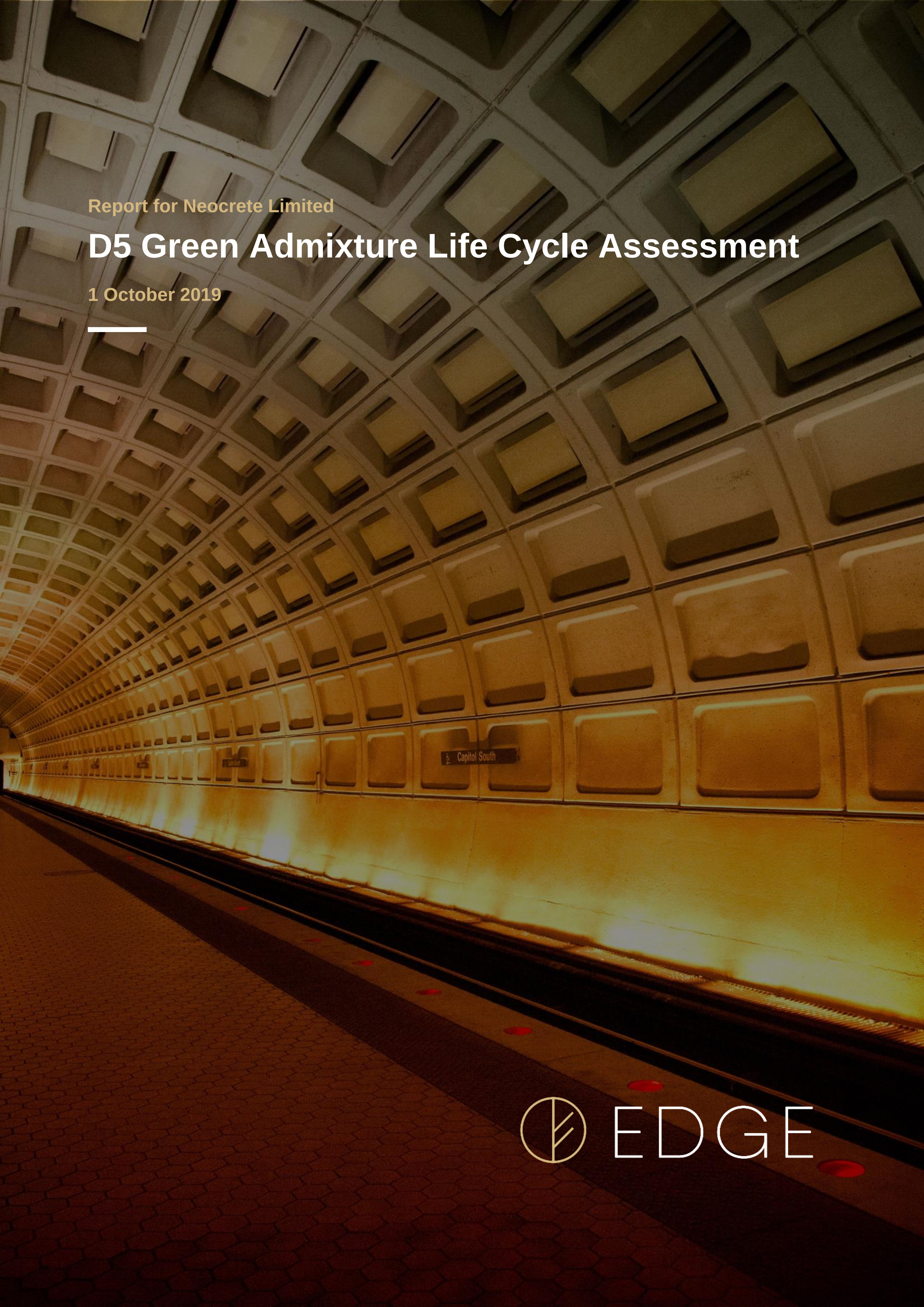
Report for Neocrete Limited

D5 Green Admixture Life Cycle Assessment

1 October 2019



EDGE

Project Delivered for:

Zarina Bazoeva

Neocrete Limited

PO BOX 90055

Victoria St West, Auckland 1142, New Zealand

zarina@neocrete.co.nz

Project Delivered by:

Jonas Bengtsson - CEO

EDGE

39 East Esplanade, Manly, NSW 2095, AUSTRALIA

0404 758 586 - jonas@edgeenvironment.com

Revision	Revision Details	Author	Date Published
1.0	Draft for Neocrete	Jonas Bengtsson	27 August 2019
2.0	Draft for Neocrete	Jonas Bengtsson	16 September 2019
3.0	Report	Jonas Bengtsson	19 September 2019
4.0	Report	Jonas Bengtsson	1 October 2019

Executive Summary

Introduction

After water, concrete is the most heavily consumed product on the planet. Cement is the key ingredient of concrete, responsible for its strength and performance. The process of making cement also emits vast amounts of carbon dioxide – for every tonne of cement produced, roughly the same weight in carbon is released into the atmosphere.

Neocrete Limited is the exclusive Australasian distributor of D5 Green, a highly innovative, multifunctional admixture for concretes, mortars, dry building mixtures and grouts.

D5 Green significantly increases the strength of concrete. This means cement content can be substantially reduced, lowering the carbon footprint of concrete.

Neocrete has commissioned Edge Environment (EDGE) to conduct a scoping life-cycle assessment (LCA) of the carbon footprint of a range of concrete mixes with and without D5 Green.

Life Cycle Assessment Results

The goal of the LCA is to establish the environmental credentials and potential from using the D5 Green admixture in concrete mixes by comparing equivalent mixes with and without the D5 Green admixture and cement substitute materials. The primary intended audience for the LCA is building and infrastructure project teams, specifically focussed on green ratings such as Green Star and Infrastructure Sustainability (IS) Rating.

