Carbon Emission Factors of Geosynthetics

Comparability Assessment and Determination of Representative Values for the Finnish Market

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INTRODUCTION

Background, Objective and Research Question

The problem

The construction sector contributes approximately 13% of global carbon emissions. Geosynthetics reduce the use of natural aggregates, material consumption and transport.

The gap this thesis addresses

In Finland, the CO2data database provides standardised emission factors for infrastructure carbon footprint calculations. For geosynthetic products these are largely absent, and variation between manufacturers, EPD programmes and reporting approaches raises concerns about comparability.

Research aim

To determine representative production-stage carbon emission factors for geosynthetic products used in Finnish infrastructure, based on data reported in existing EPDs.

MAIN RESEARCH QUESTION

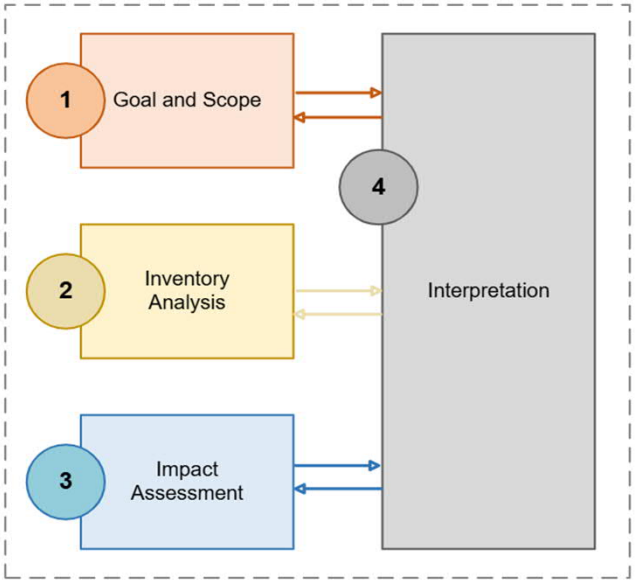
Which emission factors for geosynthetic products are representative for the Finnish market?

Examined through the comparability of published declarations, the drivers of variation between them, the effect of recycled feedstock, and the form a representative factor should take.

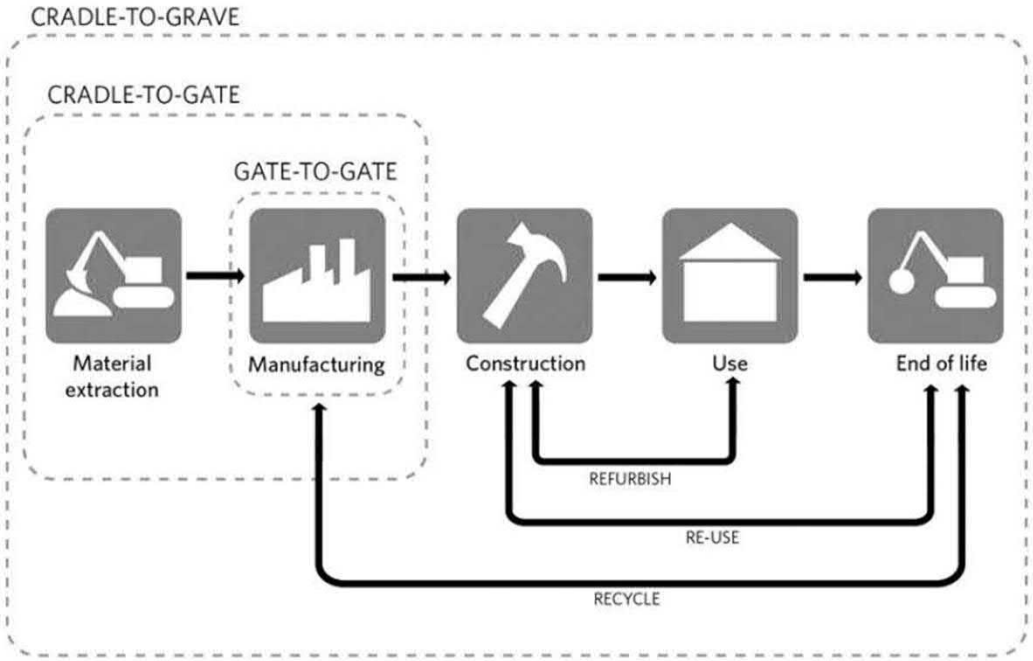
Life Cycle Assessment: Framework and Scope

LCA evaluates environmental impacts across a product's entire life cycle from raw material extraction to end-of-life.

