ENVIRONMENTAL PRODUCT DECLARATION

OMNIGRIP HYBRID HF

RECYCLED GLASS HIGH FRICTION SURFACE TREATMENT

OMNIGRIP DIRECT
Smarter Road Safety

In accordance with ISO 14025:2006 and EN 15804:2012+A2:2019/AC:2021

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An EPD should provide current information and may be updated if conditions change.
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AUSTRALASIA EPD®
ENVIRONMENTAL PRODUCT DECLARATION

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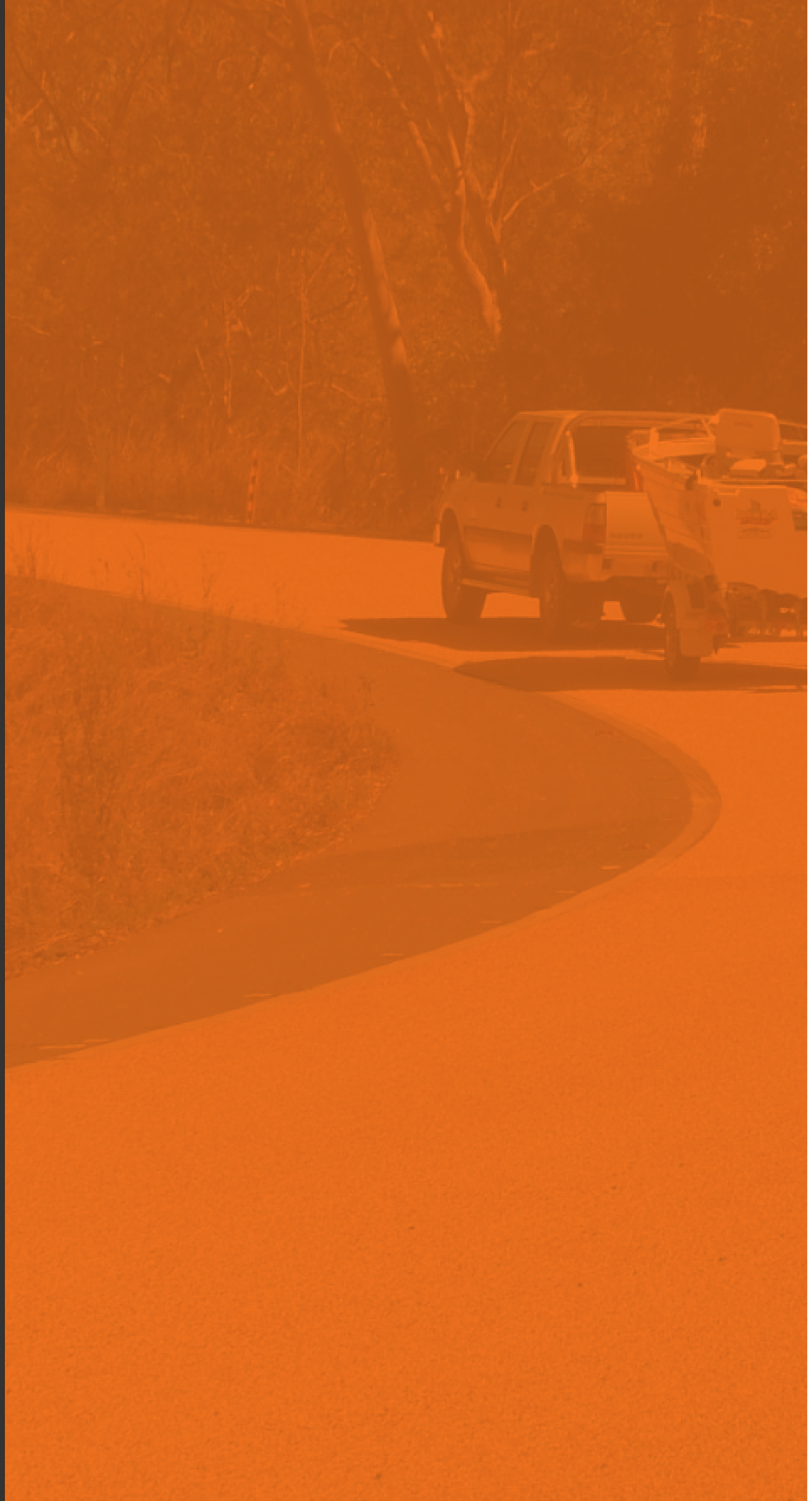

WHAT IS AN ENVIRONMENTAL PRODUCT DECLARATION?

An Environmental Product Declaration (EPD) is a standardised way of quantifying the potential environmental impacts of a product or system. EPDs are produced according to a consistent set of rules – Product Category Rules (PCR) – that define the requirements within a given product category. EPDs within the same product category but registered in different EPD programmes, or not compliant with EN 15804, may not be comparable. For two EPDs to be comparable, they must be based on the same PCR (including the same version number) or be based on fully-aligned PCRs or versions of PCRs; cover products with identical functions, technical performances and use (e.g. identical declared/functional units); have equivalent system boundaries and descriptions of data; apply equivalent data quality requirements, methods of data collection, and allocation methods; apply identical cut-off rules and impact assessment methods (including the same version of characterisation factors); have equivalent content declarations; and be valid at the time of comparison.