The declared unit adopted is **1 m^3 of ready-mix concrete**. The scope of the study was **cradle to gate** (modules A1-A3 as per EN 15804).

The figure below shows the global warming impact (carbon emissions, kgCO_2eq) per cubic meter of ready-mix concrete from cradle to gate.

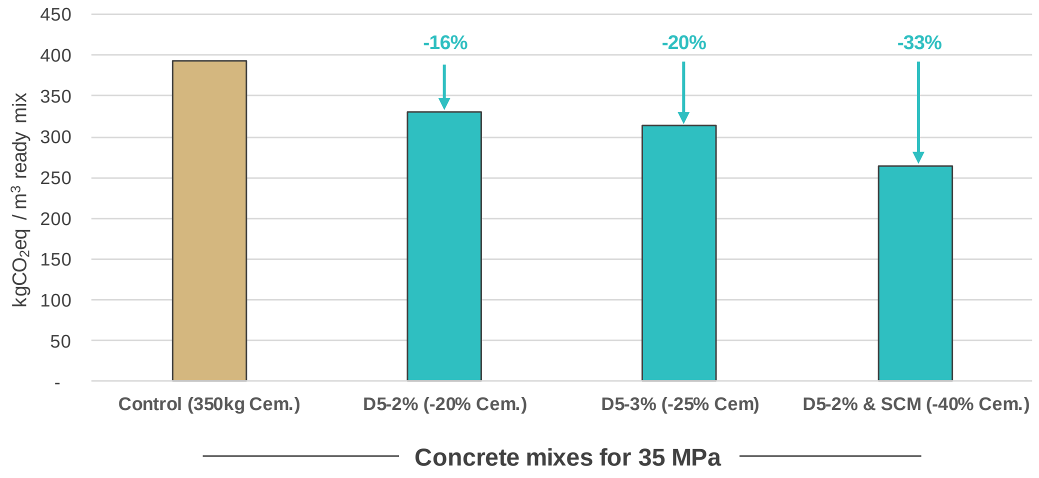


Figure 1 | Global warming impact per m^3 of ready-mix concrete.

- This LCA shows up to 20% global warming impact reduction per cubic meter of ready-mix concrete from cradle to gate from the use of D5 Green, and up to 33% global warming impact reduction from a combination of cement substitution and the use of D5 Green admixture.
- Across the full spectra of environmental impact categories used in the Green Star LCA credit, the mixes with D5 Green have lower environmental impacts in most categories: global warming, acidification, eutrophication, photochemical oxidation impact potential and fossil energy consumption. Some mixes had higher ozone layer depletion and mineral resource depletion potential compared with the control mix.
- The impact per cubic meter of ready-mix concrete from D5 Green is approximately 2% of the overall global warming impact. The highest impact from D5 Green is the plasticiser, followed by transport to NZ.

Recommendations

Based on the ready-mix concrete mixes modelled in this LCA, we recommend that Neocrete use this study to inform customers of the potential environmental benefits and implications from using D5 Green.

We further recommend that Neocrete makes their LCA publicly available and in a format that it can be used for modelling on whole building or infrastructure LCAs.

Contents

1 Introduction

After water, concrete is the most heavily consumed product on the planet. Cement is the key ingredient of concrete, responsible for its strength and performance. The process of making cement also emits vast amounts of carbon dioxide – for every tonne of cement produced, roughly the same weight in carbon is released into the atmosphere.

Neocrete Limited is the exclusive Australasian distributor of D5 Green, a highly innovative, multifunctional admixture for concretes, mortars, dry building mixtures and grouts.

D5 Green significantly increases the strength of concrete[1]. This means cement content can be substantially reduced, lowering the carbon footprint of concrete.

Neocrete has commissioned Edge Environment (EDGE) to conduct a scoping life-cycle assessment (LCA) of the carbon footprint of a range of concrete mixes with and without D5 Green.

[1] Strength gains of 24-34% from using 2-3% D5 was independently verified at tests conducted in March-May 2019 in Lower Hutt, NZ.

2 Goal and Scope

2.1 Goal and Intended Audience

The goal of the LCA is to establish the environmental credentials and potential from using the D5 Green admixture in concrete mixes by comparing equivalent mixes with and without the D5 Green admixture. The primary intended audience for the LCA is building and infrastructure project teams, specifically focussed on green ratings such as Green Star and Infrastructure Sustainability (IS) Rating.

2.2 Declared Unit and Physical Scope

The declared unit adopted is **1 m^3 of ready-mix concrete**. The scope of the study was **cradle to gate** (modules A1-A3 as per EN 15804). The cradle to gate scope is selected considering the range of transport distances and diverse functions and uses of concrete in the built environment.

2.3 System Description

2.3.1 Ready-mix concrete

The diagram below shows the cradle to gate inputs, outputs and processes of Ready-mix concrete production.

