ICE Database Insights:
Methodological Challenges Behind the Scenes

Case Studies of Biogenic Carbon, Allocation and Recycled Content

12th June 2025

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circularecology.com

Today's Webinar

- Introduction
- Overview of the ICE Database
- Methodological Challenge 1: Biogenic Carbon
  - Linoleum: A case study on biogenic carbon
  - A look ahead to timber
- Methodological Challenge 2: Allocation Issues in Stone
- Methodological Challenge 3: Recycled Content
  - Copper: A case study on recycled content
- ICE v4.1 Announcement
- Q&A Session

Your Presenters Today

Dr Craig Jones

Managing Director

- *Original author ICE Database*
- *20 years experience product footprints & LCA*

Joe Rouse

Senior Consultant

- *Project Manager on ICE*
- *Experience in Life Cycle Assessments and Product Carbon Footprinting*

Background & Introduction

Circular Ecology – Introduction

Environmental consultancy, founded in 2013

Offer a range environmental services:

- Whole-Life Embodied Carbon Assessments for Construction Projects
- Organisational Carbon Footprints, Scope 1, 2 & 3
- Product Carbon Footprints
- Life Cycle Assessments (LCA)
- Carbon Footprint Verification & Assurance
- Net Zero Carbon Strategy
- Carbon Footprint Database (library) Development
- Online E-Learning Training Courses
- Carbon Offsetting and Tree Planting

Hosts the Inventory of Carbon & Energy (ICE) Database

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Scaling Carbon Reduction Initiative (SCRI)

Launch of our **Scaling Carbon Reductions Initiative (SCRI)**

- Key to our purpose **to release impactful work, to enable scalable carbon reductions**
- We will be diverting a specified amount from some of our sales into the SCRI
- Funds will be used to **develop free carbon footprint data, tools and resources**
- Publication of an annual impact report disclosing the amount raised and use of funds

https://circularecology.com/scaling-carbon-reductions-initiative.html

ICE Database Supporters

HOPE SOLUTIONS

RAIL SAFETY AND STANDARDS BOARD

ICE v4.0 Funders

BCIS

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UKRI Innovate UK

https://circularecology.com/ice-supporters.html

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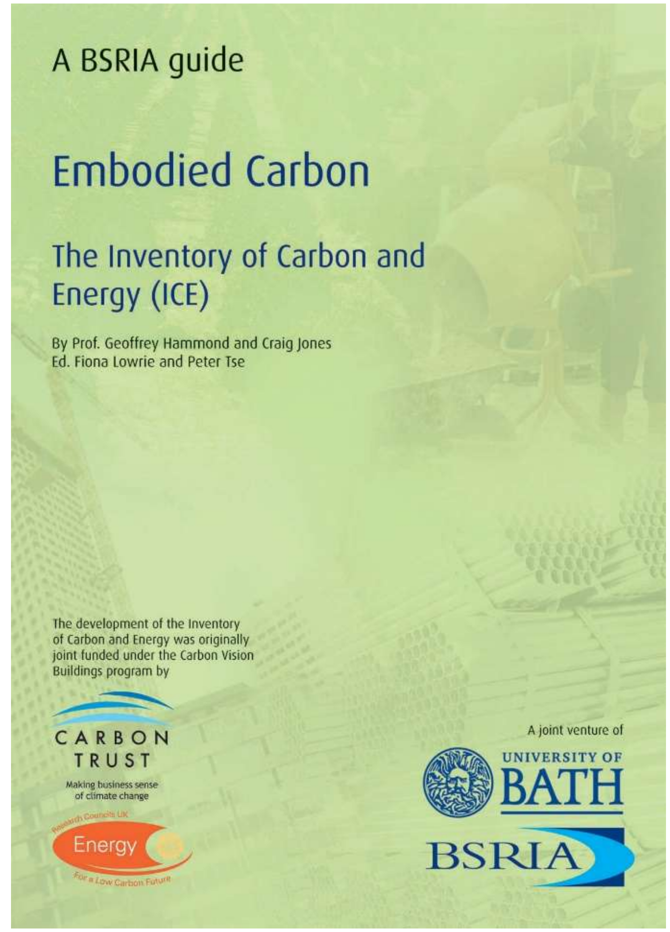
Overview of the ICE Database

The Inventory of Carbon & Energy (ICE)

- An **embodied energy and carbon database** for building materials
    - First version 2005 released by Dr Craig Jones and Professor Geoff Hammond, University of Bath
- Data for over 200 materials
    - Primarily for Construction Materials
- Over 50,000 worldwide users
- BSRIA hardcopy published in January 2011
- Excel version free to download from **www.circularecology.com/ice-database.html**



ICE Background Dataset

The digitisation of Environmental Product Declarations has allowed us to access large online libraries of EPD data, vastly expanding our available data for ICE.

- Previous iterations of the ICE Database relied on **manual processes to extract data**
- EPDs make up most of the ICE Background Dataset, but are **not always accurate or reliable**
- Our approach focuses on **quality-driven analysis** using the **best available data**

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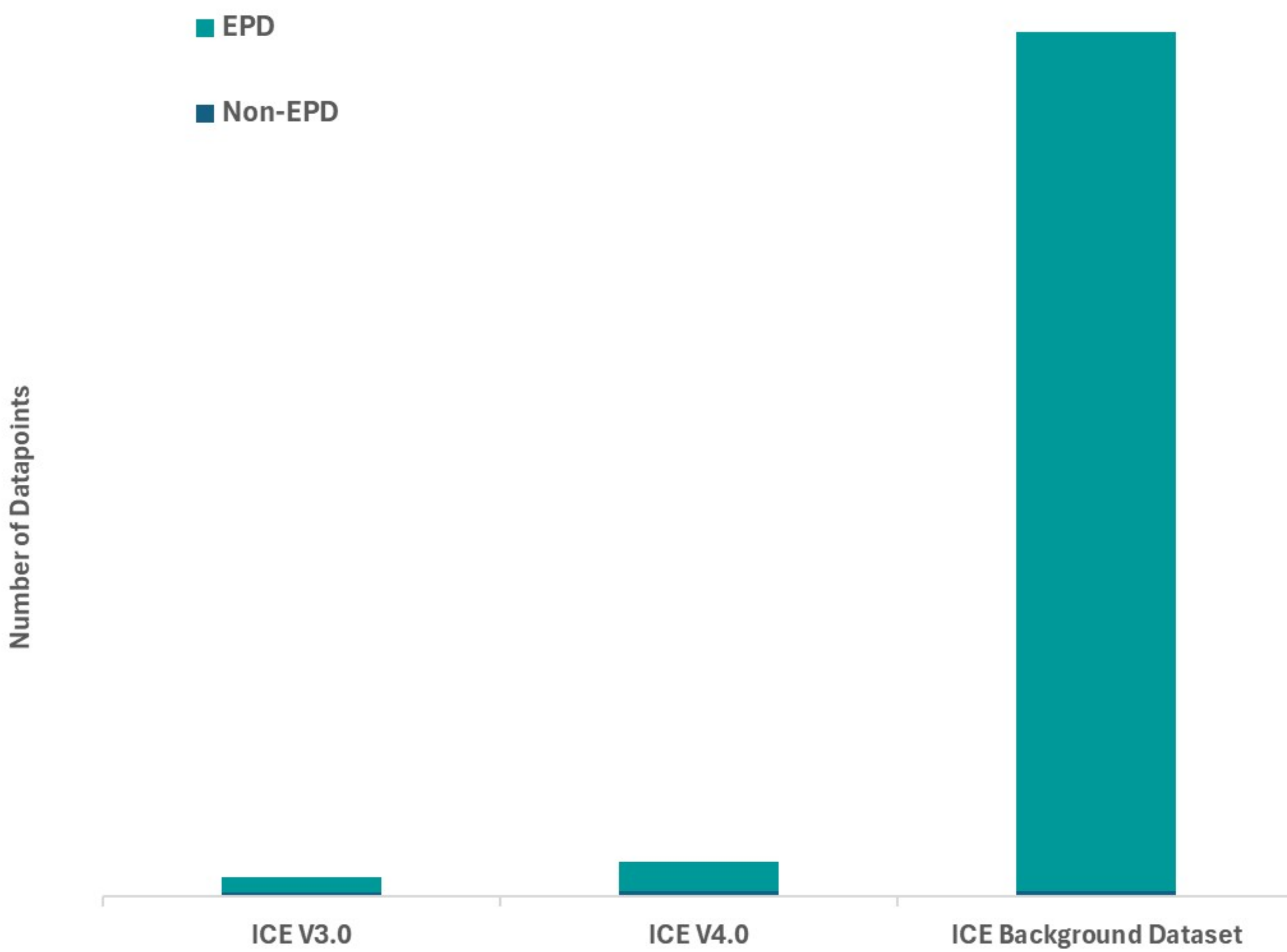
ICE Background Dataset



