A NET-ZERO CARBON CONCRETE INDUSTRY FOR AOTEAROA NEW ZEALAND

Roadmap to 2050

concretenz
BUILDING RESILIENCE

BUILDING INNOVATION PARTNERSHIP

BRANZ
Funded from the Building Research Levy

FOREWORD FROM
CONCRETE NEW ZEALAND

We are excited to share our net-zero carbon roadmap, which sets out a realistic plan for how the cement and concrete industry in Aotearoa New Zealand will continue to reduce its CO_2 emissions to zero by 2050.

We asked trans-Tasman sustainability firm thinkstep-anz to develop the report with us. It builds on the 2021 initiative Our Concrete Future by the Global Cement and Concrete Association.[1] The imperative to reduce greenhouse gas emissions is a global one, and the cement and concrete industry around the world is playing its part. We are joining the global push to decarbonise our industry and to help build the sustainable world of tomorrow.

In New Zealand, our sector has been on its own journey to decarbonise, having already delivered an 11% reduction between 2005 and 2020 while growing our production by 11%.[2] We can and will do more.

To reach our ambitions, the industry needs significant regulatory, technological, structural, and behavioural changes across the cement and concrete value chain.

We invite specifiers, customers, engineers, procurers, standards authorities, and government and non-government agencies to contribute to our common goal of a zero-carbon future.

The pathways thinkstep-anz has identified by working with all major parties in the concrete value chain show that the vision of a net-zero cement and concrete sector in New Zealand is achievable. Working together, all involved in the industry value chain can make the vision a reality.

We aim to review annually, and report on progress across the pathways every five years to ensure new technologies and innovation (as well as regulatory and other changes) are included and the currently proposed pathways can be updated.

We welcome the funding contributions for this piece of work from MBIE's (Ministry of Business, Innovation and Employment) Building Innovation Partnership (administered through the University of Canterbury), the Building Research Levy, and from Concrete NZ Inc.

Rob Gaimster
Chief Executive | Concrete NZ

1 Global Concrete and Cement Association Concrete Future – Roadmap to Net-zero 2021. https://gccassociation.org/concretefuture/wp-content/uploads/2021/10/GCCA-Concrete-Future-Roadmap-Document-AW.pdf

2 Concrete New Zealand - NZ Concrete Industry Emissions Reduction 2020 https://concretenz.org.nz/page/s_introduction

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EXECUTIVE SUMMARY: OUR **ROADMAP TO NET-ZERO**

We are determined to reduce our industry's greenhouse gas (GHG) emissions to net-zero by 2050. We are committed to New Zealand's Zero Carbon Act and its goal to ensure our country plays its part in reducing GHG emissions under the Paris Agreement. Our roadmap sets out a plan for how we will do this and play a major role in building the sustainable world of tomorrow. It describes an achievable pathway to producing net-zero concrete by 2050 that works for our industry in New Zealand.

MAPPING OUT THE ROAD AHEAD

This roadmap covers both ready-mixed concrete and concrete products. It builds on past and current initiatives. It involves the major parties in the concrete value chain:

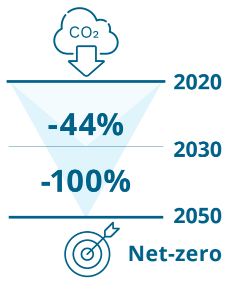
- → cement manufacturers
- → concrete producers
- → manufacturers of concrete products
- → designers of buildings and infrastructure
- → construction companies and contractors.

To be successful in continuing to reduce our emissions, further R&D, investment and commitment from researchers, government and all stakeholders throughout the concrete value chain will be crucial.

This roadmap has been developed with support from sustainability firm thinkstep-anz through engagement with Concrete NZ's member groups: Cement, Masonry, Precast, Readymix and Learned Society

TARGETS FOR 2030 AND 2050

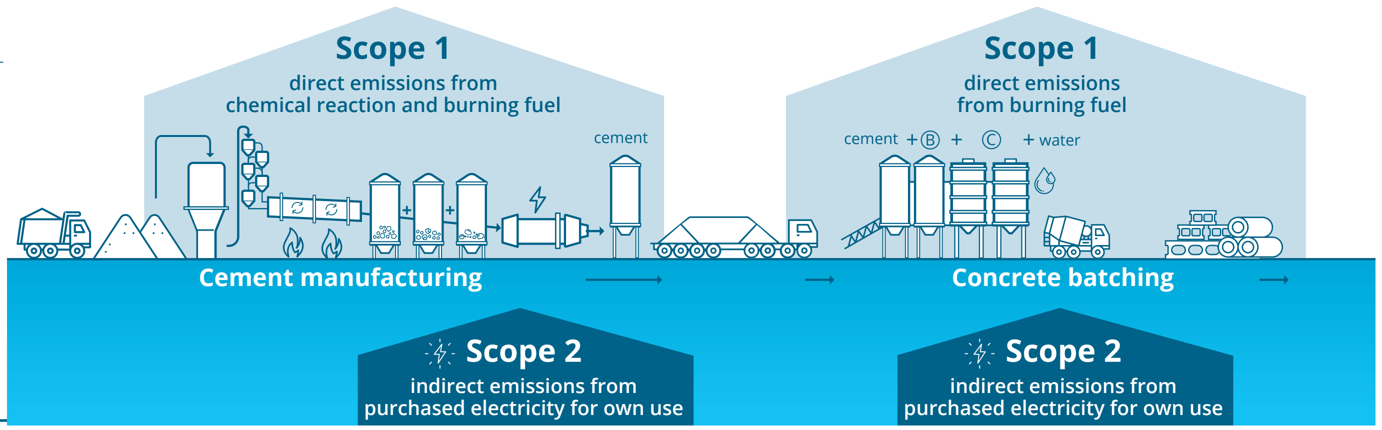
This roadmap identifies ways to reduce the direct (Scope 1) and electricity-related (Scope 2) GHG emissions from our industry by 44% from 2020 levels by 2030 (as described in the body of this report). The 2020 reference year was chosen to align with the Global Cement and Concrete Association's (GCCA) Cement and Concrete Industry Roadmap for Net Zero Concrete.



Our focus on Scope 1 and Scope 2 emissions aligns with the GCCA's global roadmap and other national roadmaps. It also focuses on areas where our industry has direct influence.

Figure 1 illustrates Scope 1 and Scope 2 emissions in the cement and concrete manufacturing process. If indirect (Scope 3) emissions are included to align with an Environmental Product Declaration approach, this reduction is 29% by 2030 (see Annex B).

Figure 1. Scope 1 and 2 emissions from producing cement and concrete



HOW WE ARE GOING TO ACHIEVE THIS

THE IMPACT OF PORTLAND CEMENT

Manufacturing Portland cement releases CO_2 directly through a chemical reaction. This chemical reaction is a major share of our industry's total emissions.

WE FOCUS ON:

- **reducing emissions** as much as possible
- removing what we can't reduce through **capturing carbon and recarbonation**

WE DO NOT:

- **rely on carbon offsetting**

WHERE OUR ACTIONS WILL MAKE THE BIGGEST DIFFERENCE

UNTIL 2030:

We will further reduce the emissions of cement through alternative fuels and increasing the use of mineral additions (e.g., ground limestone) and Supplementary Cementitious Materials (SCMs). SCMs are typically mineral by-products of industrial processes with lower embodied carbon than cement. New Zealand has some history of using SCMs, but there is scope for growth. 2023 will see greater volumes of SCMs entering the market.

