environmental sciences proceedings

MDPI

Proceeding Paper

From Transparency to Impact: Findings from the Development of Australia's First Environmental Product Declaration and Carbon Neutral Ready-Mix Concrete †

Evan Smith [1,*] and Charlotte Wang [2]

1 Holcim (Australia) Pty Ltd., Milton, QLD 4064, Australia
2 Edge Environment Pty Ltd., Manly, NSW 2095, Australia; jielicharlottewang@gmail.com
* Correspondence: evan.smith@holcim.com
† Presented at the ICSD 2021: 9th International Conference on Sustainable Development, Virtual, 20–21 September 2021.

Abstract: Concrete contributes 8% of global greenhouse gas (GHG) emissions. The development of a concrete EPD is a critical "missing" piece to having all key infrastructure and building products represented by an EPD in Australia. The publication of the first EPD for ready-mix concrete in Australia has led to exciting new opportunities to improve the way low-carbon concrete is specified in tenders and contracts. With the ability to provide mix-specific third-party verified data, EPDs are leading the way for construction contractors and clients to send a clear signal of intent for embodied carbon reduction in the concrete supply chain.

Keywords: concrete; low carbon concrete; carbon neutral concrete; low embodied carbon concrete; Environmental Product Declaration

check for updates

Citation: Smith, E.; Wang, C. From Transparency to Impact: Findings from the Development of Australia's First Environmental Product Declaration and Carbon Neutral Ready-Mix Concrete. *Environ. Sci. Proc.* **2022**, *15*, 23. https://doi.org/10.3390/environsciproc2022015023

Academic Editors: Cheyenne Maddox and Lauren Barredo

Published: 6 May 2022

1. Introduction

All around the world, the expectation for Governments and organisations to provide enhanced transparency and disclosure of environmental impacts, such as greenhouse gas (GHG) emissions, has been growing. This follows the landmark COP 21 Paris Agreement in 2015 in which all nations agreed to ambitiously pursue efforts to combat climate change and its effects [1].

To deliver the ambitions of the Paris Agreement and keep global average temperature rise well below 2 °C, all sectors of the economy must decarbonize [1]. Currently, buildings account for 39% of energy related global CO_2 emissions [2], demonstrating the importance of the building and construction sector in fulfilling these ambitions. Of this sector contribution, 28% comes from operational carbon, with 11% arising from the energy used to produce building and construction materials, usually referred to as embodied carbon [2].

At the same time, the global demand for construction materials is also growing due to worldwide population growth and an increase in urbanisation. As a key input into concrete, the most widely used construction material in the world, cement is a major contributor to climate change [3]. The chemical and thermal combustion processes involved in the production of cement are a large source of carbon dioxide (CO_2) emissions. Each year, more than 4 billion tonnes of cement are produced, accounting for around 8 per cent of global CO_2 emissions [3]. This clearly demonstrates both the essential need for construction materials now and in the future, as well as the necessity for the construction materials industry to be a leading part of the solution addressing climate change.

The first Environmental Product Declarations (EPDs) for ready-mix concrete in Australia (ViroDecs™) constituted a major investment in comprehensively analysing and communicating to customers the embodied environmental impacts of Holcim's ready-mix concrete.

The development of a concrete EPD is a critical "missing" piece to having all key infrastructure and building products represented by an EPD in Australia. Its publication supports designers and developers to drive improved sustainable procurement and materials selection.

Prior to the publication of the first EPDs for ready-mix concrete, sustainability professionals and procurement managers in the built environment sector were forced to rely on dated national average data for information on the Global Warming Potential (i.e., embodied carbon) of ready-mix concrete. This created a blurred picture for understanding the various embodied impacts of ready-mix concrete, affecting everything from the Infrastructure Sustainability (IS) Materials Calculator to whole-building Life Cycle Assessments under Green Star and carbon abatement strategies for organisations seeking Science Based Targets.

Not only affecting strategic and design work, the lack of company-specific (let alone mix-specific) data also constrained the built environment sector in the manner in which it specified and procured low-carbon concrete. Proxies such as Portland cement reduction and percentage of supplementary cementitious materials (SCM) used were widely adopted as a compromise position.

The publication of Australia's first EPD for ready-mix concrete has led to exciting new opportunities to improve the way low-carbon concrete is specified in tenders and contracts. With the ability to provide mix-specific third-party verified data, Holcim is leading the way for construction contractors and clients to send a clear signal of intent for embodied carbon reduction in the concrete supply chain.