Methodological Challenges - Overview

This session is focused on examples of specific and technical challenges we encounter that affect the accuracy and comparability of product carbon data.

- **Biogenic Carbon:** How it is calculated, common inconsistencies we find, and a case study on how this impacted our Linoleum analysis

- **Allocation Methods:** How differences in allocation methodology across the stone category have impacted our ability to create a fair ICE category

- **Recycled Content:** A case study on how the recycled content of copper creates difficulties when producing an ICE category

Methodological Challenge 1

Biogenic Carbon

What is Biogenic Carbon?

Biogenic Carbon:

Biogenic carbon refers to carbon that is part of the natural carbon cycle and is absorbed, released, or stored by biomass-based materials (e.g., wood, plants, natural fibres) during their life cycle

Stored/Sequestered Carbon:

Stored carbon in an EPD refers to temporarily retained carbon in the product (e.g. in wood), which may eventually be released (e.g. via combustion or decay)

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Biogenic Carbon in EPDs

Two units are used in EPDs: **kgC and kgCO$_2$e.**

kgC

- Refers to **kilograms of carbon atoms**

kgCO$_2$e

- Refers to **kilograms of carbon dioxide equivalents**

1 kgC is equal to 3.667 kgCO$_2$e
(molecular weight conversion:
$CO_2/C = 44/12$)

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Biogenic Carbon in EPDs

Information on biogenic carbon content

BIOGENIC CARBON CONTENT	kgC	kgCO_2e
Biogenic carbon content in product	219	802
Biogenic carbon content in packaging	0	0

Note: 1kg biogenic carbon is equivalent to 44/12 kg CO_2

Indicator	Unit	Tot.A1-A3	A4	A5	B2	C2	C3	C4	D
GWP-fossil	kg CO_2 eq.	1.08E+03	5.43E+00	4.24E+01	0.00E+00	5.43E-01	3.28E+00	0.00E+00	-8.19E+02
GWP-biogenic	kg CO_2 eq.	-7.74E+02	3.23E-03	1.45E+00	0.00E+00	3.23E-04	4.17E-03	8.02E+02	-2.99E-01
GWP-luluc	kg CO_2 eq.	7.31E-01	1.83E-03	1.02E-01	0.00E+00	1.83E-04	1.02E-03	0.00E+00	-2.26E-01
GWP - total	kg CO_2 eq.	3.02E+02	5.44E+00	4.39E+01	0.00E+00	5.44E-01	3.29E+00	8.02E+02	-8.19E+02

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Linoleum: A Case Study on Biogenic Carbon

Linoleum

Linoleum is a durable flooring material primarily made from natural ingredients.

Common Ingredients:

- Linseed Oil
- Cork Dust
- Wood Flour
- Jute (Backing)
- Recycled Linoleum Powder
- Calcium Carbonate (Limestone)

Linoleum contains multiple biogenic carbon sources in its constituent materials. This makes it difficult to estimate the biogenic carbon content, and to verify results when it is reported.

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Biogenic Carbon Challenges - Linoleum

Linoleum Analysis Challenges

Dataset Size
From over 100,000+ datapoints, **less than 100** are classified as linoleum

Extraction Time
Manual extraction of sequestered carbon and composition data is **time-intensive**

Sequestered Carbon Reporting
Only **14.8%** of datapoints reported sequestered carbon content, partially due to the age of our dataset

Ingredient Carbon Data
Finding **carbon data** for linoleum's constituent materials is difficult

Composition Data
24.1% of datapoints did not provide the product composition

Accuracy
Some EPDs claimed **unrealistic sequestered carbon** values

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Linoleum – Composition Challenges

- The EN 15804+A2 (2019) standard has **mandatory biogenic carbon reporting**
- **However, the linoleum dataset is small, so needs to still use older datapoints** that lack this data
- For those datapoints that do not report the stored biogenic carbon, we can **estimate this** based on the constituent materials