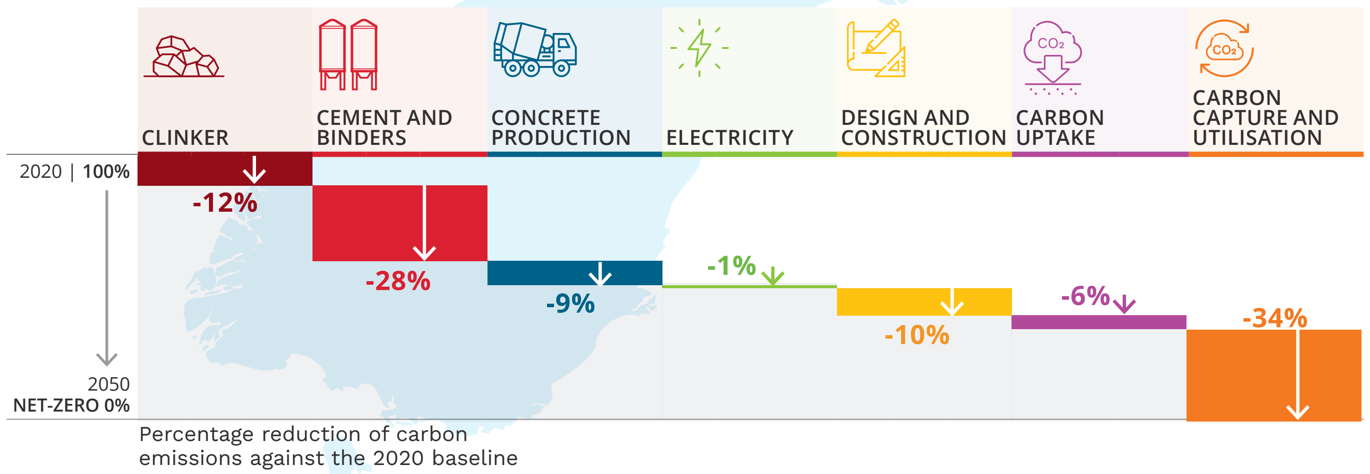
2030 - 2050:

We will focus on significant reductions in GHG emissions in cement manufacture and we are planning to use a technology known as CCUS (Carbon Capture, Utilisation and Storage) to capture any remaining emissions. Further CO_2 will be captured naturally by concrete as it ages through a process called recarbonation - a carbon uptake mechanism.

OUR PATHWAY FOR DECARBONISATION

The chart below shows the actions we expect to achieve net-zero GHG emissions from cement and concrete in New Zealand by 2050. In addition to clinker factor reduction, replacing some Portland cement with SCMs and carbon capture technologies, we expect improving efficiency in the design of buildings and infrastructure and in producing clinker to make the biggest differences. We also expect further small savings as the electricity grid continues to decarbonise.

Figure 2. Decarbonisation roadmap of cement and concrete in Aotearoa New Zealand



WHY CONCRETE IS VITAL TO A CHANGING NEW ZEALAND

The properties of concrete in both mitigating and adapting to the effects of climate change support sustainable and resilient communities both around the world and in Aotearoa New Zealand.

Concrete is the essential building material that has shaped our modern society and it is vital for building a more sustainable future. It will play an integral role in creating and maintaining thriving communities by delivering infrastructure, homes, clean water, clean and renewable energy and by providing a more resilient built environment as our climate changes.

The second-most consumed commodity in the world after water, concrete plays a central role in modern life. Buildings, road and rail, the electricity system, air, and seaports, provisions for drinking water, wastewater and stormwater, resilience against natural hazards and the effects of climate change – hardly an area of human activity where concrete doesn't play a role.

Builders of energy-efficient high-rise buildings and residential housing appreciate concrete for its thermal mass, reducing noise and heating and cooling bills, and providing fire safety. The relatively low cost and high speed of construction, as well as its strength and durability, make concrete ideal for housing foundations.

Concrete is almost infinitely versatile in building and construction, be it the ready-mixed concrete placed on-site into almost any shape, precast wall panels and other components, concrete blocks and pavers, pipes, and culverts, and more. At end-of-life, concrete can be repurposed, reused, or recycled.

As we adapt to climate change, sea levels continue to rise and we are seeing more extreme weather events leading to flooding and fire. Concrete will form part of the solutions to New Zealand's infrastructure and construction challenges while continuing its everyday use. The concrete industry in Aotearoa places more than four million cubic metres of quality-assured material every year around the country. In building for the future, this amount will only climb.

It is crucial that we reduce the CO_2 footprint of cement and concrete while enabling the more than 10,000 people in the industry to produce and supply lower-carbon product to where New Zealand needs it.

AVAILABILITY

Concrete is a local material. Our concrete industry supplies the country with quality-assured concrete and has not been held back by recent supply chain constraints.

DISASTER RESILIENCE

Concrete stays standing more often in the face of disaster events such as fire and flooding. This reduces the need for rebuilding and helps communities to recover faster.

CARBON UPTAKE

Concrete absorbs a significant amount of CO_2 over its lifetime. The process called recarbonation has been recognised by the UN's Intergovernmental Panel on Climate Change.

DESIGN VERSATILITY

Concrete as a finished surface lowers construction costs and the need for maintenance. It is versatile, can be shaped into any form and is available in an array of colours and surface textures. It gives designers huge versatility and can be constructed onsite or offsite.

AFFORDABILITY

Concrete is a cost-effective material and has not been subject to the high price volatility of other materials.

THERMAL MASS

Concrete can absorb and store heat that can be used for passively heating or cooling environments. This reduces the need for energy-intensive heating and cooling solutions.

STRENGTH AND DURABILITY

Concrete structures last longer and require less maintenance. Concrete can be designed for low-strength and ultra-high-strength purposes.

CIRCULAR ECONOMY

The industry uses recycled material from other waste streams such as secondary aggregates and SCMs. Waste is also used as an alternative fuel in cement kilns. Concrete structures are increasingly being repurposed and reused at the end of their useful life, rather than being demolished. Where the asset is no longer fit for purpose, concrete can be crushed and used to replace primary aggregates.

INTRODUCTION

Severe weather events have highlighted the need to focus on the twin imperatives of climate change: mitigation and adaptation. Concrete is a key part of New Zealand's future sustainability, adaptation and resilience plans due to its unique attributes.

Concrete is an essential element that forms part of wind farms, hydroelectric schemes and geothermal plants. It can also improve the resilience of buildings and communities through better stormwater management, flood defences and many other forms of critical infrastructure.

As supporters of the Global Cement and Concrete Association (GCCA), Concrete NZ's members have committed to producing carbon-zero concrete by 2050 in line with global climate targets. This roadmap sets out how we will achieve this within the New Zealand context.

GCCA 2050 CEMENT AND CONCRETE INDUSTRY ROADMAP FOR NET-ZERO CONCRETE

The GCCA global roadmap sets out a net-zero pathway to help limit global warming to 1.5ºC. The action put forward in the global roadmap has been endorsed by the UN and the World Business Council for Sustainable Development.

The global cement industry has already made progress with proportionate reductions of CO_2 emissions in cement production of 20% over the last three decades (GCCA, 2021). The global roadmap aims to achieve the same reduction in only a decade.