This EPD provides environmental indicators for OmniGrip Direct's Hybrid HF - Recycled Glass High Friction Surface Treatment manufactured in Victoria, Australia. This EPD is a "cradle-to-gate with options" declaration covering production and application ("construction") of the surface treatment. This EPD is verified to be compliant with EN 15804. EPDs of construction products may not be comparable if they do not comply with EN 15804. OmniGrip Direct, as the EPD owner, has the sole ownership, liability and responsibility for the EPD.

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CEN STANDARD EN 15804:2012 + A2:2019 SERVES AS THE CORE PCR	
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PCR REVIEW WAS CONDUCTED BY	The Technical Committee of the International EPD ® System Chair: Claudia A. Peña, University of Concepción, Chile. Contact via the Secretariat environdec.com/contact
INDEPENDENT VERIFICATION OF THE DECLARATION AND DATA, ACCORDING TO ISO 14025	☐ EPD process certification (internal) ☒ EPD verification (external)
PROCEDURE FOR FOLLOW-UP OF DATA DURING EPD VALIDITY INVOLVED THIRD-PARTY VERIFIER	☐ Yes ☒ No

OMNIGRIP DIRECT
Smarter Road Safety

OMNIGRIP DIRECT SPECIALISES IN SMARTER SAFETY TECHNOLOGIES AND IN PARTICULAR, SAFETY TECHNOLOGY AND SURFACING FOR THE HIGHWAY, BUILDING AND CONSTRUCTION INDUSTRIES. OMNIGRIP DIRECT PROVIDES REAL AND READY SOLUTIONS FOR SAFER ROADS, ENHANCED URBAN DESIGN AND DIVERTING WASTE FROM LANDFILL.

OmniGrip Direct is a road and building safety and civil works company, specialising in developing and applying safety surfaces using Australian recycled glass to help governments address climate-change and emissions, and to reduce landfill. OmniGrip Direct is part of the Polar Enviro group of companies.

OmniGrip Direct provides durable recycled coloured surfaces for bus lanes, bike lanes, pedestrian crossings and coloured and patterned surfaces for state and local government placemaking projects. Clients include contractors for state and local government infrastructure projects as well as facility managers and developers. OmniGrip Direct also provides high-friction safety surfaces to state road managers and local governments, improving safety by reducing skidding and sliding on bends, and enabling vehicles to stop faster at intersections and pedestrian crossings.

Austroads Guidelines (2021) shows high friction surface treatments reduce:

- Rear-end crashes at intersections by 40%
- Rear-end crashes at other location by 40%
- Loss-of-control crashes when turning left and right by 10%
- Run-off road crashes and loss-of-control crashes at non-intersection locations by 10%.

Various other studies have found even greater reductions (Merritt et al., 2020; Merritt et al., 2015; Simpson, 2005). For example, what may have been the largest statistically-sound large-scale evaluation of applications of high friction surfaces across the US by Merritt et al. (2020) for the Federal Highway Administration found that high friction surface treatments reduced:

- Total crashes by 57% on curves and 78.8% on ramps
- Injury crashes by 48.5% on curves and 63.5% on ramps
- Wet-road crashes by 83.2% on curves and 92.1% on ramps
- Head-on, side-swipe and opposite-direction crashes on curves by 30.9%.

OmniGrip Direct and the Australian Road Research Board (ARRB) developed a new high-friction surface, comprising a post-consumer recycled-glass blended aggregate. It performs similarly to traditional calcined-bauxite high-friction surface treatment (HFST), with significantly higher high-friction skid-reducing properties than normal road surfaces, increasing safety for drivers and riders (ARRB in press). The surface treatment surpasses VicRoads' (and other states') minimum standards for surface friction coefficients and texture depth (ARRB in press). Furthermore, the use of recycled glass in the surface contributes to policies of various Australian States regarding diverting waste from landfill (e.g. Recycled First in Victoria).

The hybrid high-friction surface uses a post-consumer recycled-glass blended aggregate, where the blended mix replaces the imported calcined-bauxite traditionally used in high friction surface treatments.

This is a unique product, revolutionising the high friction surface market with a new product that will assist road managers with meeting recycled material targets, social procurement targets and reducing road trauma on Australian roads. Increased use will reduce post-consumer glass becoming landfill, adding value to glass collected by local and state governments. The insurance industry will benefit from reduced property and injury crashes on roads.

ACKNOWLEDGEMENT

OmniGrip Hybrid HF was developed via an industry partnership with the Australian Road Research Board, funding from Sustainability Victoria, and assistance from EcologiQ, a Victorian Government Big Build initiative.