2. Materials and Methods

Data collected from across Holcim's Australian operations, including over 190 concrete batching plant sites and 46 quarries was fed into an ISO14044-compliant Life Cycle Assessment (LCA) model by specialist practitioners to generate an Environmental Product Declaration (EPD) to ISO 14025 and EN 15804, which have been independently reviewed by an approved third-party verifier.

The primary data for the LCA are based on 2017 calendar year production data. SimaPro (v8.4) was used for the LCA modelling, using background data from:

1. The Australian National Life Cycle Inventory Database (AusLCI) (2017);
2. ecoinvent 3.4 (2017);
3. World Business Council for Sustainable Development (WBCSD) Cement Sustainability Initiative (CSI) Tool Project database (international version) (2018);
4. Product specific EPDs for admixtures and fibres.

Allocation was necessary to proportion inputs and outputs to intermediate flows at the quarry and processes at the batching plant level. As much as possible, intermediate flows were allocated physically based on weight (quarries) or based on m^3 of concrete (at the batching plant). At the quarry level, whenever physical allocation was not possible, economic allocation was carried out based on Holcim's internal cost system.

Regarding inputs, it was assumed that fly ash and silica fumes are waste products and therefore burden-free. Ground granulated blast furnace slag from steel blast furnace production was allocated economically. BS EN 16757:2017 specifically lists the following materials relevant to the study as co-products:

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

As such, the above materials are considered as coproducts 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 were 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 AusLCIdataset conforms to EN 15804 when applying allocation to its various processes and sub-processes. Data quality for the foreground data was assessed in terms of geographic and temporal representativeness is shown in Figure 1. All data sources were scored at medium or higher.

Module	Input/outputs	Sub-processes	Data source	Temporal scope	Geographic scope	Quality
A1	Coarse aggregate Manufactured sand Fine aggregate	Electricity	Electricity provider invoices	2017	All states	High
		Diesel	Supplier invoices	2017	All states	High
		Pollutants	National Pollution Inventory (NPI) data	2017	All states	High
		Mains water	Water utility invoices	2017	All states barring NSW	Medium
		Water – other sources (lakes, groundwater, rainwater)	Metered withdrawal data	2017	All states barring NSW	Medium
		Water discharge from site	Measured site data	2017	All states barring NSW	Medium
		Explosives (Manufactured sand and Coarse aggregate only)	Invoices	2017	All states (excluding the Kalgoorlie Quarry in WA which purchases raw feed from an external source)	High
		Gravel	Calculated – spoil + production amount	2017	All states	High
		Spoil	Holcim waste records	2017	All states	High
A2	Aggregate transport	Background data used to model	Actual transport distances and loads per trip	2017	All states (excluding Lynwood Quarry which transports by freight rail)	High
A3	Concrete batching plant	Electricity	Electricity provider invoices	2017	All states	High
		Diesel	Supplier invoices	2017	All states	High
		Mains water	Water metres, with utility invoices as a back-up	2017	All states	High
		Water – other sources (lakes, groundwater, rainwater)	Estimate based on water balance	2017	All states	Medium
		Water discharge from site	Estimate based on Holcim site performance metrics	2017	All states	Medium
		Lubricating oil Conveyor belt	AusLCI concrete process	2015	National	Medium
	GP Cement Fly ash Slag Silica fume Admixtures Fibres	Background data used to model	Holcim internal technical database containing mix designs	2017	All states	High
	Packaging waste	Background data used to model	Estimate based on researched packaging material and sizes	N/A	N/A	Medium

Background data sources were also assessed with respect to their timeliness, with all data sources being last updated within the 10 years required under the PCR 2012:01.

Figure 1. EDP Data quality.

The processes included in the LCA are presented in a process diagram in Figure 2 below.