Four Phases of LCA



Definition of system boundaries



Life Cycle Module Framework

PRODUCT STAGE (A1–A3)

A1	A2	A3	A4	A5	B1-B7	C1-C4	D
Raw material	Transport to factory	Manufac-turing	Transport to site	Instal-lation	Use stage	End of life	Beyond boundary

ENVIRONMENTAL PRODUCT DECLARATIONS

EPDs and PCRs

EN 15804 → **PCR** → **EPD** → **CO2data**

The standard

Fixes the modular structure A1 to D and the 13 core indicators for every construction product.

The category rulebook

Applies the standard to one product category, so differences between declarations reflect the products.

One product

Type III declaration under ISO 14025. Quantified, verified, registered, valid about five years.

The national database

Representative factors a designer can apply uniformly across a project.

What a PCR defines

1. System boundaries
2. Functional or declared unit
3. Allocation procedures
4. Data quality criteria
5. Impact assessment method
6. Mandatory impact categories

What an EPD reports

13 core impact indicators required by EN 15804+A2

4 of them are GWP: fossil, biogenic, land use change, and their total

5 years of validity, after which the declaration is reviewed and reissued

■ A mandatory methodological framework for Type III EPDs that specify how environmental impacts are assessed and reported within a product category.

■ A standardised document declaring the environmental performance of a product over its life cycle

■ **EPDs are manufacturer-specific - the same product from different factories has different values**

THEORETICAL BACKGROUND

What a Declaration Contains, and Why Two May Not Match

	Declared unit	PCR and standard	Background database	Modules declared	Background report
What it is	1 m², 1 kg or 1 t	EN 15804+A2 with EF, or +A1 with CML	ecoinvent, GaBi or UVEK, and its version	Which stages are reported	Assumptions and data records
Why two may differ	Units differ, and one declaration may cover a whole family	Different programs write different rules for the same category	Older data carry a more carbon-intensive energy supply	Some give modules separately, others only a total	Not published, so only the declaration itself can be assessed

MATERIALS AND METHODS

Inside One Published Declaration

General information

Tensar International Limited	Tensar® TriAx® TX190L
Programme operator Kiwa-Ecobility Experts Voltastr. 5 13355 Berlin Germany	**Owner of the declaration** Tensar International Limited Units 2-4 Cunningham Court Shadsworth Business Park Blackburn, United Kingdom
Registration number EPD-TENSAR-148-EN (Rev.1_20.05.2022)	**Declared product / declared unit** 1 m^2 geogrid
This declaration is based on the Product Category Rules PCR B - Geosynthetic products 2022-02-08 (draft)	**Scope** Tensar® TriAx® TX190L geogrid is a product of the product series TriAx TX100. It is produced and distributed by Tensar International Limited, located in Blackburn (United Kingdom). The EPD refers to the specific product. EPD type: Cradle to grave with options, and with modules C1-C4 and module D. Kiwa-Ecobility Experts shall not be liable with respect to manufacturer information, life cycle assessment data and evidence.
Issue date 14.01.2022	**Verification** The European standard EN 15804+A2:2019
Valid to 14.01.2027	

Extracted for the master dataset

Declared unit **1 m²**	Grammage **300 g/m²**	PCR **B, geosynthetics**
Background database **ecoinvent 3.6**	Program **Kiwa-Ecobility Experts**	Valid to **2027**