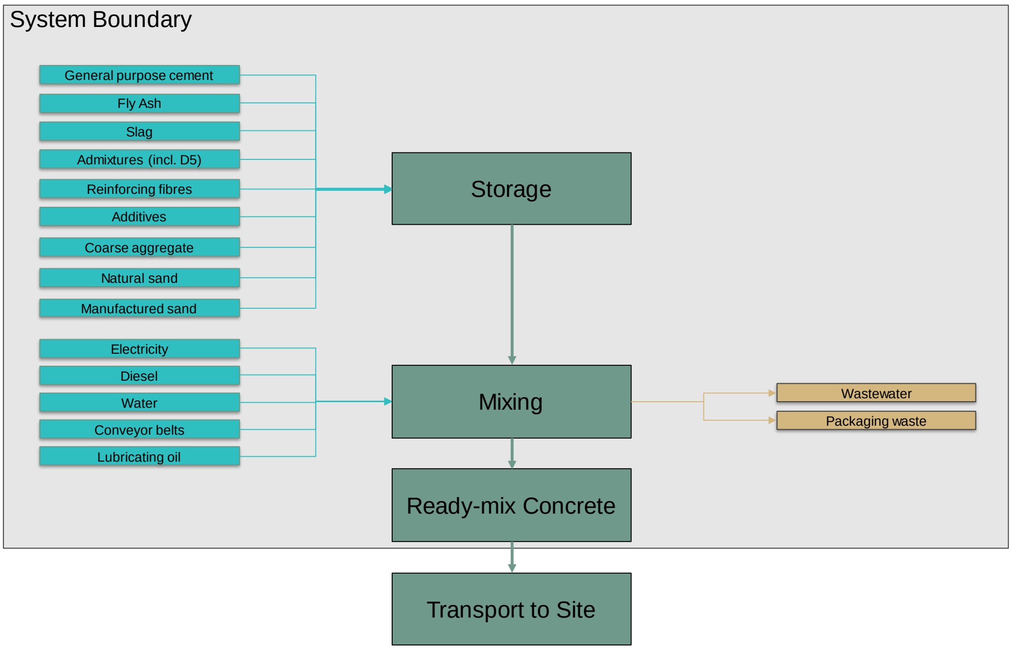


Figure 2 | Ready-mix concrete, cradle to gate system diagram.

2.3.2 D5 Green Admixture

The figure below shows the system diagram covering the cradle to gate of D5 Green admixture cradle to gate production.

D5 Green is produced in a factory in Russia - Tokar Ltd., in North Ossetia-Alania, Vladikavkaz, east of Black Sea. The raw materials are coming from three regions in Russia: Caucasus (where the factory is based), the Urals and Altai.

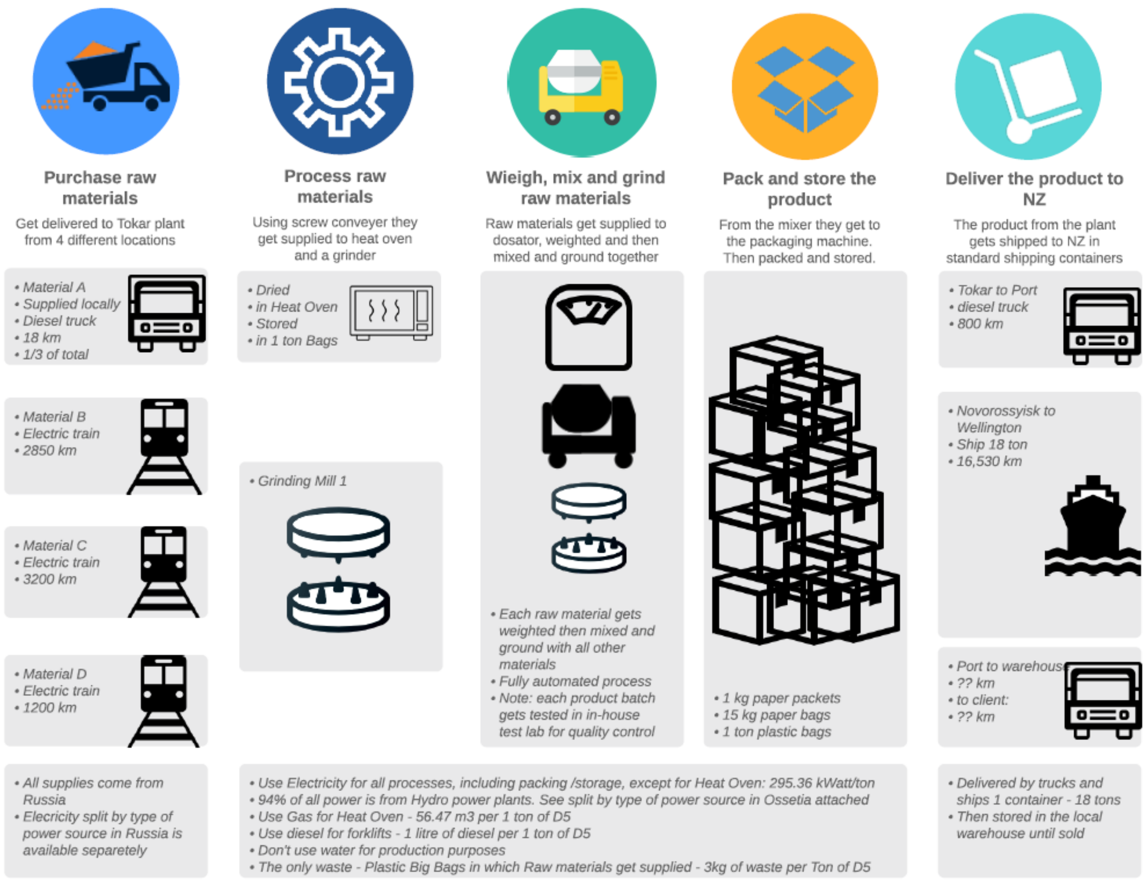


Figure 3 | D5 Green system overview

2.4 Environmental Impact Assessment

While the key focus of interest is on greenhouse gas emissions, often referred to as carbon footprint, the LCA will provide the results for the full range of environmental impacts used in Green Star as this is a key target area for Neocrete. The environmental impact categories and assessment methods used are presented in the table below.

Table 1: Life cycle impact assessment.