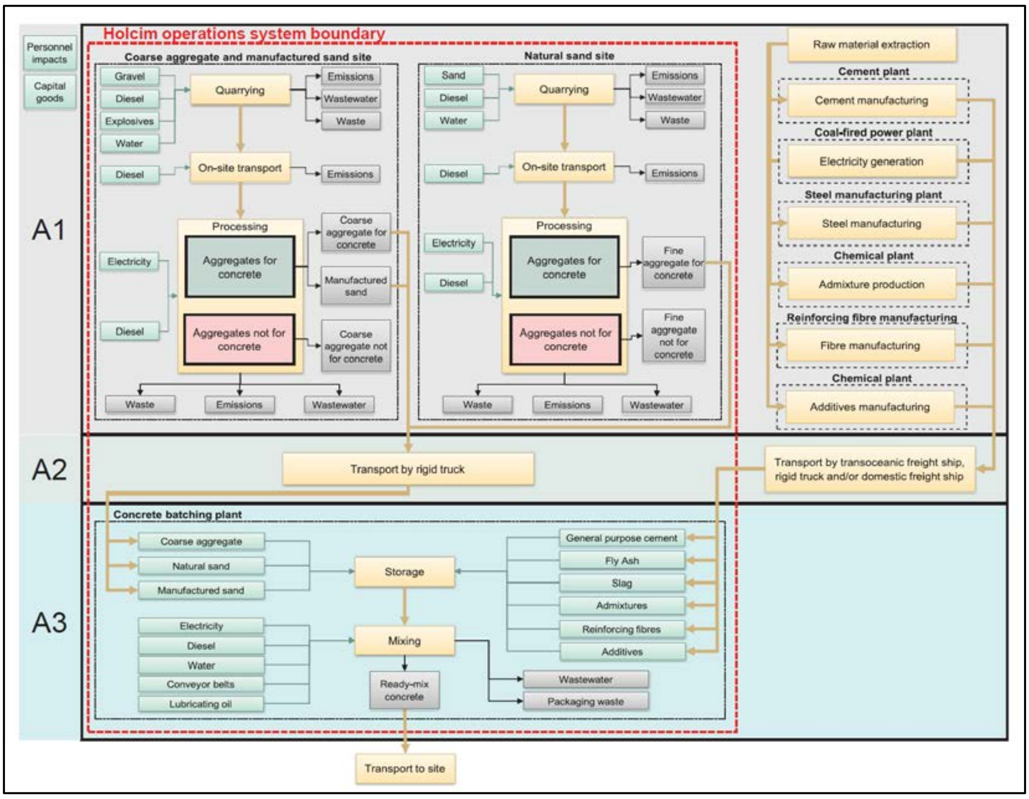

Figure 2. System diagram—the processes included in the EPD LCA in a process diagram.

The key assumptions and limitations of the EPD LCA are outlined and assessed in Figure 3.

Assumption or limitation	Potential impact on LCA results	Discussion	Adjusted impact on LCA results
Raw material data for most of the materials in concrete production is based on generic information.	Significant	The EN 15804 standard permits generic data for upstream processes, however, this is where the main impacts are for products across the life cycle.	Medium
Transport distances assumed for all raw materials barring quarry products	Medium	Conservative assumptions regarding transport distance were made based on country of origin and transport mode information.	Low
It was assumed that all concrete mixes require or result in an equal amount of site resources or discharges.	Medium	The uncertainty analysis undertaken to understand the potential likely impact of this assumption on the LCA results demonstrates that it has a minimal impact on most impact categories.	Low
National average values for site resource use and discharge (quarries and concrete batching plants)	Significant	The uncertainty analysis undertaken to understand the potential likely impact of this assumption on the LCA results demonstrates that it has a minimal impact on most impact categories.	Low
Tolling plants are assumed to have a similar site resource use profile as Holcim operated concrete batching plants.	Low	Concrete batching plant resource use constitute less than 1% of environmental impact in each impact category. Tolling plants (i.e. third part plants toll manufacturing for Holcim) have the same site resource use profile as Holcim branded sites.	Low

Figure 3. The key assumptions and limitations of the EPD LCA.

3. Results

The Holcim's normal-class concrete products included in this EPD have been grouped according to a set of key properties outlined in Figure 4.

Property	Explanation	Application in product grouping
Strength	Concrete strength is measured in units of pressure (MPa) and refer to the load bearing properties of the material.	There are 5 normal-class strength categories in the EPD: 20, 25, 32, 40 and 50 MPa
Blend	The blend refers to the type and number of supplementary cementitious materials (SCMs) included in the mix design.	The 4 normal-class blend categories in the EPD: G - general mix (no SCM) F - fly ash included B - ground granulated blast furnace slag included T - triple blend (includes slag & fly ash)
Slump	A measure of the consistency of fresh concrete, based on the measured reduction in mm of the height of a pile of concrete, as recorded via the 'slump test' method.	A single slump category (80mm) was adopted as an overarching parameter for the normal-class mixes included in the EPD. Please note: the WA-50-B product group consists of mixes at 120 slump
Cement content range	The amount of general purpose cement in 1 m^3 of concrete	Each normal-class product group in the EPD has a defined cement content range for which the EPD results are considered 'representative' (as defined in Section 2.5 of the PCR 2012:01).