Technical data, product weight

Name	Value	Tolerance	Unit
Weight of product /TR 041 B.3/	300	-35	g/m2

Declared unit and conversion to 1 kg

Product	Unit	Value
Declared Unit	m^2 geogrid	1
Unit weight	g/m^2	318
Conversion factor to 1 kg	-	3.15

Results table, GWP rows

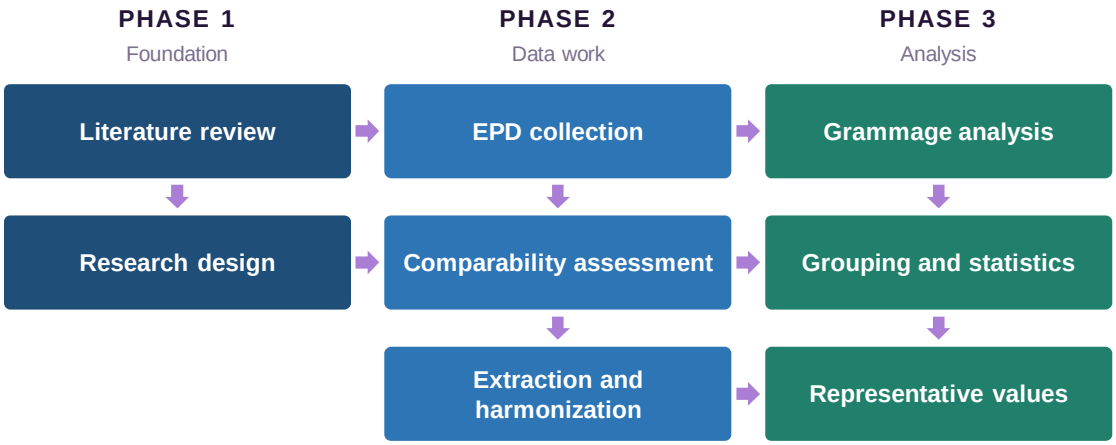
Parameter	Unit	A1	A2	A3	A4	A5
						Core environmental impa
ADP-mm	kg Sb-eqv	5,44E-06	2,57E-07	2,28E-07	9,79E-07	3,91E-07
ADP-f	MJ	2,29E+01	1,83E-01	1,61E+00	5,83E-01	1,29E+00
AP	mol H^+ eqv.	2,22E-03	1,72E-04	1,31E-04	2,24E-04	1,53E-04
EP-fw	kg PO_4 eqv.	8,77E-06	1,07E-07	1,31E-06	3,90E-07	6,24E-07
EP-m	kg N eqv.	3,66E-04	4,50E-05	3,00E-05	7,90E-05	3,05E-05
EP-t	mol N eqv.	4,06E-03	4,99E-04	3,28E-04	8,71E-04	3,36E-04
GWP-b	kg CO_2 eqv.	2,77E-03	1,93E-06	5,96E-05	1,78E-05	1,48E-04
GWP-f	kg CO_2 eqv.	6,30E-01	1,28E-02	9,94E-02	3,86E-02	7,02E-02
GWP-luluc	kg CO_2 eqv.	1,52E-04	6,73E-06	1,09E-05	1,42E-05	1,18E-05

Which modules are declared

Description of the system boundary																		
Product stage			Construction process stage		Use stage							End of life stage					Benefits and loads beyond the system boundaries
Raw material supply	Transport	Manufacturing	Transport from manufacturer to place of use	Construction -installation process	Use	Maintenance	Repair	Replacement	Refurbishmen	Operational energy use	Operational water use	De-construction / demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	X	X	X	X	MND	MND	MND	MND	X	X	X	X	X

MATERIALS AND METHODS

Research Design and Comparability Screening



SUPPLEMENTARY WORK

Expert interviews	Factory visit	Transport calculation	Additional analyses
Naue, Solmax, Meltex	Meltex Oy	27 routes to Helsinki	Recycled pairs; module contributions

72	38	11	84
declarations	manufacturers	programs	product entries

Four comparability criteria, applied to every declaration before any comparison

1

Standard version and characterization method

+A2 with EF factors as the reference; +A1 with CML retained and flagged.

