics	CTUh	1,20E-07	1,20E-07	1,49E-07	1,20E-07
Human toxicity, non-cancer - metals	CTUh	2,27E-07	2,26E-07	2,74E-07	2,30E-07
Human toxicity, cancer - organics	CTUh	6,97E-09	6,94E-09	7,84E-09	7,12E-09
Human toxicity, cancer - inorganics	CTUh	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Human toxicity, cancer - metals	CTUh	9,51E-09	9,46E-09	1,08E-08	9,66E-09
Ecotoxicity, freshwater - organics	CTUe	1,33E+02	1,33E+02	1,79E+02	1,41E+02
Ecotoxicity, freshwater - inorganics	CTUe	3,53E+02	3,53E+02	4,74E+02	3,75E+02
Ecotoxicity, freshwater - metals	CTUe	2,07E+03	2,07E+03	1,71E+03	2,19E+03

Bonneagar Iompair Éireann
Transport Infrastructure Ireland

Ionad Ghnó Gheata na Páirce,
Stráid Gheata na Páirce,
Baile Átha Cliath 8, D08 DK10, Éire

www.tii.ie

+353 (01) 646 3600

Parkgate Business Centre,
Parkgate Street,
Dublin 8, D08 DK10, Ireland

info@tii.ie

+353 (01) 646 3601