Impact Category	Measurement Unit (eq. = equivalence)	Assessment Method and Implementation
Mandatory		
Global warming	kg CO_2 eq. (GWP100)	CML (v4.2) based on IPCC AR4
Ozone depletion	kg CFC 11 eq.	CML (v4.2) based on WMO 1999
Acidification of land and water	kg SO_2 e eq.	CML (v4.2)
Eutrophication,	kg PO_4^{3-} eq.	CML (v4.2)
Photochemical ozone creation	kg C_2H_4 eq.	CML (v4.2)
Abiotic resource depletion (elements)	kg Sb eq.	CML (v4.2)
Abiotic resource depletion (fossil fuels)	MJ net calorific value	CML (v4.2)

3 Method

The scoping LCA study has been developed to comply with relevant aspects of the standards:

- ISO 14040:2006 and ISO14044:2006+A1:2018 which describe the principles, framework, requirements and provides guidelines for life cycle assessment (LCA) (ISO, 2006; ISO, 2018).
- ISO 14025:2006 Environmental labels and declarations – Type III environmental declarations -- Principles and procedures, which establishes the principles and specifies the procedures for developing Type III environmental declaration programmes and Type III environmental declarations (ISO, 2006).
- EN 15804:2012+A1:2013 Sustainability of construction works – Environmental product declarations which provides core product category rules (PCR) for Type III environmental product declarations (EPD) for any construction product and construction service.

3.1 Background data modelling

The inventory data for the processes are entered in the SimaPro® LCA software (v9.0) and linked to the pre-existing background data for upstream feedstocks and services. Inventory data was selected per the standards, in the following order of preference:

1. Environmental Product Declarations for the same type of product in a similar geographic region.
2. Ecoinvent 3.5 database (Ecoinvent Centre, 2017) for all international processes using global average processes and for the New Zealand energy mix.
3. The Australian Life Cycle Inventory (AusLCI) being compiled by the Australian Life Cycle Assessment Society (ALCAS) – this data will comply with the AusLCI Data Guidelines (Australian Life Cycle Inventory Database Initiative (AusLCI), 2015).
4. Other sources with sensitivity analysis reported to show the significance of this data for the results and conclusions drawn.

EDGE complied with the additional five criteria in selecting data for modelling:

- **Relevance:** select sources, data, and methods appropriate to assessing the chosen product's LCI.
- **Completeness:** include all LCI items that provide a material's contribution to a product's life cycle emissions.
- **Consistency:** enable meaningful comparisons in life cycle impact assessment (LCIA) information.
- **Accuracy:** reduce bias and uncertainty as far as is practical.
- **Transparency:** when communicating, disclose enough information to allow third parties to make decisions.

The background processes used in this project is presented in Appendix A.

3.2 Cut-off rules

It is common practice in LCA/LCI protocols to propose exclusion limits for inputs and outputs that fall below a minimum threshold percentage of the total, with exceptions if the input/output has a significant impact. According to *PCR 2012:01 Construction Products and Construction Services*:

> "Life Cycle Inventory data for a minimum of 95% of total inflows (mass and energy) to the upstream and core module shall be included. Inflows not included in the LCA shall be documented in the EPD. Data gap with an assumed potential importance in the included modules shall be reported in the EPD including an evaluation of its significance."

Capital goods and plant equipment for the production of D5 Green has been excluded from the assessment, and the impact is assumed to be minor based on previous studies and literature.

3.3 Co-product allocation

BS EN 16757:2017 specifically lists the following materials relevant to the study as co-products:

- Fly ash;
- Ground granulated blast furnace slag; and
- Silica fume.

As such, the above materials, are considered as co-products of their production process and the impacts for their production process are allocated according to *PCR 2012:01 Construction Products and Construction Services* (co-produced goods, multi-output allocation). Default background data from LCA databases was used to model the above co-products:

- Fly ash: the AusLCI process for fly ash treats it as a waste material and only includes transport impacts.
- Ground granulated blast furnace slag: the AusLCI process for slag is allocated based on economic value, as the product has significant economic value at the point of collection.
- Silica fume: the ecoinvent process for silica fume treats it as a waste material and only includes transport impacts.

The allocation approach of the AusLCI LCA database was adopted as a default for secondary data and processes (e.g. secondary fuel in cement production). The AusLCI dataset conforms to EN 15804 when applying allocation to its various processes and sub-processes.

4 Life Cycle Inventory

This section provides the life cycle data used for the modelling.

4.1 D5 Green Admixture

This section includes the life cycle inventory used to model the D5 Green cradle to site LCA.

The raw materials, packaging of raw materials and transport is presented in the table below.

Table 2 | Purchase of raw materials per 1t of D5 Green produced

Input	Quantity	Unit	Transport
Volcanic ash[2]	0.36	t	18km diesel truck (empty return)
Aluminate of volcanic rock minerals[3]	0.20	t	Electric train
Silicate of volcanic rock minerals[4]	0.20	t	Electric train
Superplasticiser	0.24	t	Electric train
Plastic bags (PET)	3.00	kg	

The processing and preparation of D5 Green is presented in the table below.

Table 3 | Processing and preparation per 1t of D5 Green produced

Input	Quantity	Unit	Notes
Gas	56.47	m3	39.3E-03 GJ/m^3
Electricity	295.36	kWh	94% from hydropower
Diesel	1.00	L	38.6MJ/L
Outputs	**Quantity**	**Unit**	**Notes**
Plastic bags (PET)	3.00	kg	Landfill

Note on waste and emissions: Emissions from combustion of gas and diesel are included as site emissions. No other emissions and waste from the site have been included in the inventory. The Tokar production facility has completed a full refurbishment of to automate the production process and minimise/eliminate waste of:

- raw materials
- the product
- dust emissions

The plant is installed with advanced filters, which collect the dust from the raw materials and the product and put it back into production.

The packaging of D5 Green is presented in the table below. When sold in paper bags, the product is delivered on pallets with 2t of product and plastic film over it.