Figure 4. Ready-mix concrete key grouping properties for EPD.

The global warming potential (GWP) environmental impacts (unit kg CO_2 equivalents (GWP100)) for 1 m^3 of Holcim ViroDecs^{TM} normal-class ready-mix in New South Wales (NSW) and the Australian Capital Territory (ACT) are shown in Figure 5.

PRIMARY INDICATORS			GWP
Strength (MPa)	Blend	Cement content (kg/m^3)	kg CO_2 eq
20	G	245–280	273
	F	180–224	220
	B	118–145	171
	T	100–123	152
25	G	255–315	297
	F	200–249	241
	B	130–159	185
	T	106–124	154
32	G	298–355	343
	F	227–285	273
	B	138–170	196
	T	122–147	176
40	G	380–430	405
	F	279–347	328
	B	177–216	243
	T	156–189	219
50	G	500–515	514
	F	371–436	414
	B	233–285	303
	T	241–255	284

Figure 5. Cradle to gate GHG emissions (kg CO_2-eq) for 1 m^3 of ViroDecs^{TM} normal-class ready-mix concrete in NSW and ACT. Blend categories: G—General Portland cement mix (no SCM), F—fly ash included, B—ground granulated blast furnace slag included, T—triple blend (includes slag & fly ash). Results presented for medium mix designs using data from 2017. Cement content ranges are provided to assist customers in identifying whether the concrete purchased is covered by the ViroDecs^{TM} EPD. Purchased concrete with a lower or higher cement content is not covered by the ViroDecs^{TM} EPD.

It was found that Holcim's normal-class ready-mix concrete has a range of greenhouse gas (GHG) emissions across each different states, strengths, and blend, covered by the EPD (Figure 6). The GHG emissions associated with 1 m^3 of Holcim normal-class ready-mix concrete in New South Wales (NSW) and the Australia Capital Territory (ACT) Australia are shown in Figure 6 for:

- Holcim ViroDecs^{TM}—General Portland Cement;
- Holcim ViroDecs^{TM}—Fly Ash Blend;
- Holcim ViroDecs^{TM}—Blast Slag Blend;
- Holcim ViroDecs^{TM}—Triple Blend.

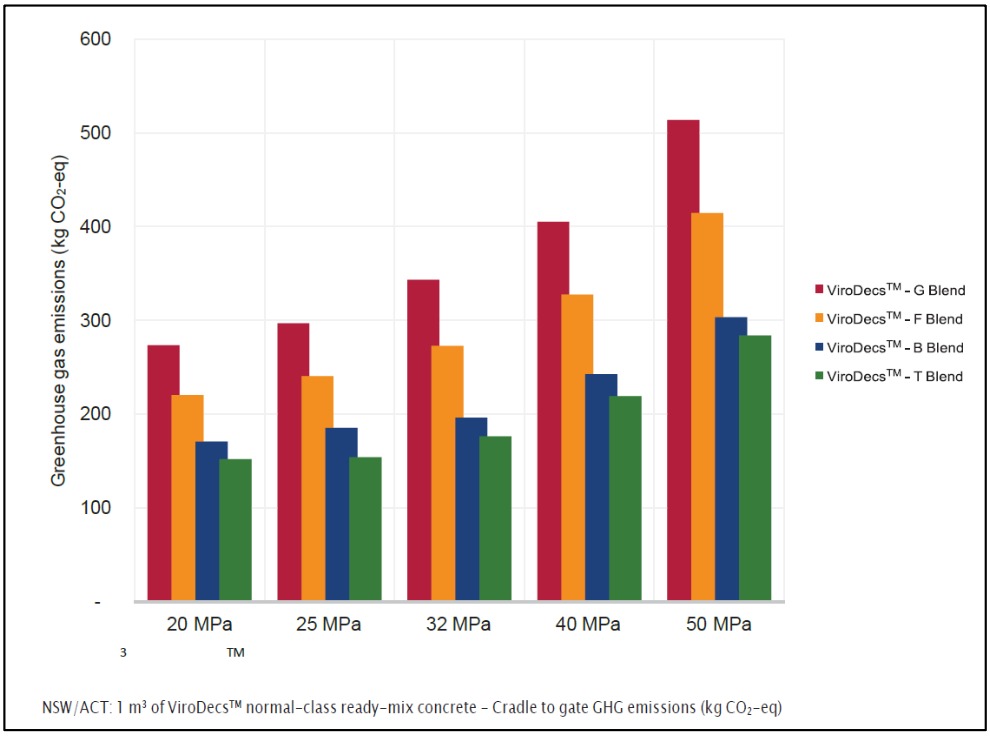

Figure 6. Cradle to gate GHG emissions (kg CO_2-eq) for 1 m^3 of ViroDecs^{TM} normal-class ready-mix concrete in NSW and ACT. Blend categories: G—General Portland cement mix (no SCM), F—fly ash included, B—ground granulated blast furnace slag included, T—triple blend (includes slag & fly ash).