Red bus lanes and yellow pedestrian crossings using OmniGrip CST and median surface using OmniGrip Re-Surface.
Source: EcologiQ/BMD

HIGH-FRICTION SURFACE TREATMENT (HFST) - PRODUCT INFORMATION

This EPD covers a high-friction surface treatment (HFST) that can be applied to new or old asphalt roads. The hybrid product's material components are sourced from local and imported materials. Aggregates are mixed at a processor in northern Melbourne, Victoria and the product applied on site by applying the binder and spreading the product by hand. This EPD is for a specific product with specific manufacturing sites and processes (i.e. not averaged across multiple production sites).

PRODUCT IDENTIFICATION

The HFST product's UN CPC is 54211 (general construction services of highways (except elevated highways, streets and roads). The Hybrid HFST product is compliant with the Department of Transport and Planning (Vic.) Specification 430: High Friction Surface Treatment and meets the technical requirements of the Department of Transport and Main Roads Queensland's MRST111 High Friction Surface Treatments (subject to TIPES approval) (Department of Transport, 2018; Department of Transport and Main Roads, 2023).

DECLARED UNIT

One metre-squared section (m^2) of installed Hybrid HFST (this treatment is 1 layer of applied aggregate, approximately 5mm thick and with a mass of 8.77kg/m^2).

PRODUCT COMPOSITION

The primary materials of the Hybrid HFST are recycled crushed glass (RCG) as aggregate and fines, artificial corundum (black fused alumina), and epoxy resin. One component of the product is excluded: iron oxide pigment, that is additionally used in the resin mix.

The installation process includes the minimal use of tape along application area borders and methylated spirits for cleaning applicator tools. Tape and methylated spirits are excluded, as they comprise a minimal (<1%) contribution to materials and energy inputs and impacts. The packaging of the primary materials is all reused on site, by the supplier, or makes up less than 1% of materials, impact and energy and are also excluded. The final product does not use any packaging.

Table 1 declares the HFST product components and total product mass (kg). Table 2 declares any hazardous and dangerous substances from the "Candidate List of substances of very high concern for authorisation" that are present in concentrations >0.1%.

Table 1: Content declaration, per declared unit of high-friction surface treatment

PRODUCT COMPONENTS	WEIGHT (KG)	POST-CONSUMER RECYCLED MATERIAL (WEIGHT %)	BIOGENIC MATERIAL (WEIGHT % AND KG C/KG)
Recycled crushed glass, aggregate	Materials listed in mass order (highest to lowest). Individual material masses not published due to commercial confidentiality.	100	0,0
Artificial black corundum		0	0,0
Resin		0	0,0
Recycled crushed glass, fines		100	0,0
Pigment*		0	0,0
Total	**8.77**	**54.7**	**0,0**

** Excluded from assessment*

Table 2: Dangerous substances declaration, per unit of high-friction surface treatment

HAZARDOUS OR DANGEROUS SUBSTANCE	CAS	WEIGHT - %
bis-[4-(2,3-epoxipropoxi)phenyl]propane	1675-54-3	4.0–6.6
Oxirane, 2,2'-[1,6-hexanediylbis(oxymethylene)]bis-	16096-31-4	0.3–0.7
Phenalkamine Polymer	N/A	4.0–6.6
Triethylenetetramine	90640-67-8	0.3–0.7

Note: Product safety data sheets (SDS), OmniGrip Direct (2021a, 2021b).

SYSTEM BOUNDARIES

This EPD has a “cradle-to-gate with options” scope. Table 3 declares the specific EPD scope including modules A1-A3 plus A4-A5 – the production stage of the product materials and components, and installation at the road work site. As per the PCR 2019.14 for Construction Products, this product meets the relevant conditions for this scope, that is, the product:

- becomes physically integrated with the road surface layer during installation so they cannot be physically separated at the end of life;
- is no longer identifiable at the end of life as a result of the physical and chemical transformation process;
- contains no biogenic carbon.

The Hybrid HFST may be fully reclaimed within the asphalt at the end of the asphalt’s life as Reclaimed Asphalt Pavement (RAP). Calculated as per the PCR 2019:14, the share of GWP-GHG (non-biogenic greenhouse gas emissions) results from A1-A3 stemming from product-specific data – “specific data used” – is 4.5%.

Table 3: EPD scope

	PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END-OF-LIFE STAGE				RESOURCE RECOVERY STAGE
	Raw material supply	Transport	Manufacturing	Transport	Construction installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling potential
Module	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Module declared	x	x	x	x	x	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Geography	AU, CN, EU	AU	AU	AU	AU												
Specific data used	4.5%																
Variation - Products	N/A																
Variation - Sites	N/A																

X = included in EPD; ND = module not declared; N/A = not applicable, AU = Australia, CN = China, EU = Europe

A1: RAW MATERIAL SUPPLY

CORUNDUM

Corundum is produced artificially as black fused alumina. It requires the reduction of mined bauxite in an electric arc furnace, with the addition of coke, at a temperature of over 2000 degrees Celsius (Strubel, 2012). OmniGrip Direct sources this material from China.