2

Background database and its version

ecoinvent 3.6 or later current; UVEK on ecoinvent 2.2 flagged as outside the 5 and 10 year limits.

3

Availability of stage-level data

Aggregated A1 to A3 suffices for representative values; separate modules needed for the stage-level analysis.

4

Scaling method for family declarations

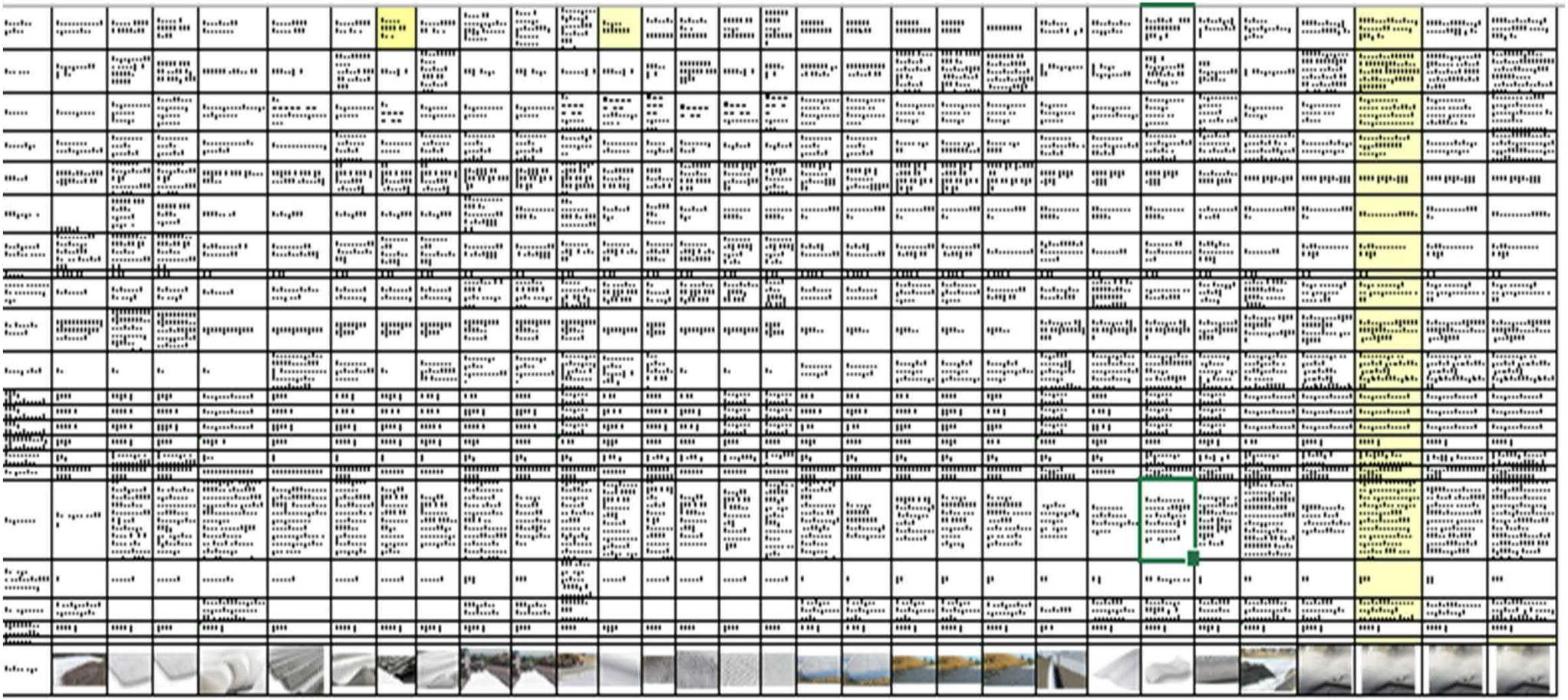
Worst-case reference products flagged; fixed-plus-scalable declarations computed variant by variant.