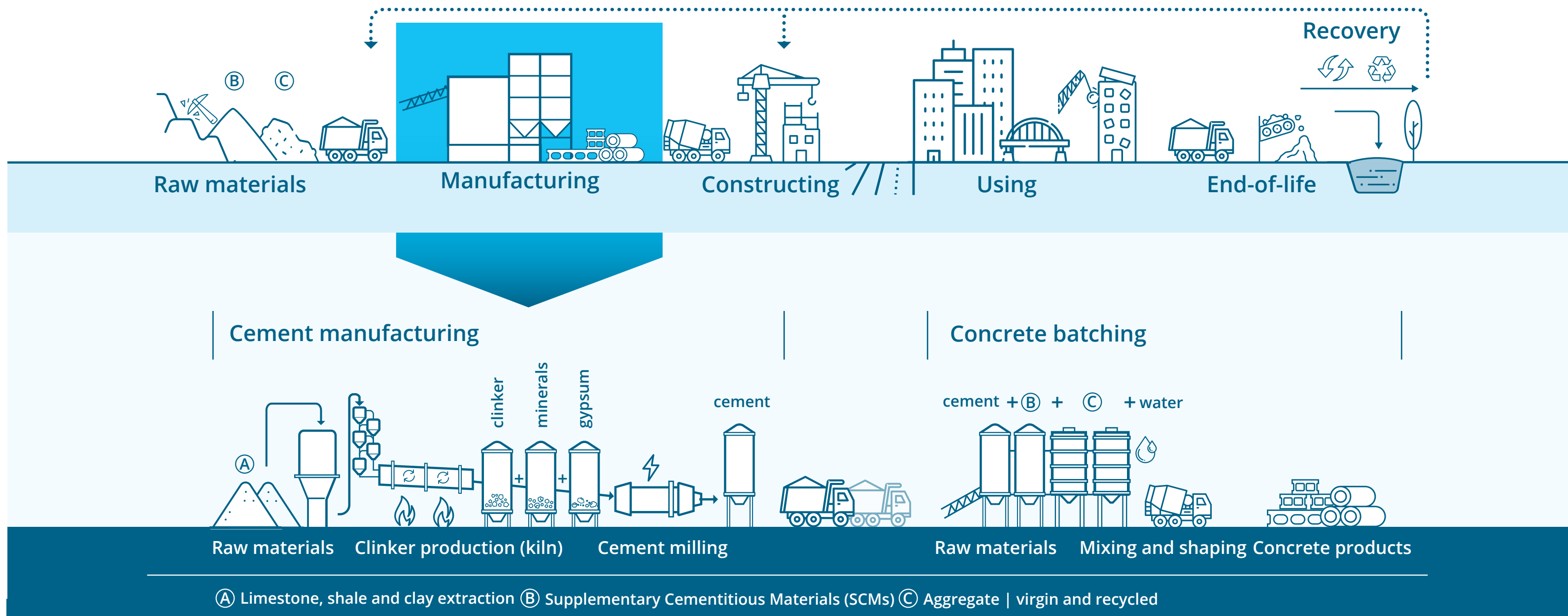
Actions in the global roadmap between now and 2030 will prevent almost five billion tonnes of CO_2 emissions from entering the atmosphere compared to a business-as-usual scenario.

NEW ZEALAND'S **CEMENT AND CONCRETE SECTOR**

In its simplest form, concrete is made from a mixture of cement, crushed stone/gravel, sand, and water. Its properties are shaped to create almost infinite solutions using additions such as chemical admixtures. Cement is a binder material traditionally manufactured from limestone and clay and is a key ingredient in concrete.

Concrete plays a major role in New Zealand's built environment. It is long-lasting, resists fire and flooding events, reduces the transmission of noise and vibration, and stores heat, making heating and cooling buildings more efficient.

Figure 3. The life cycle of cement and concrete



WHAT ARE SCMs?

A big part of concrete's GHG emissions stems from the energy needed for making cement and through the chemical reaction involved.

Supplementary cementitious materials (SCMs) can partially replace the cement in concrete. They're often mineral by-products of industrial processes typically with lower embodied carbon than cement.

SCMs can either be incorporated into cement or directly into concrete.

The most common SCMs are ground granulated blast-furnace slag (GGBS) from steelmaking, fly ash from coal-fired power stations, and silica fume.

SCMs can also be manufactured, such as calcined clay. Natural SCMs, such as high-silica volcanic ash and pumice, need to be developed further so they can be used in New Zealand.

While GGBS and fly ash are the dominant SCMs in today's market, the gradual phase-out of coal-fired power stations and conventional blast furnaces for steelmaking means that these SCMs will increasingly be substituted for the other types of SCMs during the time horizon covered by this roadmap.

BUILDING OUR ROADMAP TO NET-ZERO CONCRETE

WHO WE ENGAGED WITH

- Cement manufacturers (in separate workshops with Golden Bay, Holcim New Zealand and HR Cement)
- Ready-mixed concrete manufacturers
- Precast concrete manufacturers
- Precast pipes and tank manufacturers
- Masonry manufacturers
- Concrete NZ Learned Society
- Sustainability managers from the wider construction sector

WHAT WE ANALYSED

Our findings cover direct (Scope 1) and electricity-related (Scope 2) GHG emissions for producing cement and concrete up to the point the concrete leaves the batching plant. For cement, we included process emissions from manufacturing Portland cement, as well as emissions from burning fuels and using electricity within the cement plant. The scope for concrete production was the same and includes emissions from fuel combustion and electricity.

This roadmap includes all cement used in concrete within New Zealand, whether manufactured in New Zealand or imported. It therefore uses a consumption perspective rather than a production perspective.

Given that recarbonation (carbon uptake) is a slow but ongoing process, CO_2 reabsorption is estimated for all concrete in use within New Zealand.

Our focus on Scope 1 and Scope 2 emissions was chosen to align with other concrete decarbonisation roadmaps around the world. It also helps us to focus on those areas where we have the most influence.

Our indirect (Scope 3) emissions – including emissions from transport, manufacturing aggregates, manufacturing SCMs, and end-of-life – are reported in Annex B. These Scope 3 emissions were found to be approximately 40% of the total emissions of concrete over its full life cycle in 2020 (see Annex B).

STRATEGIES FOR DECARBONISATION

STRATEGIES FOR DECARBONISATION

We are focusing on the strategies developed by the GCCA in its global roadmap. We confirmed in workshops with members of the New Zealand cement and concrete industry that these strategies are appropriate for our industry and that nothing important is missing.

The strategies are:

CLINKER

Reducing emissions from clinker production

Use of alternative fuels, particularly biofuels, in the cement kiln and greater efficiencies in clinker production.

CEMENT AND BINDERS

Reducing emissions from cement and binders

Using less cement by replacing it partly with SCMs and mineral additions (particularly limestone) in Portland cements. This category also includes novel non-Portland cements.

CONCRETE PRODUCTION

Efficiency in concrete production

Making concrete batching more efficient, e.g., using more effective admixtures to reduce the cement required per cubic metre of concrete produced.

ELECTRICITY

Decarbonisation of electricity

Further decarbonising New Zealand's electricity grid, which reduces the carbon emissions from cement grinding and concrete batching.

DESIGN AND CONSTRUCTION

Efficiency in design and construction

Demand-side measures, such as lightweight structural members and changes in standards allowing for different concrete specifications and testing.

CARBON UPTAKE

Hardened concrete exposed to the atmosphere absorbs CO_2 through a process called recarbonation.

CARBON CAPTURE AND UTILISATION

Removing CO_2 from the chemical process for producing Portland cement from exhaust gases or directly from the air.

Figure 4 on page 12 shows the strategy and the decarbonisation of cement and concrete within Aotearoa New Zealand in more detail.