RECYCLED CRUSHED GLASS

OmniGrip Direct uses post-consumer, multi-colour recycled crushed glass, sourced from regional NSW. This is used in two forms – aggregate and fines. This secondary material undergoes transformation from its end-of-waste stage into useable crushed glass aggregate and fines. This transformation process includes collection, sorting washing and crushing and is included in the Hybrid HFST system.

RESIN

Epoxy resin is manufactured in and imported from Europe. A small amount of pigment is included in the resin mix to achieve a desirable surface colour. Pigment has an insignificant impact and has been excluded from the analysis.

TRANSPORT TO MIXING SITE

Corundum is shipped from its origin port in China to Melbourne, Victoria. It is then trucked from the Port of Melbourne to a third-party processor in northern Melbourne, Victoria. Recycled crushed glass aggregate is trucked from regional NSW to the processor in northern Melbourne, Victoria.

AGGREGATE MIXING

The two types of aggregate – corundum and RCG – are mixed with a gravity-fed hopper system by a third-party processor. Assumed 1 hour of LPG (propane) consumption for this process, including aggregate mixing and shelf and truck loading/unloading by a Toyota forklift. The resulting 1.875kg propane consumption per tonne aggregate is based on estimates by Toyota Material Handling Northern California (2017).

ELECTRICITY GENERATION

Electricity is consumed in the A3 warehouse general activities and in charging tools and heating resin for the product installation. It is modelled as the Victorian grid average and allocated as a portion of total site electricity consumption as provided by OminGrip Direct, using the HFST proportion of revenue.

A2: TRANSPORT

Resin is shipped from Europe to Melbourne, Victoria. It is then trucked to OmniGrip Direct’s warehouse in Thomastown, Victoria. RCG fines are transported by truck from regional NSW to Thomastown, Victoria. The mixed corundum-RCG aggregate is delivered by truck from the processor in northern Melbourne to OmniGrip Direct’s Thomastown facility.

A3: MANUFACTURING

OmniGrip Direct’s ‘manufacturing’ process includes the unloading and storing of materials, and loading of the work truck. The preparation of materials and for installations includes the charging of battery-powered tools, warming the resin vats with electric heating blankets, and general warehouse operations. These processes consume electricity and LPG. Electricity generation is included under A1, leaving only LPG under A3. This has been allocated a portion of the site’s total consumption as provided by OmniGrip Direct, using the HFST proportion of revenue.

A4: TRANSPORT

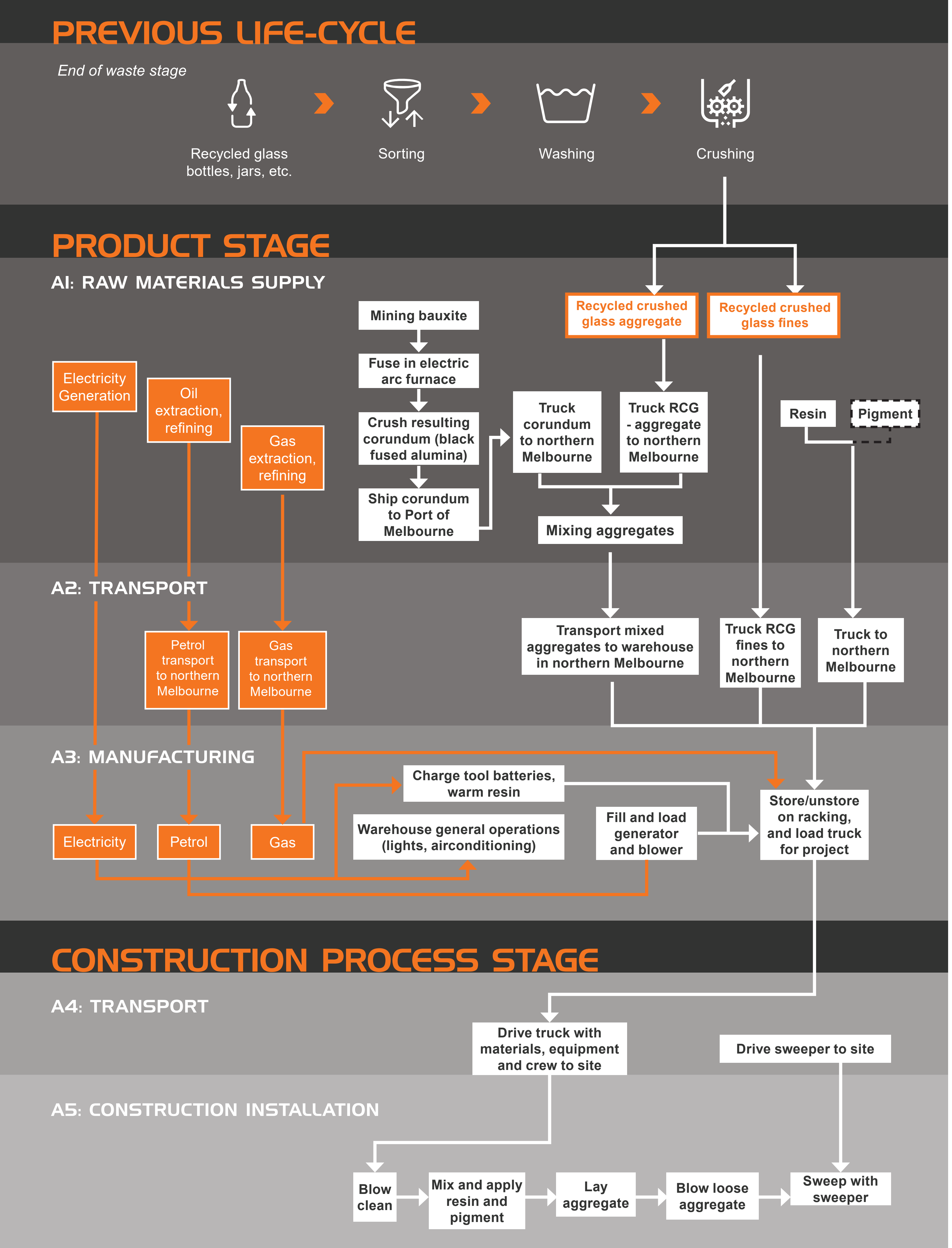
HFST can be applied in various locations. This EPD uses two application location scenarios based on previous OmniGrip Direct projects to model transport impacts: a local metro application and a rural application. The local scenario, used for the primary environmental impact assessment, uses a distance of 21km, based on an application site at Avondale Heights in metropolitan Melbourne. The rural scenario is based on another previous installation on the Great Ocean Road, 225km from the production site.