4. Discussion

To evaluate the performance of Holcim's ViroDecs^{TM} normal-class ready-mix concrete range, the EPD results were benchmarked against the Green Star concrete reference case, IS materials calculator default concrete mix, and the Australian National Life Cycle Inventory Database (AusLCI). The following figure shows the results (Figure 7).

The modelling showed that in comparison to the Australian National Life Cycle Inventory Database's (AusLCI) general ready-mix concrete with no cement substitution:

- Holcim's ViroDecs^{TM} General had up to 28% less CO_2-equivalent than the Australian average;
- Holcim's ViroDecs^{TM} Fly Ash Blend had up to 42% less CO_2-equivalent than the Australian average;
- Holcim's ViroDecs^{TM} Slag Blend had up to 52% less CO_2-equivalent than the Australian average;
- Holcim's ViroDecs^{TM} Triple Blend had up to 57% less CO_2-equivalent than the Australian average.

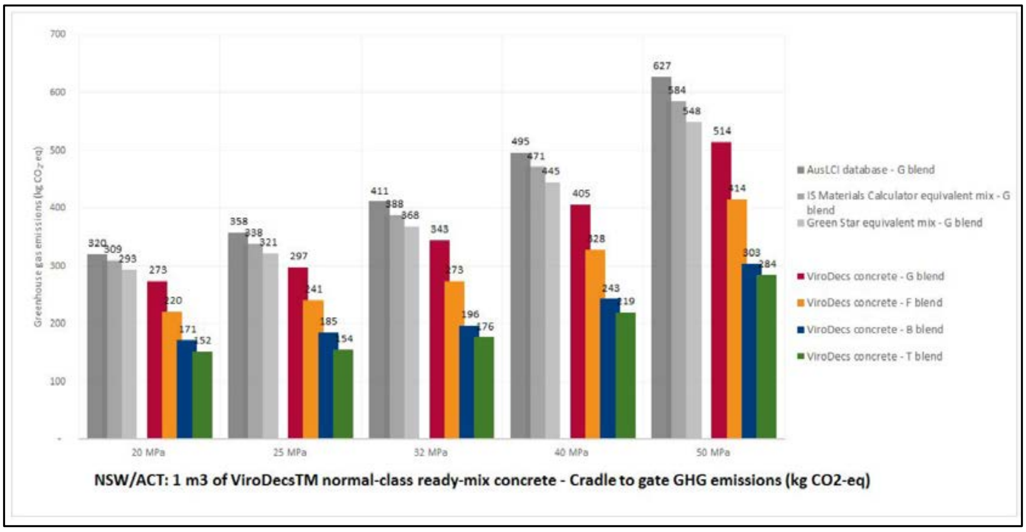

Figure 7. Cradle to gate GHG emissions (kg CO_2-eq) for 1 m^3 of ViroDecsTM normal-class ready-mix concrete in NSW and ACT benchmarked against the Green Star concrete reference case, IS materials calculator default concrete mix, and the Australian National Life Cycle Inventory Database (AusLCI).

Highlighting the potential benefits of the lower carbon concrete with a 57% reduction in embodied carbon, on a hypothetical 500,000 m^3 large scale infrastructure project, using 50 MPa ready-mix concrete instead of the equivalent normal-class concrete could reduce greenhouse gas emissions by up to 170,000 tonnes of CO_2-equivalent. This is a GHG emissions reduction equivalent to removing 32,635 cars from Australian roads (based on 0.401 kg CO_2-eq per km of car travel (AusLCI) and an average travel distance 13,400 km per car in FY17/18 (ABS: https://www.abs.gov.au/ausstats/abs@.nsf/mf/9208.0 (accessed on 4 December 2019))) or powering 24,285 Australian homes with renewable energy sources (based on an average greenhouse gas impact of seven tonnes CO_2-eq for an Australian household per year from energy use (http://www.yourhome.gov.au/energy) (accessed on 4 December 2019)) for a year.