DECARBONISATION OF CEMENT AND CONCRETE WITHIN AOTEAROA NEW ZEALAND

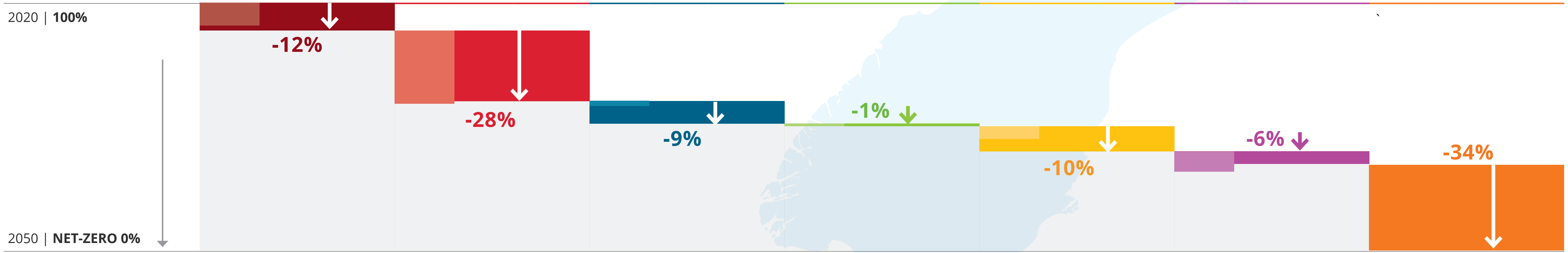
OUR **ROADMAP EXPLAINED**

We have developed specific pathways to decarbonisation for New Zealand, due to some key differences from global scenarios:

- → New Zealand currently has a low uptake of SCMs compared to other countries.
- → Electricity is already largely decarbonised in New Zealand.
- → Seismic conditions constrain the opportunity for lightweight/ slim concrete member design.
- → NZ-manufactured clinker has a lower carbon footprint than the global average due to biofuels initiatives already in place.

Figure 4. Decarbonisation roadmap of cement and concrete within Aotearoa New Zealand

	CLINKER	CEMENT AND BINDERS	CONCRETE PRODUCTION	ELECTRICITY	DESIGN AND CONSTRUCTION	CARBON UPTAKE	CARBON CAPTURE AND UTILISATION
STRATEGY →	**Reducing emissions from clinker production** Use of alternative fuels, particularly biofuels, in the cement kiln and greater efficiencies in clinker production.	**Reducing emissions from cement and binders** Using less cement by replacing it partly with SCMs and mineral additions (particularly limestone) in Portland cements. This category also includes novel non-Portland cements.	**Efficiency in concrete production** Making concrete batching more efficient, e.g., using more effective admixtures to reduce the cement required per cubic metre of concrete produced.	**Decarbonisation of electricity** Further decarbonising New Zealand's electricity grid, which reduces the carbon emissions from cement grinding and concrete batching.	**Efficiency in design and construction** Design optimisation, such as appropriate strength class specification, and project scheduling to accommodate potentially longer curing times with low carbon concretes.	Hardened concrete, exposed to the atmosphere absorbs CO_2 through a process called recarbonation.	Removing CO_2 from the chemical process for producing Portland cement from exhaust gases or directly from the air.
DECARBONISATION OF CEMENT AND CONCRETE WITHIN AOTEAROA NEW ZEALAND →	New Zealand already uses a high share of biofuels and waste fuels. This means the scope to improve is lower than it would otherwise be.	Currently, the use of SCMs in New Zealand is very low compared to other countries. It sits at around 2% of total binders in ready-mix concrete. The clinker factor in New Zealand's General Purpose (GP) cements is also relatively high, allowing scope to reduce the clinker factor and to transition to blended (GB) cements.	Gains from producing concrete more efficiently are expected to initially be small due to the introduction of new binders (SCMs and blended cements) in New Zealand. By 2050, these gains are expected to climb closer to the global average.	Electricity forms a small part of the carbon footprint of cement and concrete. In New Zealand, there is limited scope for decarbonising electricity further as the grid is already 80-85% renewable.	Revising standards to allow for slower strength development, would mean that not as much cement is required to achieve high early strength. Unlike in many other countries, there is little potential for reducing the volume of concrete in construction in New Zealand due to seismic risks.	We use the same base assumptions as the GCCA.	CCUS is required to take up all remaining emissions that cannot be reduced through decarbonisation measures. CCUS has been calculated as the remainder required to achieve carbon neutrality. There may be potential to increase CCUS beyond the level indicated in this report.
	NZ 2030 -9% NZ 2050 -11% Global 2050 -11%	NZ 2030 -29% NZ 2050 -28% Global 2050 -9%	NZ 2030 -2% NZ 2050 -9% Global 2050 -11%	NZ 2030 -1% NZ 2050 -1% Global 2050 -5%	NZ 2030 -5% NZ 2050 -10% Global 2050 -22%	NZ 2030 -8% NZ 2050 -6% Global 2050 -6%	NZ 2030 -0% NZ 2050 -34% Global -36%



WHAT WE NEED TO **MAKE THIS HAPPEN**

A CALL FOR GOVERNMENT ACTION

The government plays a critical part in our journey to achieving net-zero carbon concrete in New Zealand by 2050. New Zealand is already on the path to a low-emissions, climate-resilient future. The government has set into law a target for net-zero greenhouse gas emissions by 2050 (other than for biogenic methane).

Delivering on the roadmap's multiple pathways will require industry action and holding to a high level of ambition. We cannot achieve it in isolation. It requires the input, support and action of policymakers, governments, investors, researchers, innovators and end users to each play their part.

Below are some of the actions we believe government can take to support emissions reductions in our sector. These recommendations are consistent with existing New Zealand Government policies and approaches to climate change action.

Recommended actions for government:

- → Continue to support research and development into lower-carbon cements and concretes.
- → Continue to support emission reduction partnerships with New Zealand industry.
- → Provide formal recognition in statute and regulation of carbon uptake.
- → Develop standards for construction materials to enable the uptake of SCMs and blended cements in concrete.
- → Ensure a level playing field under the Emissions Trading Scheme for domestically produced and imported cement.
- → Increase the minimum building design life with B2 Durability from 50 to 100 years within the New Zealand Building Code.
- → Recognising the lower carbon and resilience benefits of concrete road pavements when deployed in the appropriate places.
- → Develop regulations and standards for calculating the embodied CO_2 in building materials and in structures to provide an accurate and level playing field for all materials and structures.
- → Adopt a materials-neutral approach to government procurement. It should not be the role of the government to promote one material over another. Engineers, architects and specifiers are the appropriate arbiters in material selection.
- → Recognise the benefits of concrete as a building material that, among other things, helps deliver renewable electricity and protects from the effects of climate change.

We look forward to working with government on these recommendations.

FUTURE **RESEARCH AND DEVELOPMENT PRIORITIES**

To put our roadmap into action, we need innovations for the entire concrete value chain. These innovations include removing barriers and sharing information, as well as further research and development. These areas define future R&D priorities and projects which will need to be developed separately from the work set out in this report. An estimate of the Technology Readiness Level (TRL) for each priority is indicated in Table 1 below.