A5: CONSTRUCTION INSTALLATION

The installation of the HFST involves cleaning the road surface of debris, mixing the resin on site using a generator and a slow-speed, high-torque drill with mixing paddle, applying the resin mix manually (i.e. by hand with non-motorised spreading tools), spreading the aggregate over the resin, and sweeping and blowing any loose/spilt aggregate spillage back onto the treatment area.

The generator consumes an average of 5L unleaded petrol per project with an average project size of 226m^2, as reported by OmniGrip Direct. A further 1 hour of blowing by a petrol-engine backpack blower is estimated during construction, consuming 1.5L of unleaded petrol (STIHL, 2020). An average of 1/2 hour of sweeping by a sweeping vehicle is also estimated, consuming 7.57L of diesel, assumed similar to ‘truck service/mechanic’ in Skolnik et al. (2013). Installation can require the use of a gas-fuelled thermal lance, however, OmniGrip Direct was unable to differentiate the LPG consumed by this process from that used in the warehouse processes (A3). Therefore all LPG is included under module A3.

Figure 1: System diagram for Hybrid HFST (corundum, RCG)



LCA METHODOLOGY

The LCA supporting the EPD has been prepared applying methods outlined the PCR 2019:14 Construction Products and the Australasian Annex to the General Programme Instructions (GPI) of the International EPD System, which also aligns with EN 15804.

The LCA impacts are calculated using the standard EN 15804:2012+A2:2019 characterisation method, excluding long-term and infrastructure emissions, as well as the additional requirements of the PCR:2019 for construction products.

DATA

Foreground data has been sourced from OmniGrip Direct and background data has been sourced from the AusLCI and AusLCI shadow databases (v1.40) and Ecoinvent (v3.6), and accessed using SimaPro software (v9.4.0.2).

OmniGrip Direct provided foreground data on:

- raw materials and material quantities contained in the Hybrid HFST
- material source locations
- manufacturing processes (including electricity and gas consumption; no diesel used in manufacturing) and site locations
- construction processes.

OmniGrip Direct provided electricity, gas and fuel consumption data for the 2022/23 financial year, including:

- monthly electricity consumption (kWh) data from its Thomastown office, warehouse and production facility
- LPG cylinder and bulk gas orders (various sizes) to determine total LPG use (kgs)
- fuel purchases by fuel type (litres).

Local on-road transport distances were calculated using Google Maps and the specific site addresses (including real project sites for scenario analyses). International oceanic shipping distances were calculated using an online sea-miles calculator from the international shipping port closest to the material source to the Port of Melbourne.

Assumptions were made for:

- transport types, outside of OmniGrip Direct's control, i.e. transoceanic bulk container ships assumed for international shipping, aggregates transported by road (28t truck).
- electricity and gas used in manufacturing and construction allocated based on operational revenue, i.e. OmniGrip Direct's HFST revenue as a proportion of all OmniGrip Direct's revenue.

The background inventory data used to conduct the LCA are mostly from the AusLCI database, with two materials (corundum and epoxy resin) and two energy processes (LPG and petrol consumption) from the Ecoinvent database. All inventory process data have been updated or reviewed within the last 10 years, and most within the past 5 years.

ALLOCATION

OmniGrip Direct produces and supplies several product lines. The LCA used an economic allocation of value of HFST products produced and supplied (i.e. HFST revenue) as a proportion of total operational revenue to estimate HFST-related energy and fuel consumption.