27	50	7
INCLUDE	INCLUDE WITH FLAG	EXCLUDE

The obstacle is not a shortage of data, but the unevenness of the conditions under which it was produced.

MATERIALS AND METHODS

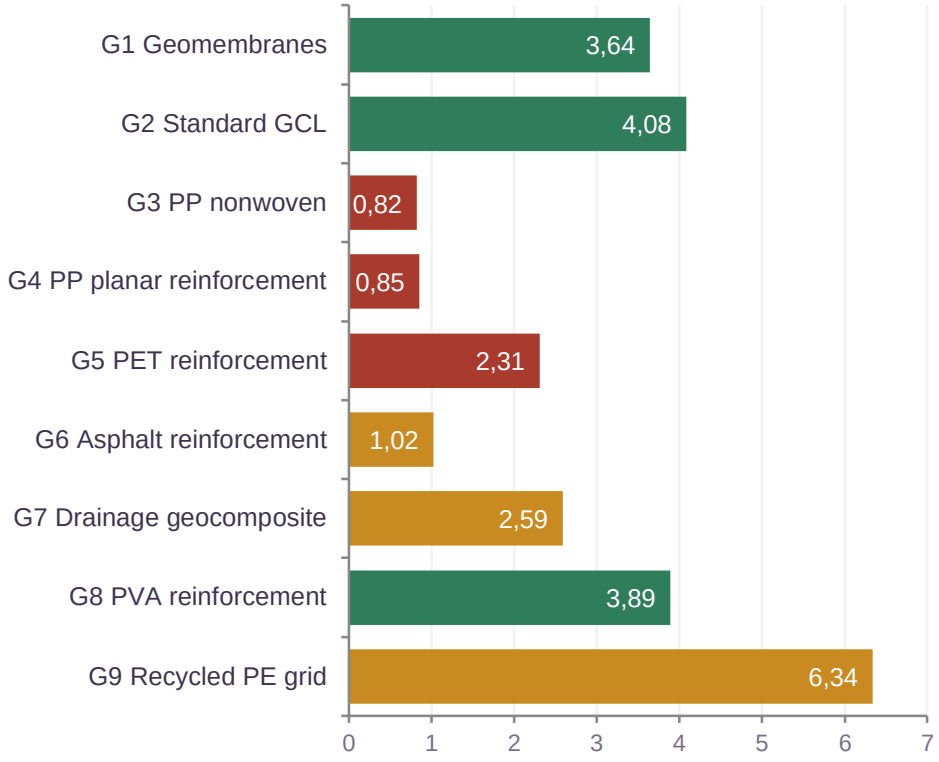
The Master Dataset



Extract from the master screening table. Every declaration was recorded on a common set of fields before any comparison was made.