Table 1. Research and development priorities

Pathway	Description	Rationale	Potential stakeholders	TRL
Cement, Concrete	Remove the barriers to the use of SCMs and GB cements	Uptake of SCMs in NZ is at about 2%. The construction industry is risk-averse and the route to specify low-carbon materials needs work.	Concrete NZ Learned Society, BRANZ (Building Research Levy), Universities, Building Innovation Partnership	<2025
	Database on low carbon cement and concrete technologies	A comprehensive database will develop trust and knowledge of these materials.	Concrete NZ Learned Society, BRANZ (Building Research Levy), Building Innovation Partnership	<2025
	Develop alternative SCMs	New Zealand has an abundance of natural pozzolans and clays which need research to commercialise them.	Concrete NZ Learned Society, BRANZ (Building Research Levy), Building Innovation Partnership	<2030
	Development and research into a regulatory pathway for CCUS	CCUS forms a considerable part of our decarbonisation roadmap.	Concrete NZ, Building Innovation Partnership, Government through the Government Investment in Decarbonising Industry (GIDI) Fund, the energy sector	>2030
Cement, Concrete, Construction	Remove the barriers to green concrete infrastructure	There is no use of concrete pavements in NZ. Severe weather events have increased the focus on resilience.	Concrete NZ, Waka Kotahi, Building Innovation Partnership	<2025
	Optimise concrete durability by specification	Linking to overseas research, only certain cement types are permitted today in NZ. Performance-based specifications could become an option.	The International Federation for Structural Concrete (fib), The International Union of Laboratories and Experts in Construction Materials, Systems and Structures (RILEM), universities and research organisations – both domestic and international	>2025
	Amend NZS 3101: Concrete Structures	NZS 3101 is the flagship design standard for concrete structures. Need to ensure there are no barriers to the use of low-carbon material in the Standard. Confirm there is no redundancy in design factors linking to other research priorities listed here.	Concrete NZ Learned Society, Standards NZ, MBIE, Structural Engineering Society New Zealand (SESOC), Engineering NZ	>2025
	Further research to enhance the carbon uptake of concrete products	Recarbonation (carbon uptake) varies by surface area exposed to air. Investigate ways to enhanced carbon uptake after installation.	Concrete NZ Learned Society, Universities, Building Innovation Partnership, Concrete NZ, Engineering NZ, Toitū	>2030
Design and Construction	Resource-efficient design principles	Review the feasibility of resource-efficient design methodology and consider New Zealand's seismic issues.	Concrete NZ Learned Society, fib, universities, and research organisations – both domestic and international	>2025
	Efficient design factors – Review design factors for redundancy	Design factors used in prevailing Codes and Standards should be interrogated and, if needed, amended to ensure efficient use of concrete in structures.	Concrete NZ Learned Society, Standards NZ, MBIE, SESOC, Engineering NZ	>2025

GLOSSARY OF TERMS

Aggregates	Aggregates for concrete comprise small stones, gravel and sand.
Carbon uptake (Recarbonation/ Carbonation)	Cement recarbonation or concrete carbonation refers to the process where CO_2 is absorbed by concrete during its use and end-of-life phase. The amount absorbed is significant but less than the total emitted in cement production.
CCUS (Carbon Capture Use and Storage)	Carbon capture, utilisation and storage (CCUS) – also referred to as carbon capture, utilisation and sequestration – describes processes that capture CO_2 emissions from industrial sources and either reuses or stores them, so they will not enter the atmosphere.
Cement	Cement is a powder manufactured through a closely controlled chemical combination of calcium, silicon, aluminium, iron and other ingredients. When mixed with water, sand and gravel, it will form concrete and mortar.
Clinker	Clinker is a material produced by heating limestone and clay at a temperature of about 1400° – 1500°C. It is the basic ingredient of cement.
Clinker factor	The percentage of clinker in cement. Lower carbon cements typically have lower clinker factors.
CO_2	CO_2 stands for carbon dioxide. It is a colourless, odourless, and non-combustible gas. It is a greenhouse gas that contributes to global warming. Formed by complete combustion of fossil fuels (coal, charcoal, natural gas, petroleum) and CO_2-containing products (such as limestone),
Global Warming Potential (GWP)	GWP is a measure of how much heat a greenhouse gas traps in the atmosphere relative to carbon dioxide (CO_2). It has been developed to compare the global warming impact of different gases. The GWP depends on how effective the gas is at trapping heat and how long it stays in the atmosphere before it breaks down.
Limestone	Limestone is a sedimentary rock mainly made up of calcium carbonate. This is why, when heated, it releases CO_2. It is the main raw material used in clinker production.
Net-zero carbon	Net-zero is used throughout this document with respect to the industry and its products and relates to the reduction of CO_2 emissions, across the whole life cycle, to zero. Carbon capture by our industry at our industrial plants is included in our actions to reduce carbon emissions to zero. Offsetting measures such as planting trees or other nature-based solutions are not included in the calculations to get to net-zero.
New binders	New binders or novel cements is a term used to designate alternatives to traditional Portland clinker-based cements. They are binding materials manufactured using novel, low-carbon processes that offer similar performance to traditional cement. Most react in a familiar way with water, but some react with CO_2 to solidify into a hardened mass.
Renewable energy	Renewable energy is energy that is produced from renewable sources. It includes energy from wind, hydro, solar, geothermal, tide, waves and biomass.
Supplementary Cementitious Materials (SCMs)	SCMs, or clinker substitutes, are a wide range of materials that can be used to replace part of the clinker in cement. They can either be blended with cement or used directly in concrete batching. They can be naturally occurring materials, industrial byproducts, or manufactured products. Examples include ground granulated blast furnace slag (GGBS), fly ash, silica fume, calcined clays (metakaolin) and natural pozzolans (high-silica volcanic ash and pumice).

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ABOUT **CONCRETE NZ**

Concrete New Zealand represents more than 500 corporates and individuals who contribute significantly to the construction sector. Concrete NZ advocates on behalf of the cement and concrete industry.

Our industry spans cement manufacturers and producers of ready-mixed concrete, masonry products and precast elements, including wall panels, pipes and culverts.

OUR VISION

"Supporting industry to position concrete as the construction material of choice for a modern and resilient New Zealand."

OUR STRATEGY AND COMMITMENTS

Our Strategic Charter rests on four pillars:

- → consolidated voice
- → raising standards
- → promoting quality
- → improving reputation.

We fund research and development, and educate and train concrete placers, specifying architects and engineers. We audit concrete plants and influence the development of government policy.

We want to promote the good work our industry is doing in steadily reducing the carbon footprint of concrete, and to incentivise more reuse, repurposing and recycling of concrete.

ABOUT **THE BUILDING INNOVATION PARTNERSHIP**

The Building Innovation Partnership (BIP) is an eight-year (2018-2026) $12.5m programme of applied research, based in Civil and Natural Resources Engineering at the University of Canterbury.

The purpose of the BIP is to improve the affordability and performance of NZ's infrastructure by supporting the uptake of digital technologies and other innovations by industry. The programme is delivered through four themes covering horizontal infrastructure and buildings.

THEME 1	THEME 2	THEME 3	THEME 4
Better investment decisions (Three Waters)	Digital technologies (BIM, AI and digital twins)	Fit-for-purpose building components (Seismic performance)	Low carbon and climate-resilient infrastructure (Low carbon materials and buidlings)

←→ **DATA METHODS AND ANALYTICS**

ANNEX A - STRATEGIES

Our pathway to decarbonising concrete in New Zealand

This annex provides more detail on the pathways that will allow the New Zealand cement and concrete industry to reach its goal of producing net-zero concrete by 2050.

CLINKER

The main precursor to cement is clinker, which is currently energy-intensive to produce. Clinker, nodules of grey, mineral material, is produced by heating crushed limestone with small amounts of ironsands and clay to around 1,400-1,500°C in a kiln.

Around 35% of the emissions from manufacturing clinker come from burning fuel at the cement kiln. These emissions can be mitigated by using biofuels such as waste wood and waste tyres.

Waste tyres also contain steel wire which removes the need to use ironsands, providing additional small savings in CO_2 emissions.