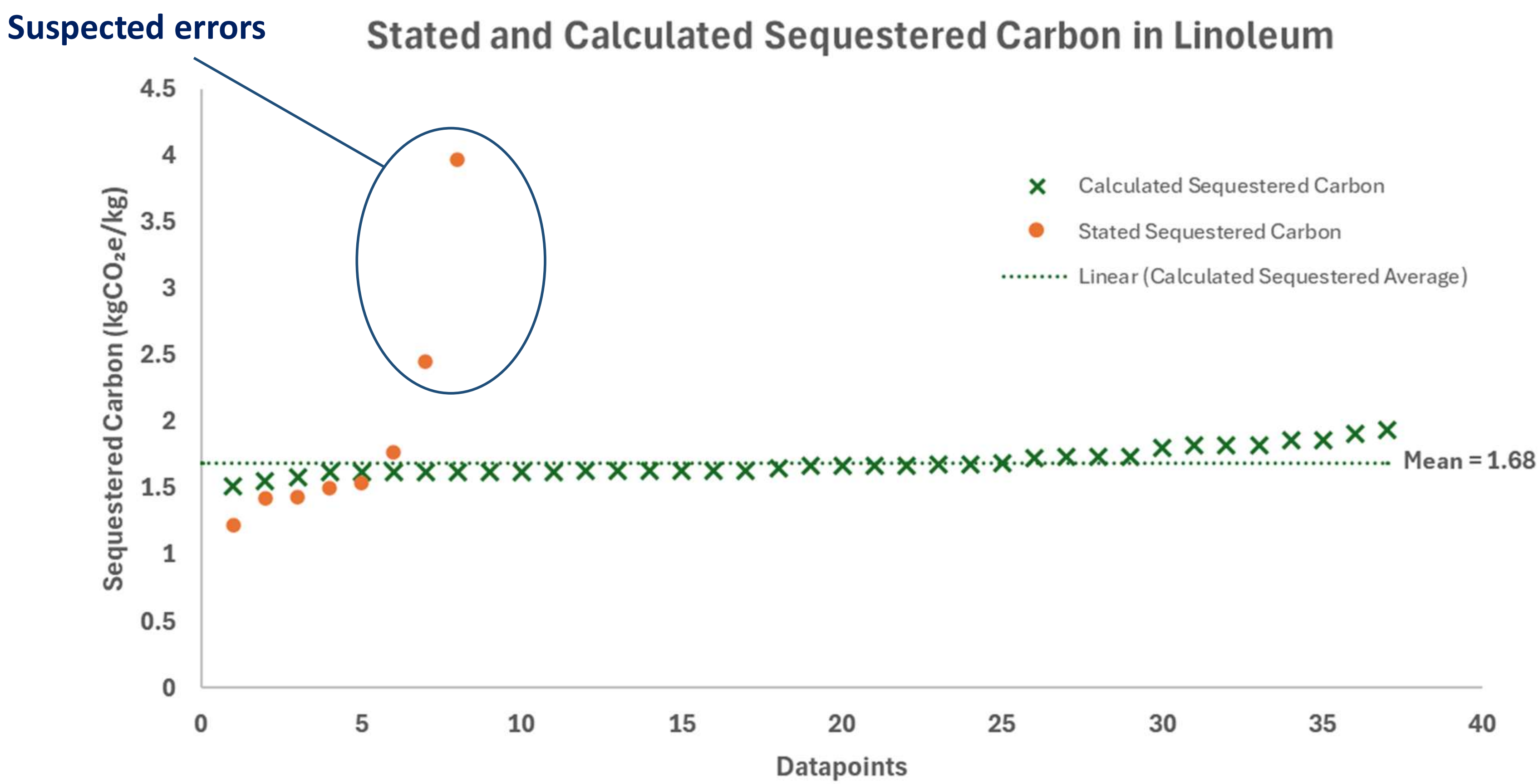
2.1 Material Content of the Product

Table 2: Composition of Marmoleum

Component	Material	Availability			Amount [%]	Origin
		Renewable	Recycled	Non-Renewable		
Binder	Linseed oil	Bio based crop			20	Canada/Europe
	Gum rosin	Bio based crop			3	Indonesia
	Tall oil		Bio based waste product from paper Industry		7	USA
Filler	Wood flour		Bio based waste product from wood processing		22	Germany
	Calcium carbonate			Abundant mineral	22	Germany
	Reused & Recycled Marmoleum		Pre- and post-consumer waste		14	Internal/External
Pigment	Titanium dioxide			Limited mineral	2	Global
	Other pigments			Limited mineral	1	Global
Backing	Jute	Bio based crop			8	India/Bangladesh
Finish	Lacquer				1	Netherlands
In Marmoleum Cocoa top layer*	Cocoa husks		Bio based waste product from cocoa Industry		1.5	Netherlands

Estimating Linoleum Biogenic Carbon

From those EPDs that report the constituent materials in their composition, we have estimated the sequestered biogenic carbon per kg:



Biogenic Carbon Challenges - Linoleum

We have individually checked each available datapoint and extracted data such as stated sequestered carbon and product composition when available. This gives us much more context to analyse each datapoint and flag suspected errors.

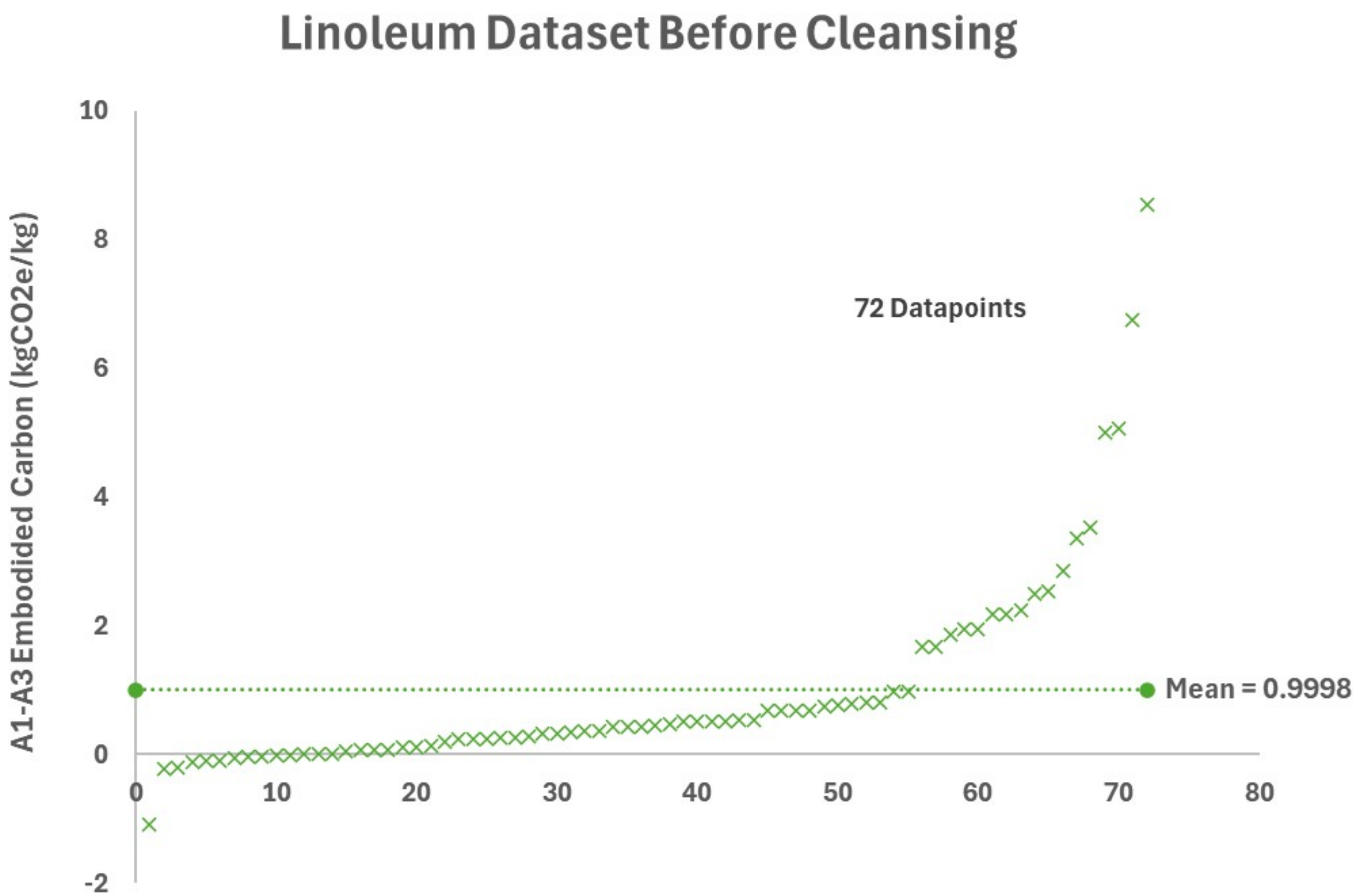
- Our dataset contains EPDs over a large time span, reflecting changes in biogenic carbon accounting and thus containing discrepancies

- Some EPDs did not report the composition of the linoleum product, making it impossible to estimate or recreate (if reported) the sequestered carbon values

- Some EPDs show their products as storing unrealistic amounts of sequestered carbon

Cleansing the Linoleum Dataset

Through a manual analysis of each linoleum datapoint, we have been able to produce a 'cleansed' and comparable dataset:



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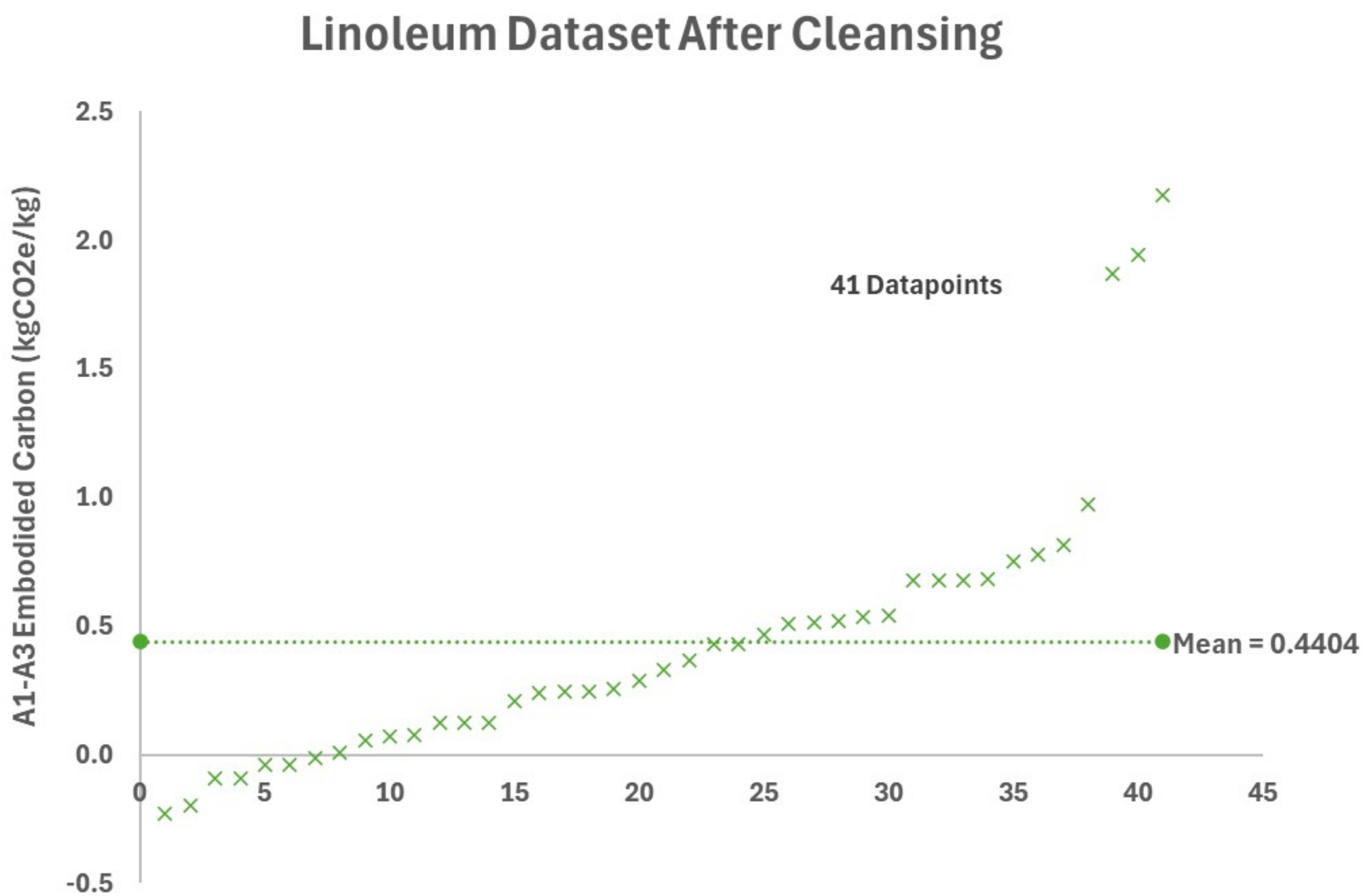

Looking Forward: Timber

Looking Forward: Timber

As we finalise analysis on the linoleum category, we can look ahead to **timber** as another major biogenic ICE category requiring an update**.**

Some Subcategories:
- Softwood
- Hardwood
- Chipboard
- Medium Density Fibreboard (MDF)
- Particle Board
- Orientated Strand Board
- Plywood

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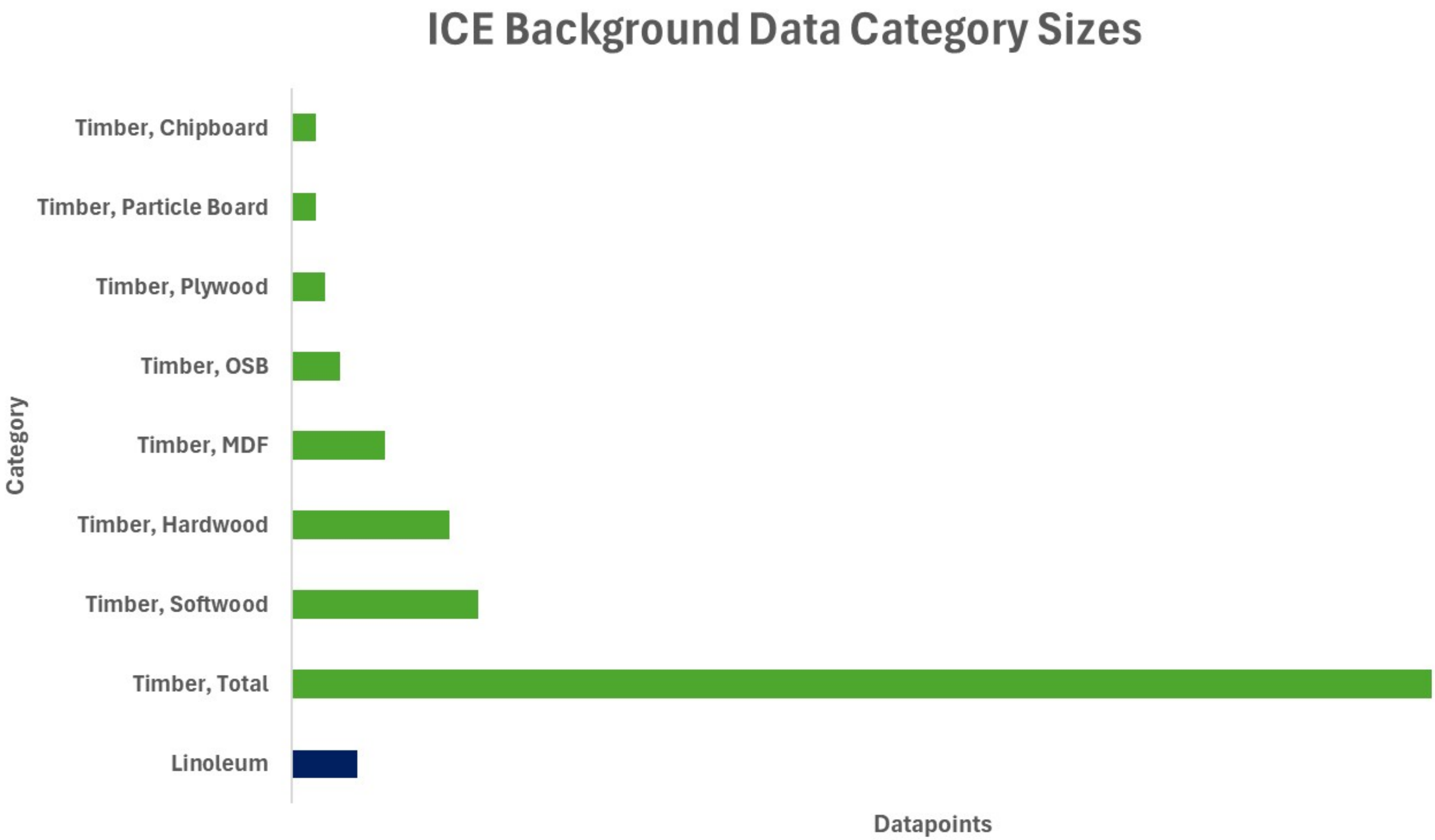
Looking Forward: Timber