RESULTS

Representative Values for Nine Groups



Group	CV
G1	7.0%
G2	5.7%
G3	51%
G4	48%
G5	57%
G6	33%
G7	30%
G8	2.4%
G9	31%

A single value

3 groups, 9 products

A value with its range

3 groups, 14 products

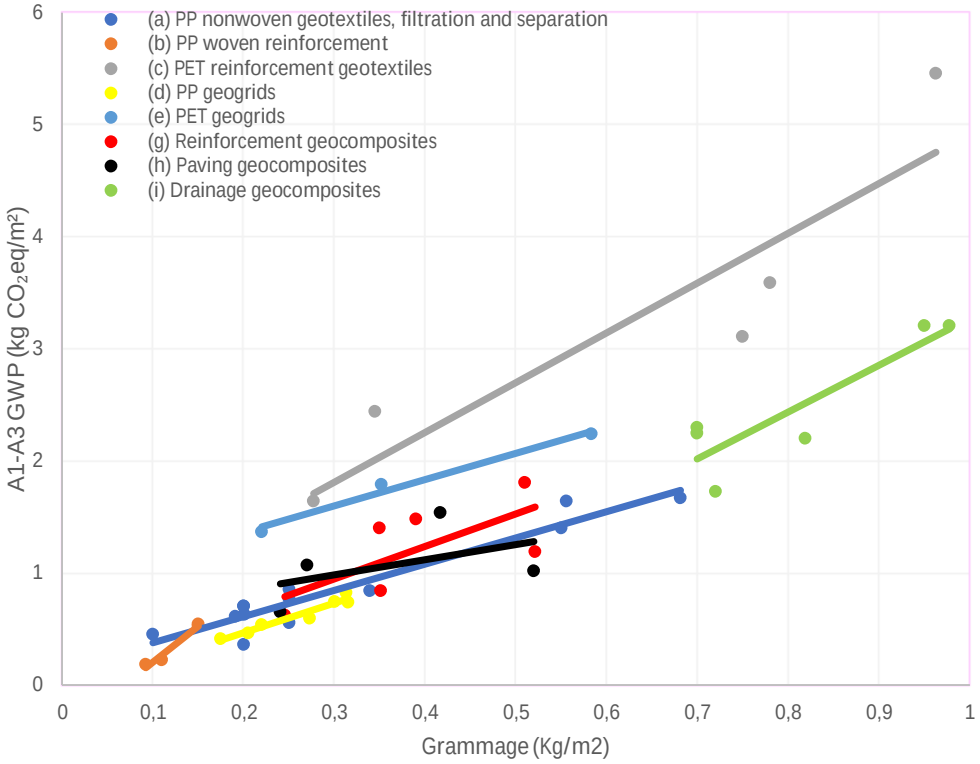
A factor per kilogram

3 groups, 42 products

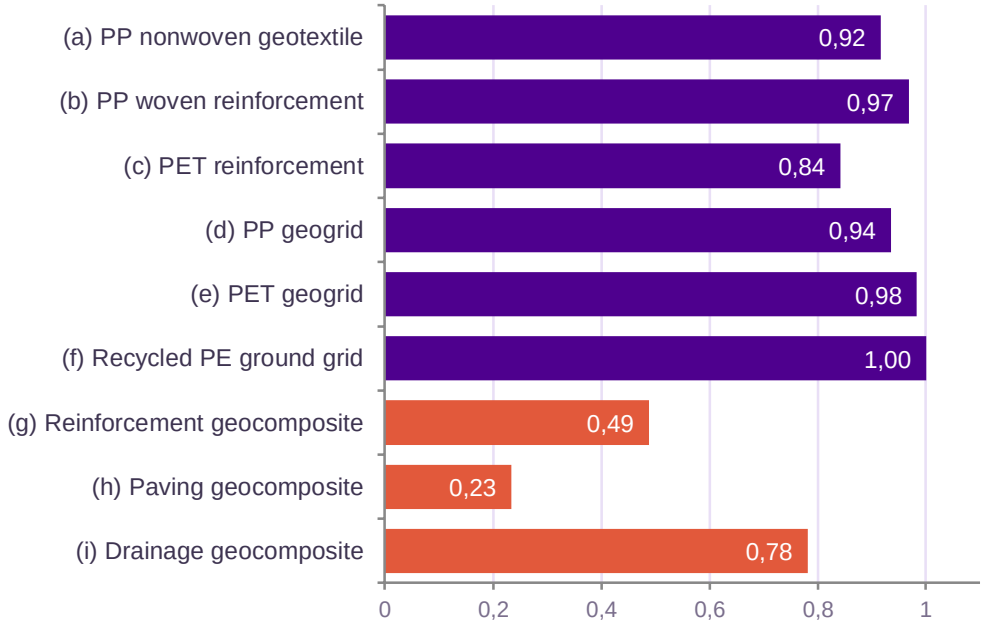
65 of 84 entries fell into these groups. 12 are reported individually, 7 excluded.