Table 4 | Packaging of D5 Green

Input	Quantity	Unit	Notes
1 kg paper packets	9.00	g	Paper, 3% of all sales
15kg paper bags	82.00	g	Paper, 90% of all sales
1 tonne plastic bags (PET)	2700.00	g	7% of all Sales
Film per 1 ton of	520.00	g	Only on pallet with 15kg bags.
Plastic band	280.00	g	over the pallet and film on pallet with 15kg bags

[2] From open quarry, no reinforcements used
[3] From open quarry, no reinforcements used
[4] From open quarry, no reinforcements used

The distribution from the production site east of the Black Sea to Wellington in New Zealand is presented in the table below.

Table 5 | Distribution of D5 Green

Input	Quantity	Unit	Description
Tokar to port	800	km	16-32t Diesel truck in 18t containers, (comes empty from Port)
Novorassyisk to Wellington	16,530	km	Ship in 18t containers
Wellington port to warehouse	50	km	16-32t Diesel truck in 18t containers
Warehouse to ready-mix plant	50	km	16-32t Diesel truck in 18t containers

4.2 Concrete Ready-mixes

The table below shows the concrete mixes included in the LCA. The concrete strength and material input quantities are provided by Neocrete. The same energy use has been used for all mixes, based on Holcim's ViroDecs™ Environmental Product Declaration[5].

Table 6 | Inputs per m^3 of concrete per mix design

Production Inputs	Name	Control (350kg Cem.)	D5-2% (-20% Cem.)	D5-3% (-25% Cem)	D5-2% & SCM (-40% Cem.)
	Target	35 MPa	35 MPa	35 MPa	35 MPa
	Actual	43.5 MPa	40 MPa	43.5 MPa	46.5 MPa
Coarse aggregate	kg	1,030	1,036	1,030	1,040
Manufactured sand	kg	680	876	808	879
General purpose cement	kg	350	283	263	215
Fly ash	kg	-	-	-	56
Silica fume	kg	-	-	-	12
D5 Green	kg	-	5.7	10.5	5.7
Water	L	213	170	166	160

[5] Source: https://epd-australasia.com/wp-content/uploads/2019/07/Holcim-ViroDecs-EPD.pdf

5 Life Cycle Results

This section provides the LCA results for D5 Green and the ready-mixes assessed.

5.1 D5 Green Admixture

The figure below shows the global warming impact contribution from cradle to site (tCO_2eq) per 1 tonne of D5 Green, with total emissions of 805 kg CO_2eq per tonne.

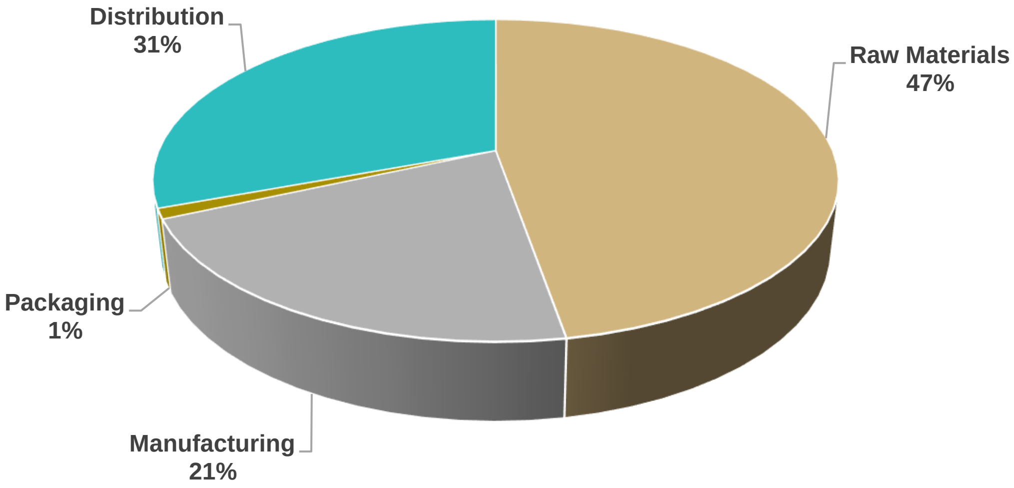


Figure 4 | Global warming impact contribution from cradle to site (tCO_2eq) per 1 tonne of D5 Green.

The table below shows the LCA impact for the relevant categories used in whole building Green Star LCAs.

Table 7 | LCA results per tonne of D5 Green from cradle to site.

Impact category	Unit	Total	Raw Materials	Manufacturing	Packaging	Distribution
Global warming (GWP100a)	kg CO_2 eq	**805**	380	169	8.3	247
Ozone layer depletion (ODP)	kg CFC-11 eq	**1.2E-04**	5.8E-05	1.4E-05	8.0E-07	4.3E-05
Acidification	kg SO_2 eq	**5.1**	2.1	0.21	0.038	2.8
Eutrophication	kg PO_4--- eq	**0.86**	0.55	0.022	0.0080	0.28
Photochemical oxidation	kg C_2H_4 eq	**0.33**	0.20	0.016	0.0022	0.11
Abiotic depletion	kg Sb eq	**3.5E-03**	3.0E-03	1.4E-05	1.8E-05	4.7E-04
Abiotic depletion (fossil fuels)	MJ	**15,304**	8,872	2,618	129	3,685

The table below shows the relative contribution per life cycle stage per impact category.

Table 8 | Relative contribution per life cycle stage.