OmniGrip Direct does not differentiate LPG consumed in warehouse processes from on-site in construction. Therefore, all of the LPG was attributed to module A3, including the gas consumed by the thermal lance that is sometimes used in construction.

The total treatment area of HFST projects delivered in Victoria in 2022/23 was used to obtain values per declared unit (m^2) used in this analysis.

The allocation of the upstream impacts of recycled crushed glass are allocated following the polluter pays principles, whereby the 'end-of-waste state' is reached at the point of disposal of municipal glass waste, where the waste has a minimal economic value. Processes included in the recycled crushed glass product (i.e. collection, sorting washing and crushing) systematically add-value to resource until it becomes a safe and viable material that meets specifications or can be used to manufacture products to product specifications.

No co-product allocation has been used.

CUT-OFF CRITERIA

As per the PCR 2019:14, inventory flows from personnel-related activities, infrastructure, construction, production equipment, and tools that are not directly consumed in the production process can be excluded from the LCA, if not known to have the potential to cause significant impact.

The production equipment used to mix and install this HFST is assumed to have an insignificant impact and has been excluded from the LCA. Much of production equipment is purchased second hand and all equipment is expected to have a lifetime of 10 years or more and has therefore been excluded.

The final use of a sweeping vehicle during the construction process (A5) has been modelled using generic 'machinery'. This, however, has a negligible impact in the system overall.

Pigment has been excluded as it has a minor material component of 0.1%, falling significantly below the 1% cut-off threshold for materials and energy inputs and environmental impacts.

Packaging for inbound materials is mostly reused onsite or by the supplier multiple times and has therefore been excluded from the LCA. The plastic bag packing of recycled glass fines falls below the 1% threshold for materials and energy inputs, and has therefore also been excluded.

KEY ASSUMPTIONS

- Aluminum hydroxide is used a proxy material for corundum. Artificial black corundum (also known as black fused alumina) is a key ingredient of the Hybrid HFST product however, no life cycle inventory (LCI) data exists. The artificial corundum manufacturing process is similar to, but likely more energy-intensive than, aluminum hydroxide production process (Strubel 2012). This EPD has followed the approach in existing EPDs that use aluminum hydroxide as a proxy for corundum (e.g., BerryAlloc, 2015; Fritz EGGER GmbH & Co., 2019; Sphera Solutions GmbH, 2022). This assumption likely has a material impact on the results.
- The two component, cross-linking epoxy resin is modelled as epoxy resin production, liquid, in Europe. There is a high level of confidence in the appropriateness of the resin data due to the closeness of the ecoinvent process to the OmniGrip Direct-sourced product and location. The resin data have a material impact on the results.
- Delivery of materials assumes a 28t capacity truck with Australian fleet-average characteristics.
- The work truck for driving to the construction site and sweeper assumed to be 3.5-16t capacity rigid trucks with Australian fleet-average characteristics.
- Modules A4-A5 are based on scenarios for an average project size. The impact of these modules is relatively small (combined approximately 10% of core indicators) as based on the scenario parameters, but this is variable.
- The electricity generation is modelled as the average Victorian grid mix. This was updated in October 2022 based on data from 2021. The generation sources include: 48% brown coal, 45% gas, 2.9% hydro, 1.2% wind, and 0.7% solar. The GHG-emissions intensity (based on GWP-GHG) of electricity is 0.988 kg CO_2 eq./kWh.

LCA RESULTS

ENVIRONMENTAL INDICATORS

The environmental indicators presented in this EPD are in line with EN 15804:2012+A2:2019.

Table 4: Core environmental impact indicators

IMPACT CATEGORY	INDICATOR	ABBREVIATION	UNIT
Climate change – total	Global Warming Potential total	GWP-total	kg CO_2 eq.
Climate change – fossil	Global Warming Potential fossil fuels	GWP-fossil	kg CO_2 eq.
Climate change – biogenic	Global Warming Potential biogenic	GWP-biogenic	kg CO_2 eq.
Climate change - land use and land use change	Global Warming Potential land use and land use change	GWP-luluc	kg CO_2 eq.
Ozone depletion	Depletion potential of the stratospheric ozone layer	ODP	kg CFC 11 eq.
Acidification	Acidification potential, Accumulated Exceedance	AP	mol H+ eq.
Eutrophication aquatic freshwater	utrophication potential, fraction of nutrients reaching freshwater end compartment	EP-freshwater	kg P eq.
Eutrophication aquatic marine	Eutrophication potential, fraction of nutrients reaching marine end compartment	EP-marine	kg N eq.
Eutrophication terrestrial	Eutrophication potential, Accumulated Exceedance	EP-terrestrial	mol N eq.
Photochemical ozone formation	Formation potential of tropospheric ozone	POCP	kg NMVOC eq.
Depletion of abiotic resources – minerals and metals^	Abiotic depletion potential for non-fossil resources	ADP-minerals & metals	kg Sb eq.
Depletion of abiotic resources – fossil^	Abiotic depletion potential for fossil resources	ADP-fossil	MJNCV
Water use^	Water (user) deprivation potential, deprivation-weighted water consumption	WDP	m^3 world eq. deprived

^ The results of this environmental impact indicator shall be used with care as the uncertainties are high or as there is limited experience with the indicator.