RESULTS

Mass Drives the Differences



All nine subgroups: how well mass predicts emissions

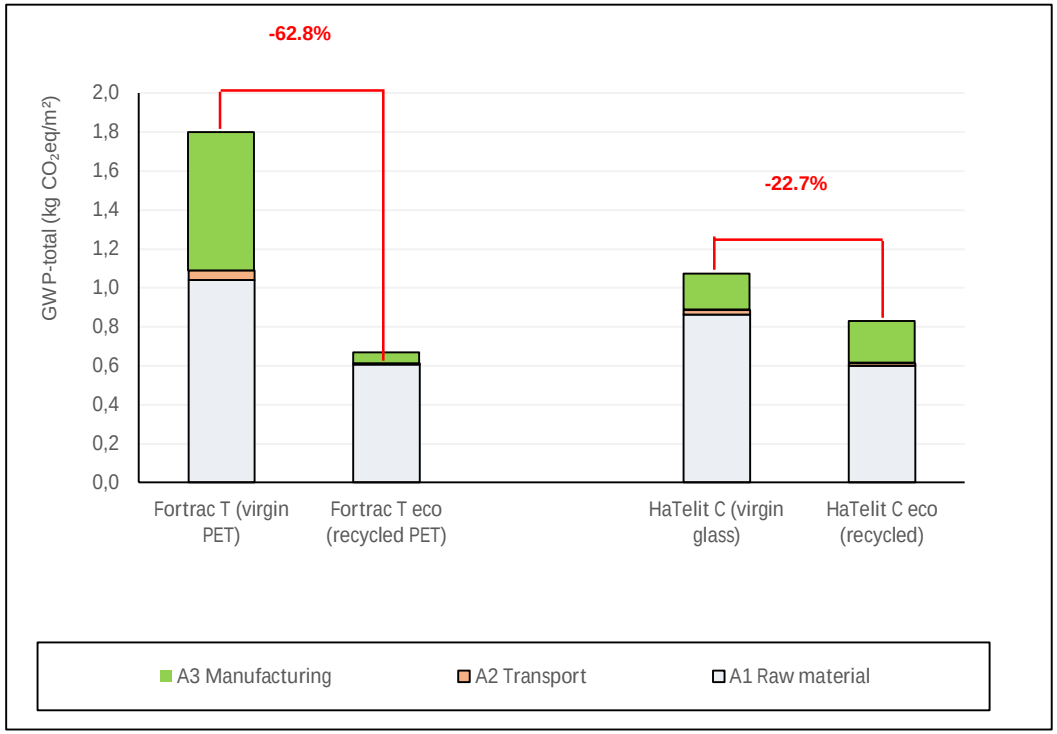


R^2 of A1 to A3 GWP-total against grammage. Threshold for a mass-based factor: 0.80.

RESULTS

Effect of Recycled Raw Materials

Two controlled comparisons, in which a manufacturer declares the same product in a virgin and a recycled version. Geometry, production site and declaration methodology are identical, so the pairs isolate the effect of the feedstock.



−62.8% **Fortrac T eco, 100% recycled PET**

1.799 to 0.669 kg CO_2eq/m², achieved despite the recycled variant being marginally the heavier of the two, at 370 against 352 g/m². Module A1 falls by 41.7% and module A3 by 92.1%.

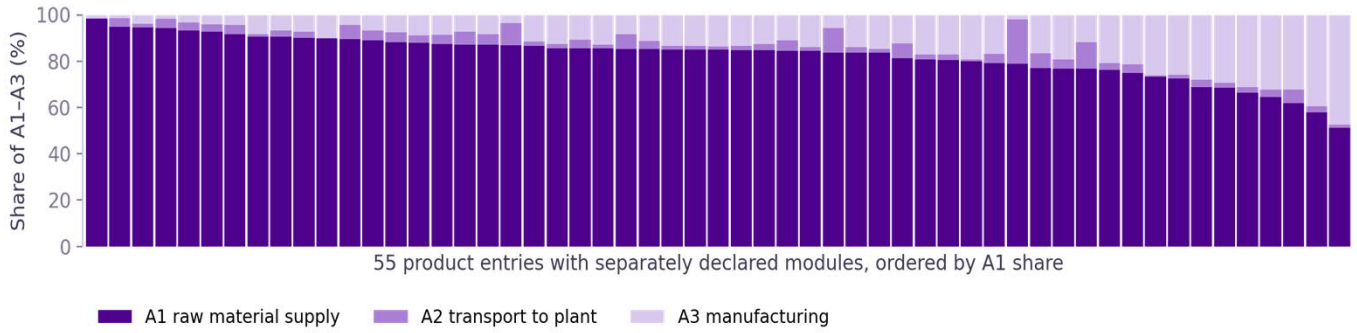
−22.7% **HaTelit C eco, recycled alkali-resistant glass**