Green hydrogen is a potential alternative kiln fuel of the future. It would eliminate the need for fossil fuel for manufacturing clinker, or 35% of the CO_2 emissions from this process. Another option is to electrify kilns. Like hydrogen, it is a longer-term alternative with significant investment in return for large benefits.

CEMENT AND BINDERS

Cement is made by adding gypsum and mineral additions to clinker and milling the materials to form a powder. Cement that is nine-tenths clinker by weight has a 'clinker factor' of 90%. Adding more limestone and/or processed clay minerals (calcined clay) to the mix reduces the clinker factor. A lower clinker factor means lower embodied carbon in the resulting cement, for the same binder performance. Internationally, this is a fast-developing field.

Substituting low-carbon alternatives, e.g., SCMs, for a proportion of the binder can also greatly reduce the carbon footprint of concrete. SCMs are typically by-products of industrial processes, e.g., fly-ash from coal-fired power stations and ground granulated blast furnace slag from iron and steelmaking.

SCMs will help us to make significant progress in our journey to decarbonise the New Zealand cement and concrete industry because our use of SCMs is currently much lower than overseas. Fly-ash can substitute up to 30% of cement in a binder, and slag up to 65%. SCMs can be added at the cement manufacturing stage, and/or when mixing or batching concrete.

Naturally occurring high-silica mineral deposits can also be used as SCMs. This includes volcanic ash and pumice, and diatomite, the accumulated and compacted skeletons of diatoms, a plant plankton. New Zealand has abundant resources of 'natural pozzolans', as these types of SCM are called. New Zealand also has reserves of kaolin-containing clays which can be heated to between 650°C and 750°C to produce calcined clay (metakaolin) – another effective pozzolan. However, further research and development is needed to commercialise them at scale.

'Novel cements', e.g. minerals rich in magnesium silicate, are also the subject of research and development worldwide and in New Zealand. This process could produce cementitious materials with a much lower carbon footprint than cement.

ANNEX A - STRATEGIES

CONCRETE PRODUCTION

Concrete production in New Zealand is predicted to become more efficient through advances in technology.

Improved concrete technology will see optimised mix design, i.e. ongoing refinements of combinations of raw materials will lead to reduced contents of cement and water for a similar performance.

Rapidly improving admixture technology is also likely to reduce cement and water contents while maintaining other properties.

Continuously improving quality assurance will provide opportunities to reduce cement content. The New Zealand Standard for Concrete Production NZS 3104:2022 has been amended to permit small reductions in cement content where a producer can demonstrate high levels of quality control.

Other technologies, for example, in-transit management of concrete also improve consistency.

ELECTRICITY

New Zealand produces 80-85% of its electricity from renewable sources, mainly hydro, wind, and low-carbon geothermal. New Zealand has the fourth highest percentage of renewable generation in the world. Our country has a goal of 100% renewable electricity – in a normal hydrological year – by 2030. Even if this goal is not achieved, the carbon footprint of electricity generation is expected to become smaller over time.

Electricity from the national grid enters the cement and concrete value chain when crushing clinker, SCMs and other inputs, and when mixing or batching readymix. However, compared with manufacturing cement, the energy required is marginal.

In contrast to much of the rest of the world, lowering the carbon footprint of national grid electricity in New Zealand will have only a small benefit for cement and concrete.

DESIGN AND CONSTRUCTION

The primary strategy to encourage more efficient design and construction (and deconstruction) in New Zealand is to include carbon emissions into the design process in the same way as cost, quality, speed and specific client requirements for the project.

Designers of buildings can reduce carbon by carefully selecting the geometry and form of structural concrete elements. This is expected to deliver reductions of 5% by 2030. These savings are lower than predicted in other jurisdictions due to the seismic requirements of New Zealand's Building Code and the design constraints this imposes.

Lower-carbon concretes tend to gain strength at a slightly lower rate than conventional Portland cement concrete. This can easily be reflected in the design, specification and the design process. Lower-carbon concretes also tend to promote more chemically resilient hydration species making them more durable.

Reducing the percentage of returned ready mixed concrete at construction sites would reduce the burden on concrete suppliers to recycle or repurpose this waste. This is a call for reducing waste in concrete construction.

Concrete is amenable to a 100-year design life for buildings and infrastructure; the longer lived the structure, the lower the annual contribution to embodied carbon. This needs to be reflected in New Zealand's Building Code.

An opportunity lies in using concrete better at end of life, e.g., repurposed in crushed form as cleanfill, as roading aggregate, or even recycled into new concrete. Precast components in structures can be reused or repurposed in a new structure. Making the most of this avenue for reducing carbon footprints depends on design and construction, as well as processes for concrete waste recovery.

CARBON UPTAKE

Exposed surfaces of hardened concrete will absorb CO_2 from the air permanently over time, at predictable rates. This is called 'carbon uptake'. The Intergovernmental Panel on Climate Change formally recognised the role of carbon uptake in sequestering atmospheric CO_2 in its sixth Assessment Report (AR6), published in 2021 and 2022.

Where the surface area to volume ratio is greater, e.g. concrete roads, there will be more carbon uptake. The same applies to crushed construction and demolition concrete waste.

From 2020 to 2050 the clinker reduction factor decreases. The reduced clinker per cubic metre of concrete results in a minor reduction in carbon uptake over the coming decades. This is conservative and might increase through initiatives such as the active exposure of crushed concrete to CO_2 at end-of-life.

CARBON CAPTURE UTILISATION AND STORAGE

Carbon capture, utilisation and storage (CCUS) is the mechanism that captures CO_2 emissions from industrial processes and stores them for long periods (centuries or even millennia) so that they will not enter the atmosphere. In cement manufacture, most of the emissions are due to the chemical reaction involved in the calcination of limestone. This means CCUS is a vital solution for the sector.

In New Zealand, CCUS technologies will take time to develop and implement. Overseas, several trials and projects are underway – offering promise for CCUS uptake in Aotearoa.

CAPTURE

Captured CO_2 can be used in a number of industries. It can be used as a chemical feedstock in industry. Other examples include urea for fertiliser and methanol, which is a feedstock for diverse chemical processes. It can also be used in the food and beverage industries.

Meanwhile, the construction industry can also play its part. Potential applications such as the manufacture of artificial aggregates, curing concrete and carbonation of recycled concrete have been identified.

STORAGE

CO_2 can be sequestered into geological deposits so it would not be released into the atmosphere.

ANNEX B - EPD ANALYSIS

The main body of this document presents a decarbonisation roadmap based on Scopes 1 and 2 (GCCA analysis). This is in line with the global cement and concrete industry methodology and focuses on aspects the industry has direct control over.

This annex presents the results of a carbon footprint analysis of all three Scopes, based on data provided in the industry's Environmental Product Declarations (EPDs). An EPD tells the environmental story of a product over its life cycle in a clear, simple format that can be understood by a wide audience. It is science-based, independently verified and publicly available. EPDs are often compared to the nutrition labels on food products. Every EPD is based on data from a detailed environmental study called a Life Cycle Assessment (LCA).

Both methods (below) look at the same data (i.e. the amount of cement and concrete) but they use different approaches to calculate the emissions.

SCOPE 1 AND 2 ('GCCA ANALYSIS')

Covers Scope 1 (direct) and Scope 2 (electricity-related) GHG emissions from producing cement and concrete.

We used the GCCA's calculator that was also used for the global cement and concrete roadmap and by other national concrete bodies around the world.