Impact category	Raw Materials	Manufacturing	Packaging	Distribution
Global warming (GWP100a)	47%	21%	1%	31%
Ozone layer depletion (ODP)	50%	12%	1%	37%
Acidification	41%	4%	1%	54%
Eutrophication	64%	3%	1%	33%
Photochemical oxidation	60%	5%	1%	34%
Abiotic depletion	86%	0%	1%	13%
Abiotic depletion (fossil fuels)	58%	17%	1%	24%

5.2 Concrete Ready-mixes

The figure below shows the global warming impact (carbon emissions, $kgCO_2eq$) per cubic meter of ready-mix concrete from cradle to gate. The mixes with D5 Green achieve up to 33% global warming impact reduction.

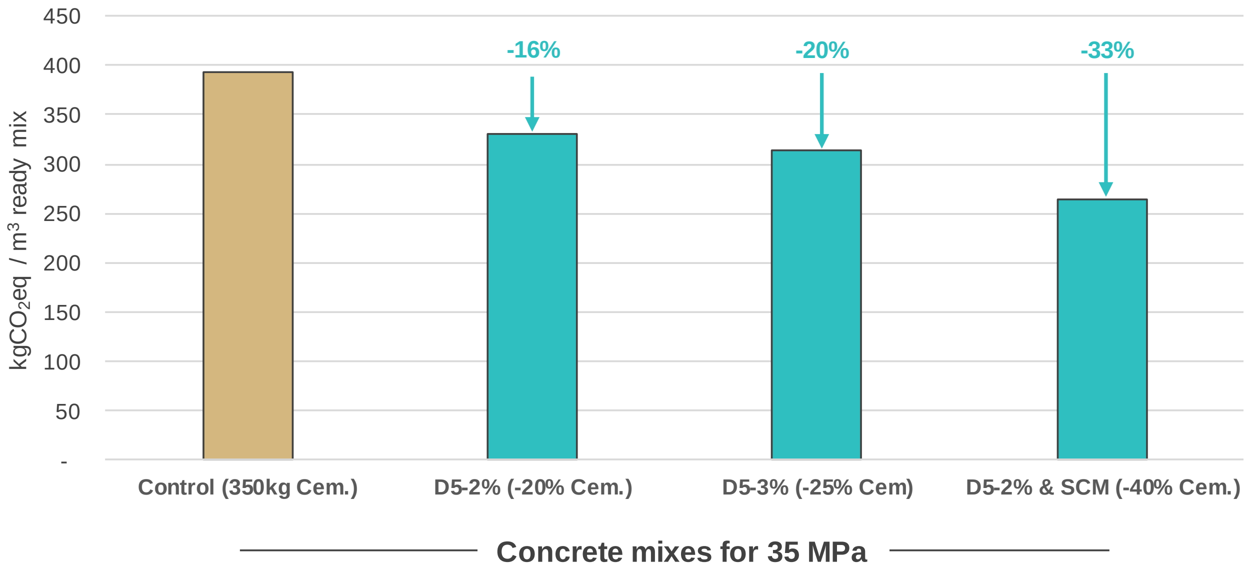


Figure 5 | Global warming impact per m^3 of ready-mix concrete.

The table below shows the LCA results for each impact used in Green Star (v1.1 and v1.2).

Table 9 | LCA results per cubic metre (m^3) of ready-mix concrete from cradle to gate.

Impact category	Global warming (GWP100a)	Ozone layer depletion (ODP)	Acidification	Eutrophication	Photochemical oxidation	Abiotic depletion	Abiotic depletion (fossil fuels)
Unit	kg CO_2 eq	kg CFC-11 eq	kg SO_2 eq	kg PO_4^{---} eq	kg C_2H_4 eq	kg Sb eq	MJ
Control (350kg Cem.)	393	5.63E-06	1.03	0.19	0.031	2.55E-04	2,631
D5-2% (-20% Cem.)	331	5.84E-06	0.89	0.16	0.028	2.58E-04	2,339
D5-3% (-25% Cem)	314	6.24E-06	0.86	0.16	0.029	2.69E-04	2,292
D5-2% & SCM (-40% Cem.)	264	5.49E-06	0.72	0.13	0.024	2.43E-04	1,959

The table below shows the impact in percentage compared with the control mixes for the two groups.

Table 10 | Impact compared with control mixes.

Impact category	Global warming (GWP100a)	Ozone layer depletion (ODP)	Acidification	Eutrophication	Photochemical oxidation	Abiotic depletion	Abiotic depletion (fossil fuels)
Control (350kg Cem.)	100%	100%	100%	100%	100%	100%	100%
D5-2% (-20% Cem.)	84%	104%	87%	87%	92%	101%	89%
D5-3% (-25% Cem)	80%	111%	84%	84%	92%	105%	87%
D5-2% & SCM (-40% Cem.)	67%	98%	70%	71%	78%	95%	74%

The figure below shows the global warming impact contribution from cradle to gate per $1m^3$ of ready-mix (D5-2% & SCM (-40% Cem.)).