1.073 to 0.829 kg CO_2eq/m² at the same grammage of 270 g/m². Module A1 falls by 30.6%, while module A3 rises by 15.7%.

- The benefit is substantial but strongly material-dependent, following how much of the footprint sits in the material replaced
- Processing recycled material can require more manufacturing energy, so recycled content must be judged on the full A1 to A3 balance
- Virgin and recycled variants should be kept as separate entries, since averaging would describe neither

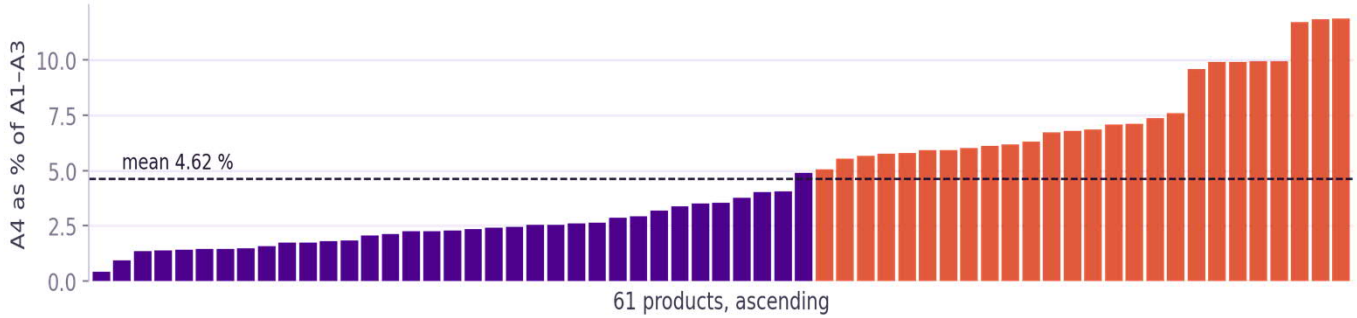
RESULTS

Where the Emissions Are



82.3% is module A1, raw material supply

Median 85%, range 51% to 98%, holding across every polymer, product form, manufacturer and EPD program. Raw material transport is about 3%, manufacturing the remaining 15%.



Calculated module A4 to Helsinki as a share of A1 to A3

4.62% mean share for transport to Helsinki

Median 3.55%, range 0.42% to 11.85%. Secutex H and Drefon S sit 1.8% apart at the factory gate and change order once transport to Helsinki is added.

Conclusions

What This Means for CO2data

- Sufficient published data exists to derive representative factors for most geosynthetic types used in Finland, but it cannot be used without a prior assessment of comparability. Of the 84 product entries, 50 carried at least one methodological flag and 7 could not enter the analysis.
- Variation between declarations is governed by the quantity of material a product contains and the polymer it is made from, rather than by differences in manufacturing.
- Geosynthetics therefore require not one representative format but three, each following the physical nature of the product class it describes: a single value, a value reported with its range, or a mass-based factor applied to the specified grammage.

Factors for CO_2data				
	0.90	**2.34**	**2.65**	**4.44**
	Recycled PE grid	PP nonwoven	PP geogrid	PET reinforcement

kg CO_2eq per kilogram of product

Thank you

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