In March 2020, in another Australian-first for Holcim and the construction industry, Holcim used the EPD to gain certification from Australian Government's National Carbon Offset Program 'Climate Active' to sell certified carbon neutral ready-mix concrete. Climate Active is a program administered by the Australian Federal Government to support businesses committed to sustainability, innovation, and industry leadership to drive voluntary climate action. The Climate Active certification enables Holcim to offset the remaining embodied carbon of its ready-mix concrete products on behalf of its customers on an opt-in basis through a transparent third party assured process, which ultimately results in carbon neutral ready-mix concrete (Holcim's ViroDecs Zero).

For a large infrastructure project in Australia (500,000 m^3), the difference between using Holcim's ViroDecs Zero Carbon Neural ready-mix concrete and the Australian average for general blend concrete with no cement substitution could be as much as 313,000 tonnes of CO_2e. This is the same as taking over 58,000 Australian cars (based on 0.401 kg CO_2-eq per km of car travel (AusLCI) and an average travel distance 13,400 km per car in FY17/18 (ABS: https://www.abs.gov.au/ausstats/abs@.nsf/mf/9208.0) (accessed on 4 December 2019)) off the road for a year.

It is noted that in addition to reducing carbon emissions, the offset projects also have the potential to bring additional benefits, including environmental (e.g., habitat and biodiversity protection), economic (e.g., income from the sale of offset units and employment to manage the project), and social (e.g., capacity building and health improvements in local communities).

5. Conclusions

In 2019, Holcim Australia set out to shake up the concrete industry by publishing the first ready-mix concrete Environmental Product Declaration (EPD) in the Australian market. Prior to the publication of the first EPD for ready-mix concrete in Australia, sustainability professionals and procurement managers in the built environment sector were forced to rely on dated national average data for information on the Global Warming Potential (i.e., embodied carbon) of ready-mix concrete. This created a blurred picture for understanding the various embodied impacts of ready-mix concrete, affecting everything from the Infrastructure Sustainability (IS) Materials Calculator to whole-building Life Cycle Assessments under Green Star and carbon abatement strategies for organisations seeking Science Based Targets.

Not only affecting strategic and design work, the lack of company-specific (let alone mix-specific) data also constrained the built environment sector in the manner in which it specified and procured low-carbon concrete. Proxies such as Portland cement reduction and supplementary cementitious materials (SCM) fractions were widely adopted as a compromise position.

The publication of the first EPD for ready-mix concrete in Australia has led to exciting new opportunities to improve the way low-carbon concrete is specified in tenders and contracts. With the ability to provide mix-specific third-party verified data, EPDs are leading the way for construction contractors and clients to send a clear signal of intent for embodied carbon reduction in the concrete supply chain.

Using EPDs as a building block, concrete can be specified in terms of global warming potential (measured in kg CO_2-eq). This opens up the opportunity for suppliers to promote their low embodied carbon products, creating healthy competition that benefits projects and the economy, as well as the environment.

The publication of EPDs for a number of construction materials in Australia highlights the importance and benefits of a standardised evidence-based approach to environmental claims and the evaluation and selection of materials based on their true sustainability performance.

Author Contributions: Conceptualization, E.S. and C.W.; methodology, C.W.; software, C.W.; validation, E.S. and C.W.; formal analysis, E.S. and C.W.; investigation, E.S. and C.W.; data curation, E.S and C.W., writing—original draft preparation, E.S. and C.W.; writing—review and editing, E.S.; visualization, C.W.; project administration E.S. All authors have read and agreed to the published version of the manuscript

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Stocker, T.F.; Qin, D.; Plattner, G.K.; Tignor, M.M.; Allen, S.K.; Boschung, J.; Nauels, A.; Xia, Y.; Bex, V.; Midgley, P.M. *Climate Change 2013: The Physical Science Basis—Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; IPCC: Geneva, Switzerland, 2014.
2. Abergel, T.; Dean, B.; Dulac, J.; Wheeler, T. *Data from Global Status Report 2018*; Global Alliance for Buildings and Construction & International Energy Agency: Paris, France, 2018.
3. Chatham House Report Johanna Lehne and Felix Preston Energy, Environment and Resources Department. *2018 Making Concrete Change Innovation in Low-Carbon Cement and Concrete*; Royal Institute of International Affairs: London, UK, 2018.