Table 5: Additional environmental impact indicators

IMPACT CATEGORY	INDICATOR	ABBREVIATION	UNIT
Particulate Matter emissions	Potential incidence of disease due to PM emissions	PM	Disease incidence
Ionizing radiation, human health*	Potential Human exposure efficiency relative to U235	IRP	kBq U235 eq.
Eco-toxicity (freshwater)^	Potential Comparative Toxic Unit for Ecosystems	ETP-fw	CTUe
Human toxicity, cancer effects^	Potential Comparative Toxic Unit for humans	HTP-nc	CTUh
Human toxicity, cancer effects^	Potential Comparative Toxic Unit for humans	HTP-nc	CTUh
Land use related impacts/ Soil quality^	Potential soil quality index	SQP	Dimensionless

** This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.*

^ The results of this environmental impact indicator shall be used with care as the uncertainties are high or as there is limited experience with the indicator.

The environmental indicators from AN 15804:2012 + A1:2013 are additionally presented.

Table 6: EN 15804:2012 + A1:2013 environmental impact indicators

IMPACT CATEGORY	INDICATOR	ABBREVIATION	UNIT
Climate change	Global Warming Potential	GWP	kg CO_2 eq.
Ozone depletion	Depletion potential of the stratospheric ozone layer	ODP	kg CFC 11 eq.
Acidification	Acidification potential for Soil and Water	AP	kg SO_2 eq.
Eutrophication	Eutrophication potential	EP	kg $(PO_4)^{3-}$ eq.
Photochemical ozone formation	Formation potential of tropospheric ozone	POCP	kg C_2H_4 eq.
Depletion of abiotic resources - elements	Abiotic depletion potential for non-fossil resources	ADPE	kg Sb eq.
Depletion of abiotic resources - fossil fuels	Abiotic depletion potential for fossil fuels	ADPF	MJNCV

RESOURCE USE, WASTE AND OUTPUT FLOWS INDICATORS

Table 7: Parameters describing resource use, waste and output flows

PARAMETER	ABBREVIATION	UNIT
RESOURCE USE		
Use of renewable primary energy excluding renewable primary energy resources used as raw materials	PERE	MJNCV
Use of renewable primary energy resources used as raw materials	PERM	MJNCV
Total use of renewable primary energy resources	PERT	MJNCV
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials	PENRE	MJNCV
Use of non-renewable primary energy resources used as raw materials	PENRM	MJNCV
Total use of non-renewable primary energy resources	PENRT	MJNCV
Use of secondary material	SM	kg
Use of renewable secondary fuels	RSF	MJNCV
Use of non-renewable secondary fuels	NRSF	MJNCV
Use of net fresh water	FW	m^3
WASTE CATEGORIES		
Hazardous waste disposed	HWD	kg
Non-hazardous waste disposed	NHWD	kg
Radioactive waste disposed	RWD	kg
OUTPUT FLOWS		
Components for reuse	CRU	kg
Materials for recycling	MFR	kg
Materials for energy recovery	MER	kg
Exported energy	EE	MJ

ENVIRONMENTAL PERFORMANCE

This section presents the environmental impacts and resource use, waste and output flows for modules A1-A3, A4 and A5 per m^2 of installed HFST at a representative local (metro) site – 21km A4 transport distance. The estimated impact results are only relative statements which do not indicate the end points of the impact categories, exceeding threshold values, safety margins or risk. The scenario included is currently in use and is representative for one of the most probable alternatives.

Table 8: Core environmental impact indicator results

INDICATOR	UNIT	AI-A3	A4	A5
GWP-total	kg CO_2 eq.	10.8	0.414	0.210
GWP-fossil	kg CO_2 eq.	10.7	0.414	0.210
GWP-biogenic	kg CO_2 eq.	7.04E-02	2.87E-05	3.55E-05
GWP-luluc	kg CO_2 eq.	3.99E-03	1.92E-07	9.71E-07
ODP	kg CFC 11 eq.	1.22E-06	6.41E-08	3.52E-08
AP	mol H+ eq.	7.49E-02	3.57E-03	7.36E-04
EP-freshwater	kg P eq.	3.07E-04	2.47E-08	1.24E-07
EP-marine	kg N eq.	1.24E-02	1.12E-03	2.32E-04
EP-terrestrial	mol N eq.	1.38E-01	1.23E-02	2.55E-03
POCP	kg NMVOC eq.	3.88E-02	3.00E-03	1.33E-03
ADP-minerals&metals	kg Sb eq.	2.24E-05	4.72E-10	5.27E-08
ADP-fossil	MJNCV	157	5.59	2.62
WDP	m^3 world eq. deprived	3.37	0.0358	0.0100