Looking Forward: Timber

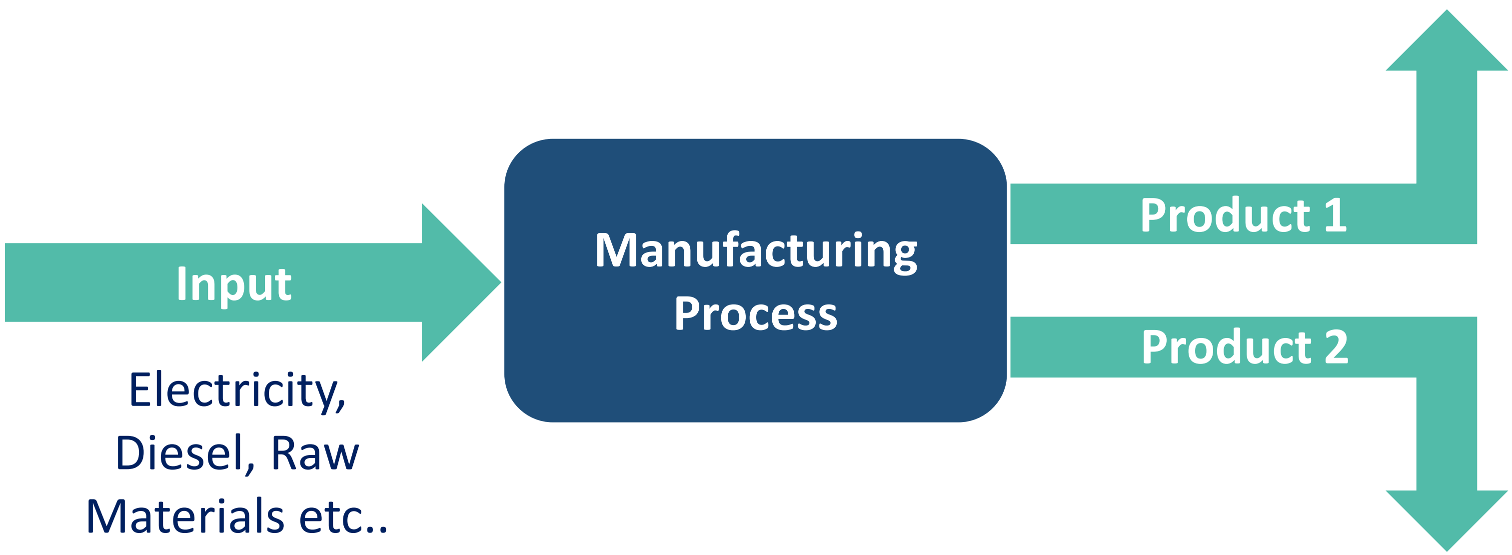
- Timber is a **much larger dataset** than Linoleum, with **over 1000 datapoints currently**
- With a category this large, manual verification of every EPD would require **significant resource**
- Our approach therefore may focus on spotting **obvious errors and inconsistencies** across each subcategory combined with assumptions on missing parameters such as carbon sequestration, density and moisture content.

Methodological Challenge 2

Allocation

Allocation

Allocation is the process of dividing environmental impacts among multiple products or outputs of a single manufacturing process



Allocation

Why It's Needed:

- Many industrial processes **produce more than one product** (e.g. steel + slag)
- Allocation determines how emissions and resource use are shared between co-products

Common Allocation Scenarios:

- By-products (e.g. sawdust from lumber production)
- Waste-to-resource flows (e.g. recycled content)

EN 15804 + A2 Allocation Guidance:

- **Avoid allocation** when possible and justify when used
- If allocation is necessary, **physical causality allocation** (mass, volume) is preferred **when the difference in revenue between co-products is low**
- In all other cases allocation should be based on **economic values**
- Sub-division **often is not possible** and the typical differences in revenue between co-products means that **EN 15804 often results in economic allocation**

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Types of Allocation Methods

Method	Description	Impact on EPDs
Mass Allocation	Impacts distributed by product weight	Simple but may misrepresent value of by-products
Economic Allocation	Based on product market value	Reflects market reality, but volatile over time
Energy Content	Allocates based on calorific value	Used for fuels or energy carriers

Variance in the allocation rules used in a material category can lead to inconsistent results when comparing even similar EPDs.

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Why Allocation Matters for ICE

1. **Incompatible Allocation Methods = Skewed Results:**
   - Using EPDs based on differing allocation methods can lead to results that are not **directly comparable**
   - Impacts may be **over- or under-represented**, especially for by-products

2. **Product Category Rules (PCRs):**
   - PCRs are the rules, requirements and guidelines that specify how to conduct a **Life Cycle Assessment** (LCA) and exist to **enable comparability across EPDs**
   - Due to differences across PCRs there is **questionable comparability** across all materials
   - Even with PCRs being available there are **large differences in allocation approaches** for some materials

You cannot reliably aggregate or compare EPDs without understanding the underlying allocation logic!

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Allocation Issues in Stone

Stone

Stone can include a range of natural and processed stone products. Allocation is common in stone production where quarrying yields multiple grades or types of stone.

Some Possible Subcategories:

- Granite
- Limestone
- Marble (Stone and Tile)
- Shale
- Sandstone
- Calcium Carbonate (Limestone)

In our stone dataset, we have found a range of different allocation approaches being used across each subcategory. In many cases, the allocation approach is not explicitly mentioned at all…

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Stone – Allocation Methods

Allocations:

The manufacturing plant where these natural stone products of granite for coverings are produced also produces other products, namely cubes, curbs and slabs. Taking it into account, an mass allocation methodology was used to define which input and output flows associated only to the production of the natural stone being studied.

Allocation:

The allocation is made in accordance with the provisions in EN 15804. Incoming energy, water and waste production in-house production (A3 – manufacturing) is allocated equally among all products through mass allocation. Economic allocation is used upstream (A1 and A2) because machine blocks from the quarry are not subject for further processing. Price for machine blocks are significant lower compared with processed schist products.

Difference in material consumption, energy and waste production in the production of different products (floor tiles, slabs, roofing etc.) are considered to be marginal, as production processes are nearly the same.