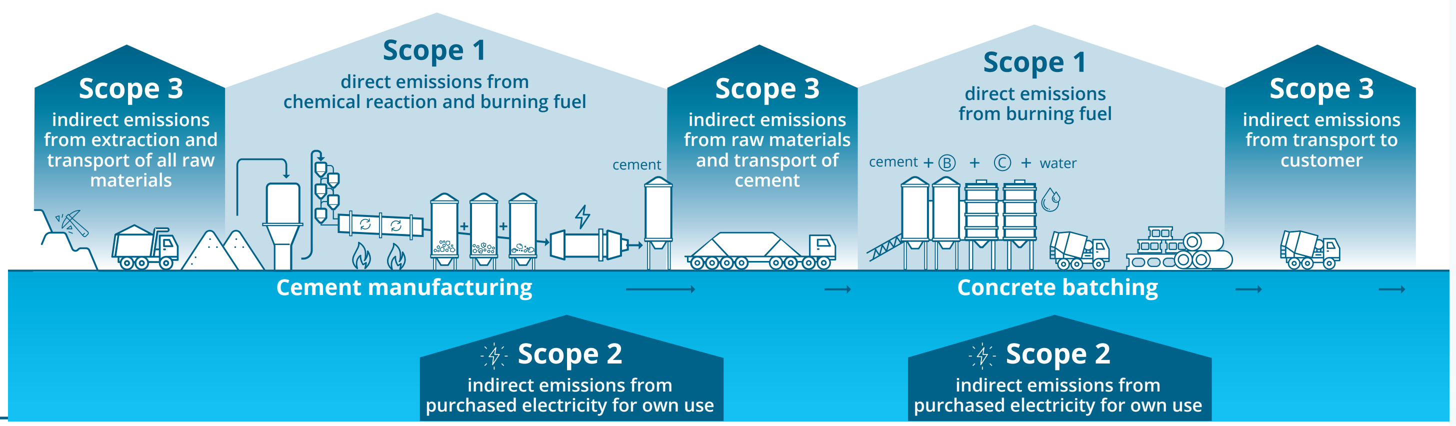
SCOPE 3 ('EPD ANALYSIS')

Covers Scopes 1, 2 and 3 GHG emissions from producing cement and concrete.

Covers the full life cycle of cement and concrete.

The results are in line with those that would you see in an Environmental Product Declaration (EPD).

Figure 5. Scope 1,2 and 3 emissions from producing cement and concrete



ANNEX B - EPD ANALYSIS

Table 2. Scope 1,2 and 3 emissions from producing cement and concrete

THE GHG PROTOCOL CATEGORISES EMISSIONS INTO THREE GROUPS OR SCOPES:	
SCOPE 1: **Direct emissions**	**For cement:** Direct process emissions All fuel-related emissions **For concrete batching plants:** All fuel-related emissions (small)
SCOPE 2: **Indirect emissions from the electricity, heat or steam a company buys**	**All electricity use**
SCOPE 3: **All other emissions that occur in a company's value chain**	**All materials purchased by the cement kiln:** Cement rock Limestone Gypsum **Transporting materials to the cement kiln** **All materials purchased by the concrete batching plant** (excluding Portland cement and novel cements, as these are already included in Scope 1): Aggregates (sand and gravel) SCMs Admixtures Water **Transporting materials to the concrete batching plant** **Transporting the concrete to the customer in an agitator truck** **Concrete End of Life** Deconstruction of discarded concrete Transport of concrete waste to waste processing Processing of concrete waste to prepare it for its final end-of-life fate (recycling or landfilling) Landfilling of concrete waste

ANNEX B - EPD ANALYSIS

EPD ANALYSIS

Our EPD analysis is based on publicly available information including:

→ published emission factors

→ EPD documents released by the industry

→ economic and growth statistics and population data for New Zealand

→ data obtained from the industry consultation we conducted for this roadmap.

The data takes into account the upstream activities involved in the cement and concrete sector. This includes the indirect emissions from extracting, producing and transporting raw materials e.g. aggregates and minerals and direct emissions from transporting cement and raw materials.

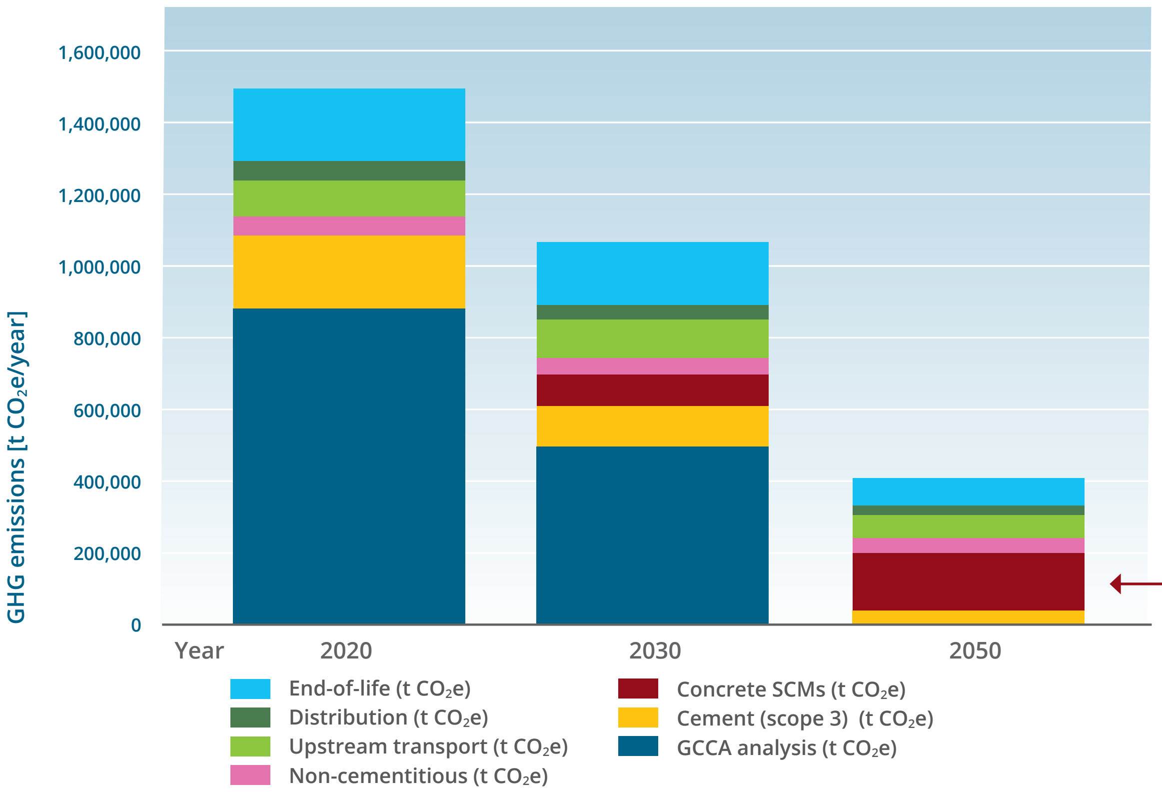
The analysis does not include any contribution from steel that might be used in reinforced concrete products.

THE RESULTS

The results of the EPD analysis for Scopes 1 and 2 are linked to the GCCA analysis results. There are some small differences due to the use of different data inputs.

The additional emissions that the cement and concrete sector will need to address through wider industry engagement are shown in Figure 6 below. The dark blue bars represents the GHG emissions from Scope 1 and 2 (aligned with the GCCA analysis). The yellow, red, pink, and green bars represent those from emissions that occur in our industry's supply chain. The light blue bar represents emissions that occur at end-of-life (landfill or recycling).