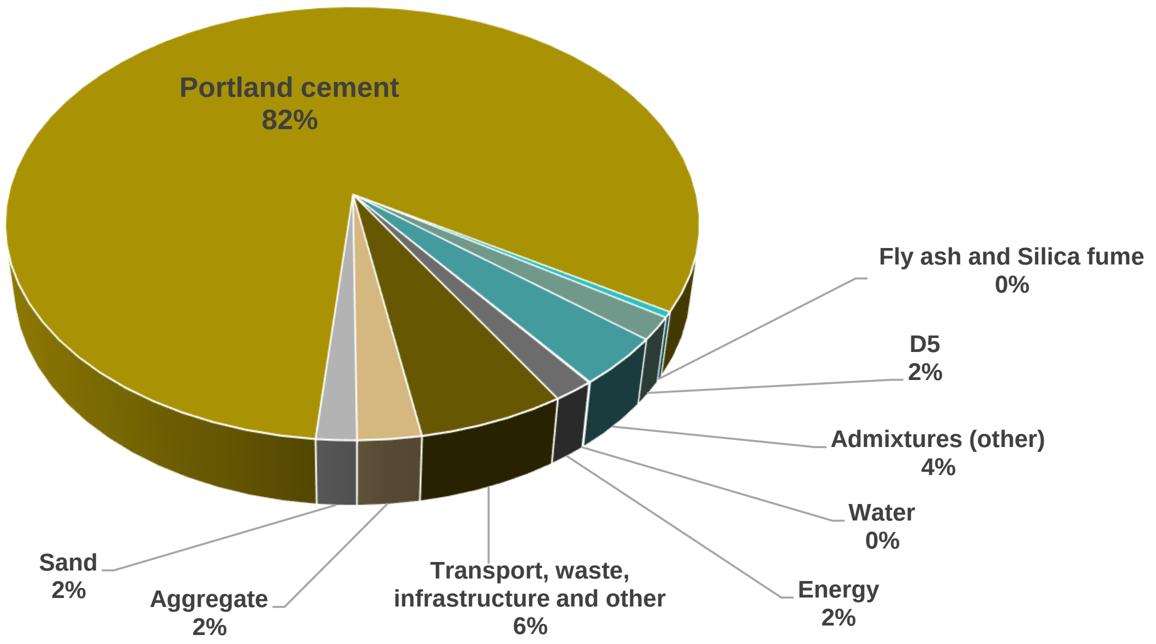


Figure 6 | Global warming impact contribution from cradle to gate (tCO_2eq) per $1m^3$ of ready-mix (D5-2% & SCM (-40% Cem.)).

6 Conclusions and Recommendations

- Concrete is the second most used commodity in the world behind water, and typically a major contributor to the embodied GHG emissions of an infrastructure or property asset.
- Cement is the key ingredient of concrete, responsible for its strength and performance. The process of making cement also emits vast amounts of carbon dioxide – for every tonne of cement produced, roughly the same weight in carbon is released into the atmosphere.
- This LCA shows up to 20% global warming impact reduction per cubic meter of ready-mix concrete from cradle to gate from the use of D5 Green, and up to 33% global warming impact reduction from a combination of cement substitution and the use of D5 Green admixture.
- Across the full spectra of environmental impact categories used in the Green Star LCA credit, the mixes with D5 Green have lower environmental impacts in most categories: global warming, acidification, eutrophication, photochemical oxidation impact potential and fossil energy consumption. Some mixes had higher ozone layer depletion and mineral resource depletion potential compared with the control mix.
- The impact per cubic meter of ready-mix concrete from D5 Green is approximately 2% of the overall global warming impact. The highest impact from D5 Green is the plasticiser, followed by transport to NZ.
- Based on the ready-mix concrete mixes modelled in this LCA, we recommend that Neocrete use this study to inform customers of the potential environmental benefits and implications from using D5 Green.
- We further recommend that Neocrete makes their LCA publicly available and in a format that it can be used for modelling on whole building or infrastructure LCAs. This can be done by:
    - Making the D5 Green LCA results available for use in concrete mix LCA calculations.
    - Publishing concrete mix LCA tools and guidance on Neocrete’s website.

Appendix A – Background Data

Table 11 | D5 Green production and distribution background data

D5 Green Input / Output	Background process and source
Volcanic ash	***gravel and sand quarry operation RoW*** from ecoinvent v3.5, exchanged all electricity flow for Russian average grid mix.
Aluminate of volcanic rock minerals	***gravel and sand quarry operation RoW*** from ecoinvent v3.5, exchanged all electricity flow for Russian average grid mix.
Silicate of volcanic rock minerals	***gravel and sand quarry operation RoW*** from ecoinvent v3.5, exchanged all electricity flow for Russian average grid mix.
Superplasticiser	***Plasticiser, for concrete, based on sulfonated melamine formaldehyde {GLO}| market for | Cut-off, U*** from ecoinvent v3.5
Plastic bags	***Polyethylene terephthalate, granulate, amorphous {RoW}| polyethylene terephthalate, granulate, amorphous, recycled to generic market for amorphous PET granulate | Cut-off, U*** from ecoinvent v3.5
Gas	***Heat, district or industrial, natural gas {RoW}| heat production, natural gas, at boiler modulating >100kW | Cut-off, U*** from ecoinvent v3.5
Electricity	0.94% ***Electricity, high voltage {RU}| electricity production, hydro, run-of-river | Cut-off, U*** and 6% ***Electricity, high voltage {RU}| market for | Cut-off, U*** from ecoinvent v3.5
Diesel	***Energy, from diesel/AU U*** from the Australasian Unit Process LCI
1 kg paper packets	***Kraft paper, bleached {GLO}| market for | Cut-off, U*** from ecoinvent v3.5
15kg paper bags	***Kraft paper, bleached {GLO}| market for | Cut-off, U*** from ecoinvent v3.5
1 tonne plastic bags (PET)	***Polyethylene terephthalate, granulate, amorphous {RoW}| polyethylene terephthalate, granulate, amorphous, recycled to generic market for amorphous PET granulate | Cut-off, U*** from ecoinvent v3.5
Film per 1 ton of	***Polyethylene, linear low density, granulate {GLO}| market for | Cut-off, U*** from ecoinvent v3.5
Plastic band	***Polypropylene, granulate {GLO}| market for | Cut-off, U*** from ecoinvent v3.5
Ship in 18t containers	***Transport, freight, sea, transoceanic tanker {GLO}| market for | Cut-off, U*** from ecoinvent v3.5
16-32t Diesel truck in 18t containers	***Transport, freight, lorry 16-32 metric ton, EURO5 {RER}| transport, freight, lorry 16-32 metric ton, EURO5 | Cut-off, U*** from ecoinvent v3.5
Electric Train	***Transport, freight train {CN}| electricity | Cut-off, U*** from ecoinvent v3.5, exchanged all electricity flow for Russian average grid mix.