ALLOCATION RULES

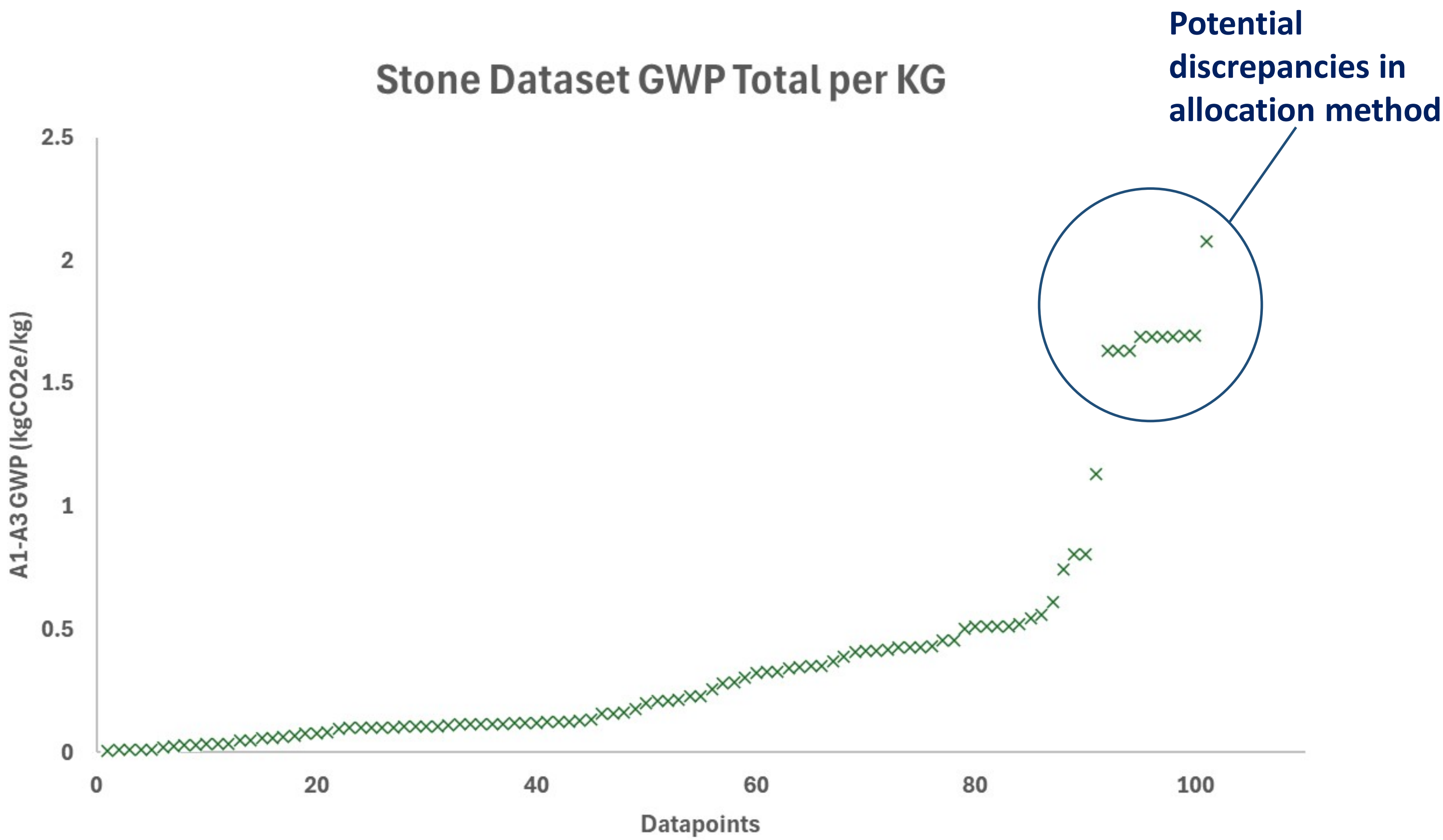
The allocation rules used, in accordance with the provisions of EN 15804 + A1: 2013, are specific for each material and the criteria used is that which is identified as the most relevant to the type of work performed. Allocation has been made even for the co-product, using the same criteria as that used for the finished product.

The allocation criteria used were:

- time required to perform the processing (elettricity, water);
- criterion of allocation for mass (oil, wood, plastics);
- criterion of allocation for worked surface (LPG, oxygen).

Stone – A Look at the Data

A brief look at the available data for the Stone category shows a large range in embodied carbon values across the dataset.



Stone – Data Spread Indicators

We spotted the allocation issues in stone by looking at the variability of the dataset, as part of our **Data Quality Indicator (DQI)** methods. This allows us to **compare variability, not absolute values,** across ICE categories. Examples of these measures include:

1. **Relative Standard Deviation (median-based):**
    - Standard deviation divided by the median

2. **Coefficient of Variation:**
    - Standard deviation divided by the mean

3. **Relative Interquartile Range:**
    - Compares the middle 50% spread of data to the median
    - Less sensitive to outliers

All these methods are useful for analysing the **validity and uniformity** of a potential material category.