Table 9: Additional environmental impact indicator results

INDICATOR	UNIT	AI-A3	A4	A5
GWP-GHG	kg CO_2 eq.	10.5	0.407	0.187
PM	disease incidence	7.57E-07	2.01E-08	2.56E-09
IRP	kBq U235 eq.	2.04E-01	8.15E-06	4.77E-03
ETP-fw	CTUe	417	1.60	0.853
HTP-c	CTUh	2.20E-08	6.69E-12	4.38E-11
HTP-nc	CTUh	2.73E-07	5.23E-10	2.10E-08
SQP	dimensionless	10.6	0.0248	0.0113

Table 10: Parameter results describing resource use, waste and output flows

PARAMETER	UNIT	A1-A3	A4	A5
		RESOURCE USE		
PERE	MJNCV	4.74E+00	6.73E-03	3.41E-03
PERM	MJNCV	0	0	0
PERT	MJNCV	4.74E+00	6.73E-03	3.41E-03
PENRE	MJNCV	160	5.58	2.62
PENRM	MJNCV	0	0	0
PENRT	MJNCV	160	5.58	2.62
SM	kg	4.80	0	0
RSF	MJNCV	0	0	0
NRSF	MJNCV	0	0	0
FW	m^3	4.65E+00	8.09E-04	1.77E-03
		WASTE CATEGORIES		
HWD	kg	0	0	0
NHWD	kg	6.39E-04	2.57E-05	7.60E-06
RWD	kg	0	0	0
		OUTPUT FLOWS		
CRU	kg	0	0	0
MFR	kg	0	0	0
MER	kg	0	0	0
EE	MJ	0	0	0

Table 11: EN 15804 + A1 environmental impact indicator results

INDICATOR	UNIT	A1-A3	A4	A5
GWP	kg CO_2 eq.	10.2	0.406	0.187
ODP	kg CFC 11 eq.	1.18E-06	5.06E-08	2.78E-08
AP	kg SO_2 eq.	6.00E-02	1.98E-03	5.60E-04
EP	kg $(PO_4)^{3-}$ eq.	2.78E-02	4.16E-04	9.50E-05
POCP	kg C_2H_4 eq.	7.28E-03	4.32E-04	5.59E-04
ADPE	kg Sb eq.	2.24E-05	4.77E-10	5.27E-08
ADPF	MJNCV	177	5.45	2.56

ADDITIONAL ENVIRONMENTAL IMPACTS - SCENARIO

This section presents the environmental impacts and resource use, waste and output flows for module A4 per m^2 of installed HFST for a second site location scenario – a rural site 225km distance away. The impacts of other modules remain unchanged.

Table 12: Core environmental impact indicator results – rural scenario

INDICATOR	UNIT	A4
GWP-total	kg CO_2 eq.	4.43
GWP-fossil	kg CO_2 eq.	4.43
GWP-biogenic	kg CO_2 eq.	3.07E-04
GWP-luluc	kg CO_2 eq.	2.06E-06
ODP	kg CFC 11 eq.	6.87E-07
AP	mol H+ eq.	3.83E-02
EP-freshwater	kg P eq.	2.65E-07
EP-marine	kg N eq.	1.20E-02
EP-terrestrial	mol N eq.	1.32E-01
POCP	kg NMVOC eq.	3.22E-02
ADP-minerals&metals	kg Sb eq.	5.05E-09
ADP-fossil	MJNCV	59.8
WDP	m^3 world eq. deprived	0.384

Table 13: Additional environmental impact indicator results – rural scenario

INDICATOR	UNIT	A4
GWP-GHG	kg CO_2 eq.	4.36
PM	Disease incidence	2.15E-07
IRP	kBq U235 eq.	8.73E-05
ETC-fw	CTUe	17.1
HTP-c	CTUh	7.17E-11
HTP-nc	CTUh	5.61E-09
SQP	Dimensionless	0.266

Table 14: Parameter results describing resource use, waste and output flows – rural scenario

PARAMETER	UNIT	A4
	RESOURCE USE	
PERE	MJNCV	7.21E-02
PERM	MJNCV	0
PERT	MJNCV	7.21E-02
PENRE	MJNCV	59.8
PENRM	MJNCV	0
PENRT	MJNCV	59.8
SM	kg	0
RSF	MJNCV	0
NRSF	MJNCV	0
FW	m^3	8.67E-03
	WASTE CATEGORIES	
HWD	kg	0
NHWD	kg	2.76E-04
RWD	kg	0
	OUTPUT FLOWS	
CRU	kg	0
MFR	kg	0
MER	kg	0
EE	MJ	0

Table 15: EN 15804 + A1 environmental impact indicator results – rural scenario

INDICATOR	UNIT	A4
GWP	kg CO_2 eq.	4.35
ODP	kg CFC 11 eq.	5.42E-07
AP	kg SO_2 eq.	2.12E-02
EP	kg $(PO_4)^{3-}$ eq.	4.46E-03
POCP	kg C_2H_4 eq.	4.62E-03
ADPE	kg Sb eq.	5.11E-09
ADPF	MJNCV	58.4

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