Table 12 | Ready-mix concrete background data

Concrete Ready-mix Input / Output	Background process and source
Coarse aggregate	***Gravel, unspecified, at mine/CH U/AusSD U*** from AusLCI shadow database
Natural sand	***Sand, at mine/CH U/AusSD U*** from AusLCI shadow database
Manufactured sand	***Sand, at mine/CH U/AusSD U*** from AusLCI shadow database
General purpose cement	***ordinary portland cement, Australian average/AU U*** from AusLCI
Fly Ash	***fly ash, delivered to plant/AU U*** from AusLCI

Concrete Ready-mix Input / Output	**Background process and source**
Silica Fume and Microsilica	***Silica fume, densified {GLO}| market for | Cut-off, U*** from ecoinvent v3.5
D5 Green	***see above***
Superplasticiser	***Plasticiser, for concrete, based on sulfonated melamine formaldehyde {GLO}| market for | Cut-off, U*** from ecoinvent v3.5
Admixtures - WRDA	***Melamine formaldehyde resin, at plant/RER U/AusSD U*** from AusLCI shadow database
Electricity	***Electricity, low voltage {NZ}| market for electricity, low voltage | Cut-off, U*** from ecoinvent v3.5
Diesel	***Diesel, burned in building machine/GLO U/AusSD U*** from AusLCI shadow database
Water	***tap water, at user, Australia/AU U*** from AusLCI

Appendix B – Network diagram of D5 Green cradle to site global warming impact

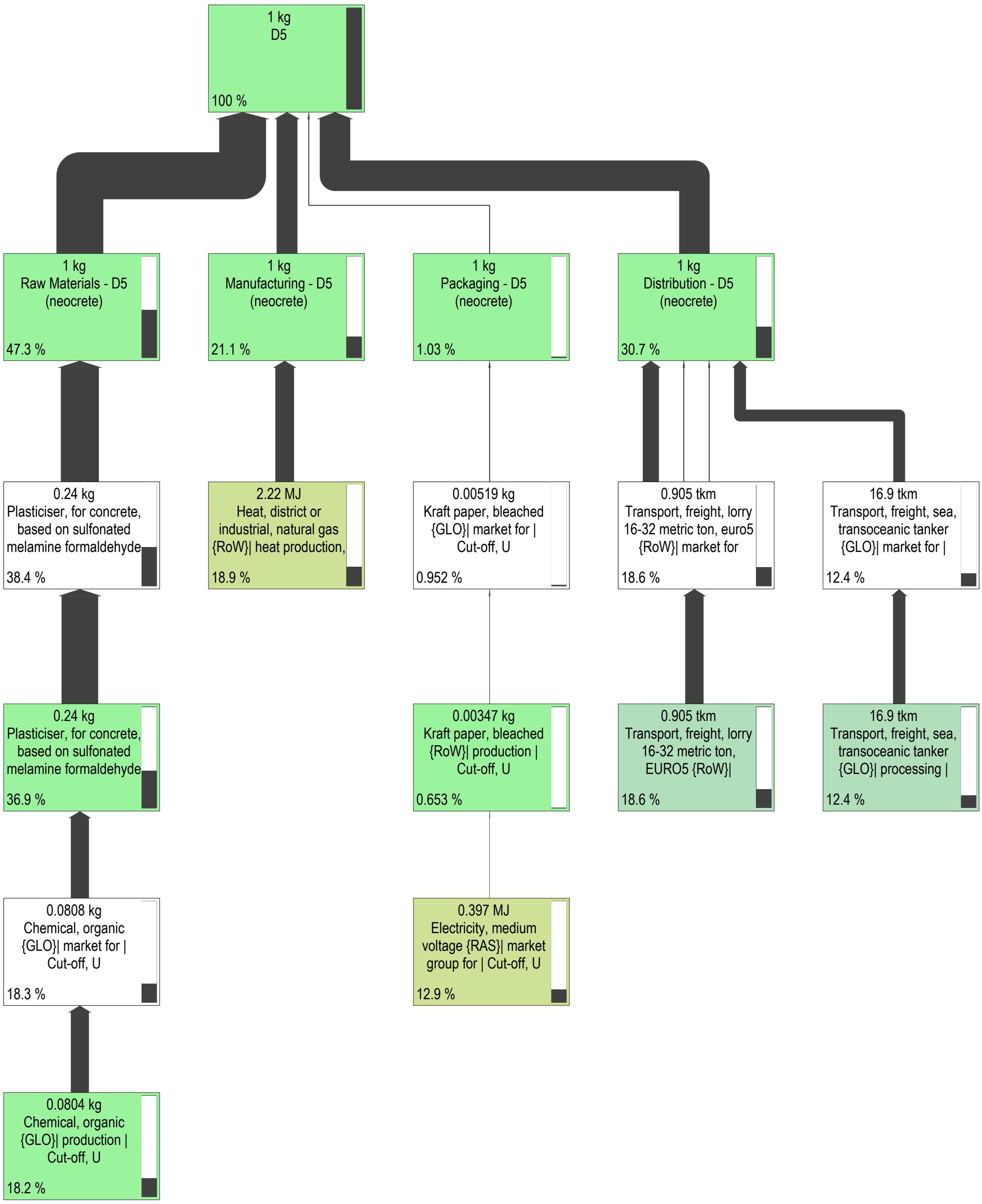


Figure 7 | Network diagram of D5 Green cradle to site global warming impact (CO_2eq) with 8% of impact cut-off applied.