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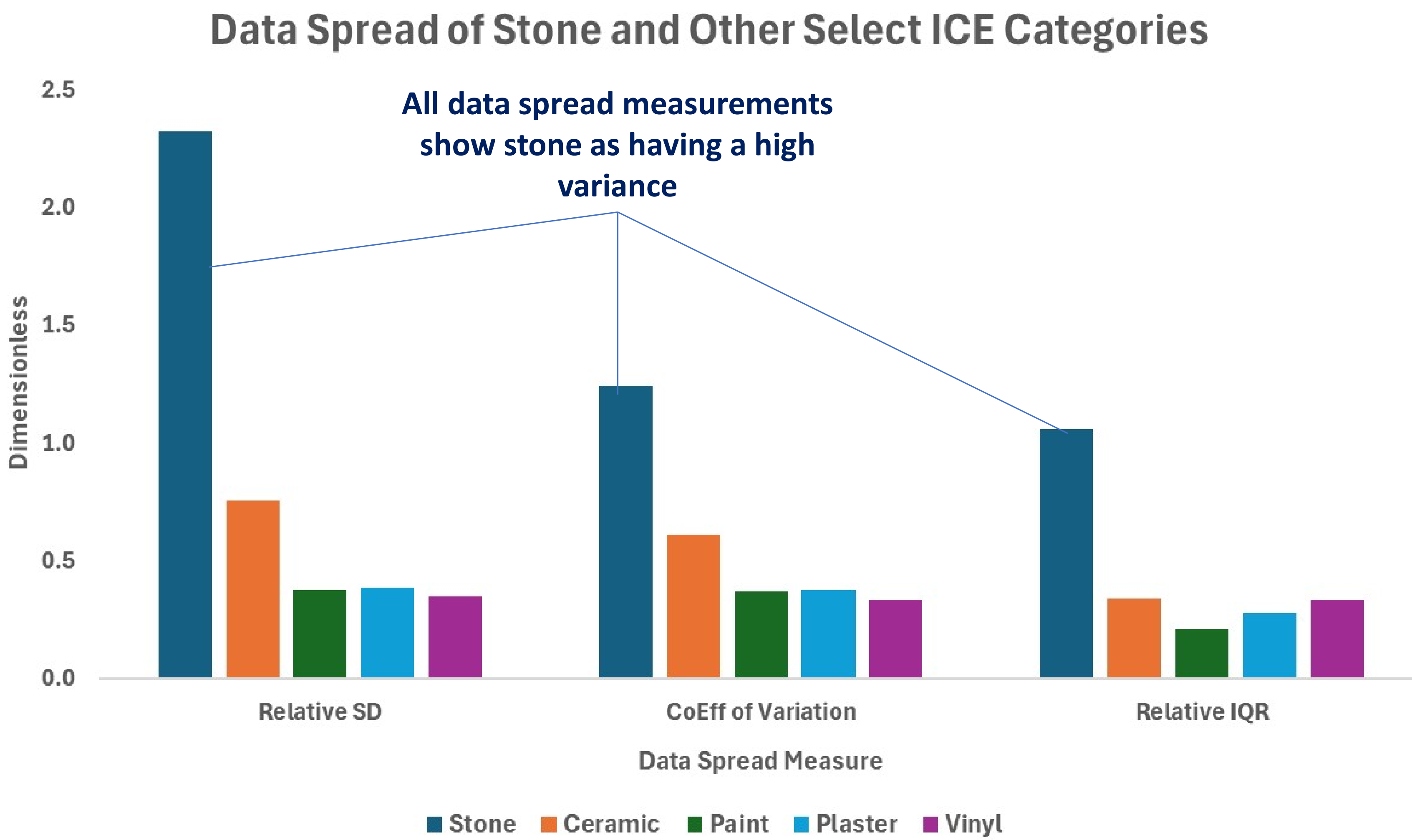
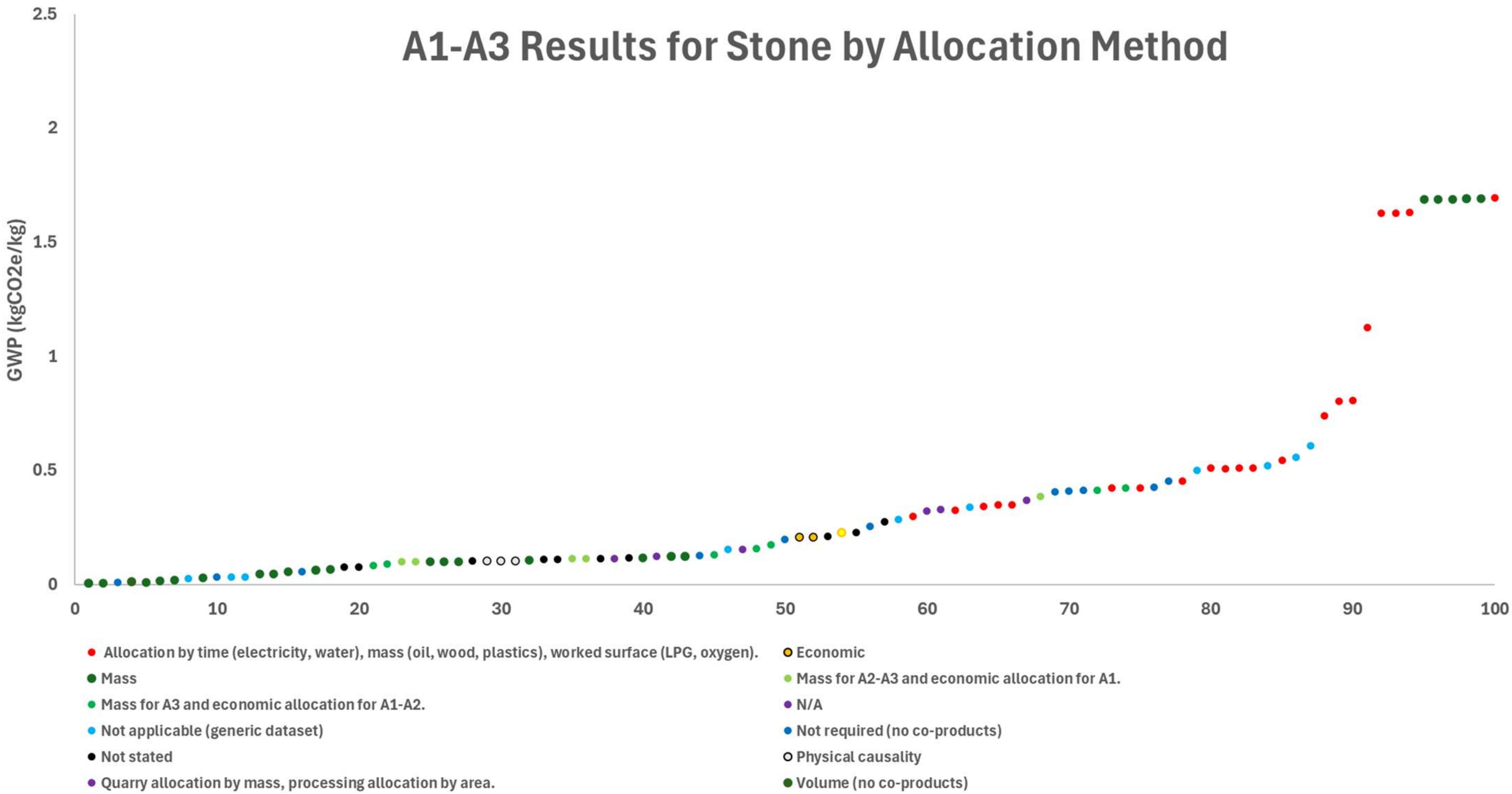
Stone – Data Spread Indicators



Stone – Data Spread Indicators

This chart shows the allocation approach, as described in the EPD, and A1-A3 results of each available Stone datapoints



Improving Alignment in Stone EPDs

Our analysis on the stone dataset indicates a mis-alignment on the LCAs conducted across this category. To address this, there are key actions that EPD practitioners, publishers, and PCR writers can take to improve alignment.

1. **EPD Practitioners:**
   - Clearly **state the allocation method** used
   - Justify the choice of method with reference to the **life cycle model and co-products**

2. **EPD Publishers:**
   - Encourage a **standardised structure** for disclosing methodology
   - Ensure allocation approaches are **consistent** and **flag limitations** when required

3. **Regulators and PCR Publishers:**
   - Provide **clear and explicit guidance** on appropriate allocation methods across product categories
   - Add **mandatory reporting** of key methodological choices
   - **Promote alignment** across PCRs

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Methodological Challenge 3

Recycled Content

What is meant by Recycled Content?

***Recycled content** refers to the proportion of a material that is made from **pre-consumer** or **post-consumer recycled material**, rather than virgin (newly extracted) resources.*

Ideally ICE Database wants to understand 3 scenarios:

Scenario	Material Type	Material Source
1	Virgin Metal	Ore mining + primary smelting
2	100% Recycled Content Metal	Recycled scrap recovery + remelting
3	Partial recycled content	Blend of virgin + recycled inputs

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Copper: A Case Study on Recycled Content

Copper – Why it's Challenging

Copper is a highly recycled material. Roughly 1/3rd of global copper demand is met using recycled copper. As such, copper products often contain a mix of primary and secondary (recycled) metal.

- **EPDs typically do not state the recycled content** or how scrap recovery is handled at end-of-life
- And are often missing enough data to estimate it (net scrap, Mod D…etc)
- The available dataset for copper is small **(<50 datapoints)**

The key challenge in this category, is that EPDs contain the GWP for the produced metal, but for ICE we need to unpick the relationship between GWP and recycled content