Figure 6. Decarbonisation (GCCA analysis + Scope 3 emissions by category)

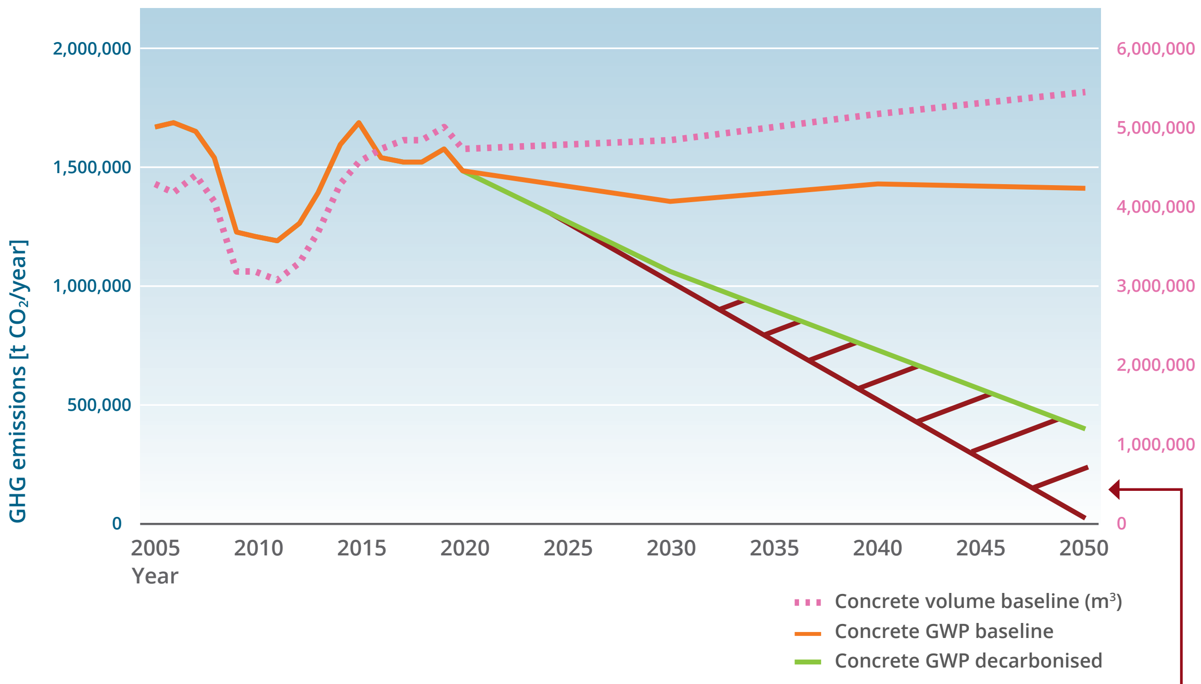


ANNEX B - EPD ANALYSIS

DECARBONISATION OVER TIME

The figure below shows the effect of the cement and concrete industry's active decarbonisation activities (the green line) including GHG removals (CCUS and recarbonation) relative to the total concrete volume baseline (dotted pink line). The forecast growth in concrete demand is driven by increasing population. The orange line shows the emissions that would result under a business-as-usual scenario.

Figure 7. Concrete volume and decarbonisation over time (GCCA analysis + Scope 3 emissions)

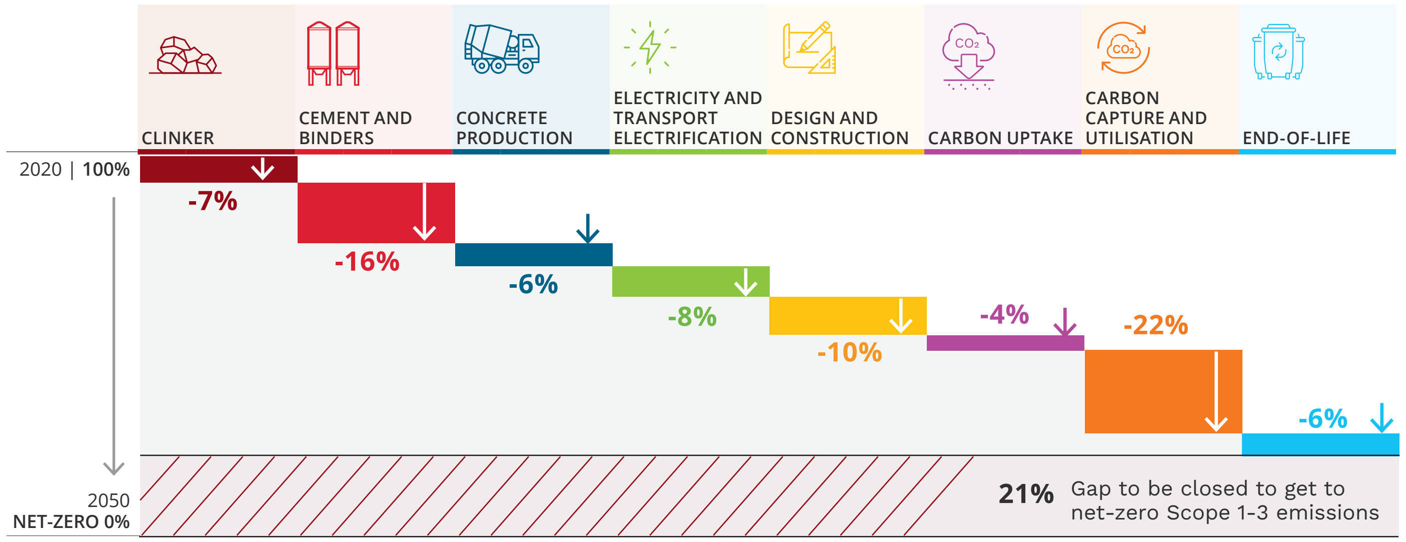


HOW TO CLOSE THE GAP

The remaining emissions are from SCMs, aggregates, transport and end-of-life. Each industry is working hard to decarbonise and these remaining emissions may also reduce towards net-zero by 2050. However, because these industries are outside of our direct control, the only decarbonisation we have forecast is partial electrification of vehicles and further decarbonisation of the electricity grid.

ANNEX B - EPD ANALYSIS

Figure 8. Decarbonisation roadmap of cement and concrete in Aotearoa New Zealand (EPD analysis)



Percentage reduction of carbon emissions against the 2020 baseline

STRATEGY	WHY THESE NUMBERS DIFFER FROM THE GCCA ANALYSIS (MAIN REPORT)
CLINKER	Minor differences in emission factors
CEMENT AND BINDERS	Less reduction as emissions from energy and transportation in SCM production are not included in the GCCA calculator
CONCRETE PRODUCTION	This analysis used absolute numbers (Scope 1, 2 and 3). The percentage is different as the total is higher.
ELECTRICITY & TRANSPORT ELECTRIFICATION	Less reduction due to higher electricity consumption, as a result of electrification of transport. Transport is not included in the GCCA calculator.
DESIGN AND CONSTRUCTION	No difference.
CARBON UPTAKE	Aligned with the GCCA assumptions. This analysis used absolute numbers (Scope 1, 2 and 3). The percentage is different as the total is higher.
CARBON CAPTURE AND UTILISATION	Aligned with the GCCA assumptions. This analysis used absolute numbers (Scope 1, 2 and 3). The percentage is different as the total is higher.
END-OF LIFE	Concrete end-of-life impacts are not included in the GCCA calculator. The reduction is due to an increase in the recycling rate instead of landfilling.

THANK YOU

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Images

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