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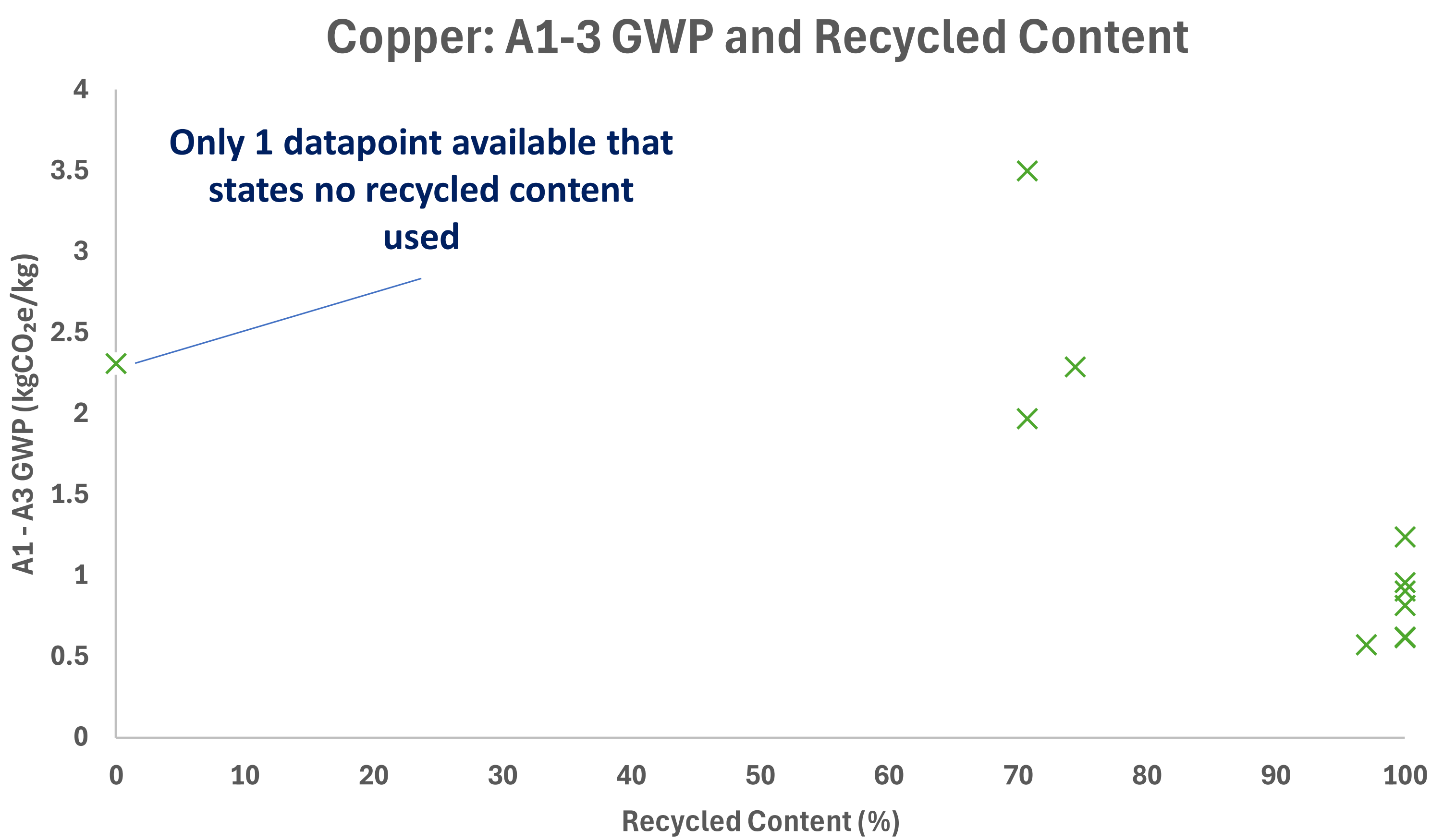
Copper – Recycled Content

Only 15 datapoints analysed for copper **stated the recycled content** of the product, making it difficult to untangle the relationship between recycled content and embodied carbon:



Copper – Tackling the Problem

Due to the small dataset , variation in recycled content accounting and ambiguity in the methodology, investigation the relationship between embodied carbon and recycled content in copper is difficult.

Our approach is:

1. **Manually extract and analyse** each datapoint available for methodology and source of copper

2. **Correlate** embodied carbon with recycled content where possible

3. **Flag and isolate** erroneous datapoints where possible

This approach is still limited by the small sample size of the dataset and the lack of information reported in the EPDs

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Methodological Challenges

Consequences for ICE

Consequences for ICE

The examples shown today are just some of the challenges we face when compiling data for ICE. Inconsistencies and conflicts in EPD methodology and mistakes in calculations require us to ask whether datapoints are comparable?

- Lack of transparency, reporting and mistakes in biogenic material reporting requires a **time-consuming** analytical approach to ensure **confidence and comparability**

- The stone category currently **cannot fairly support representative values** due to the inconsistent and sometimes obscure allocation approaches highlighted

- A lack of data and transparency on recycled content and the methodology followed requires **manual extraction of data and analysis** to unpick

Benefits of the ICE Approach

1. **Curated Data:**
   - We investigate and analyse methodological inconsistencies (e.g. allocation methods, biogenic carbon) to identify and remove problematic EPDs

2. **Cleansed & Representative Values:**
   - ICE values are not just averages — they reflect a systematic process of data review, filtering, and contextual understanding

3. **Saves Time for Practitioners:**
   - For those needing a quick carbon factor — without deep dives into individual EPDs — ICE provides a ready-to-use, considered option

4. **Free for Commercial Use:**
   - ICE remains free to download and free for commercial use (subject to free registration)

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Today's Webinar - Recap

- ✓ Overview of the ICE Database
- ✓ Methodological Challenge 1: Biogenic Carbon
  - ✓ Linoleum: A case study on biogenic carbon
  - ✓ A look ahead to timber
- ✓ Methodological Challenge 2: Allocation Issues in Stone
- ✓ Methodological Challenge 3: Recycled Content
  - ✓ Copper: A case study on recycled content

Looking Forward:
ICE v4.1

ICE Database v4.1 Announcement

In the first **90 days of launching ICE v4.0 (Dec 2024), over 1,000 organisations registered for commercial use of ICE**

We are now excited to announce an **ICE v4.1 update**, expected to launch in the **coming weeks**

This update will focus on two important materials, **Bitumen and GGBS** (Ground Granulated Blast Furnace Slag), both have **large changes in their GWPs** (changes in allocation methods)

This has consequential impacts on **asphalt**—owing to the inclusion of bitumen—and on **cement and concrete mixes** that incorporate GGBS as a supplementary cementitious material

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Upcoming Removal of ICE v2.0 Data

We have also made the decision to **soon remove all ICE v2.0 data, which is from 2011**. **ICE v4.1 may be the last version these materials appear in the ICE database, until we can obtain funding to update them**.
Our goal is to ensure that users are working with the **most robust and up-to-date information** available.

Below is a list of ICE v2.0 materials that are <u>at risk of removal</u>:

- Brass
- Bronze
- Carpet
- Clay
- Copper
- Insulation (11 types)
- Iron
- Lead
- Lime
- Paper
- Paint, solventborne
- Sealants and Adhesives
- Soil
- Stone
- Tin
- Titanium
- Zinc

- And many plastics (we will be updating some of the plastics, but it's a big dataset with complexities to update)

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How You Can Support ICE

Share with your networks **how you use the ICE Database** in projects, tools and research

Contribute to our **Scaling Carbon Reductions Initiative (SCRI)** by choosing some of the Circular Ecology products which diverts revenue from sales towards ICE and other free data and tools

Donate directly to the ICE Database and be recognised as an ICE Supporter or Contributor

Invite us to collaborate on research grant funding applications (Innovate UK, Horizon…etc), part funded research can be an important part of updating the ICE Database

https://circularecology.com/how-to-support-ice.html

Next Webinars

The final instalment of the **ICE Database Insights** series

1. **Appropriate Use of Generic Data** - Weds 16th July

Read more and sign up at circularecology.com/news/new-webinar-series-the-ice-database

More webinars planned in 2025 on **Organisational Footprinting**, **Carbon Libraries** and **Product Carbon Footprinting**

Keep an eye on our networks for more information

- Website - circularecology.com
- LinkedIn - linkedin.com/company/circular-ecology

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Q&A

Please use the Q&A interface to ask your questions

Thank you for watching

Sign up for more information on ICE and for future updates

https://circularecology.com/newsletter.html