



Decarbonising Construction: **BUILDING A LOW-CARBON FUTURE**

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IN COLLABORATION WITH

Deloitte.



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FOREWORD



Carlos Maurer

Executive Vice President,
Shell Sectors and Decarbonisation

The construction industry is vast, providing jobs for over 255 million people globally and revenues for thousands of mainly small and medium-sized companies. It makes up around 13% of the world's economy, enables other sectors to function via the infrastructure it builds, and facilitates security, health and education through homes, hospitals and schools. Construction matters.

The construction sector accounts for 37% of global CO₂ emissions*, of which 16% represent embodied carbon – CO₂ emissions coming from material sourcing and manufacturing, logistics, and construction activities. This makes it one of the biggest single sectors contributing to global warming. It is vital it decarbonises. The construction sector can also be an enabler of decarbonisation across other sectors through green buildings, renewable energy projects and production facilities for greener products, like electric vehicles.

Shell has set a target to become a net-zero emissions energy business by 2050, with shorter-term goals to ensure progress along the way. As part of this, we are working with customers, governments, and others to help address emissions in different sectors, such as construction. We aim to play a major role in

helping the construction sector decarbonise and seek to understand where the opportunities lie and how we can contribute to accelerating progress.

“Decarbonising Construction: BUILDING A LOW-CARBON FUTURE” is the result of our work with Deloitte to shine a light on the challenge of decarbonising construction and offer the industry practical solutions.

I wish to thank all those who were involved in the development of this report, for their time, energy and enthusiasm. I hope it will serve as a useful tool and framework for construction companies, equipment manufacturers, policymakers, and other stakeholders to come together and accelerate progress on decarbonisation.

Let's build, then, for the future. Starting today.



Raman Ojha

Vice President,
Shell Construction and Road

This “Decarbonising Construction: BUILDING A LOW-CARBON FUTURE” report reflects the voice of the industry, by sharing the views and perspectives of nearly 100 European, North American and Asian construction executives and experts across the value chain.

The report highlights the challenge and opportunity of reducing embodied carbon, as most carbon reduction efforts in construction have been focused on operational carbon. Creating better visibility for embodied carbon and developing dedicated solutions will be critical to decarbonising the sector successfully.

When I read what the industry has to say in this report, I see that there is a great willingness and desire to decarbonise and three things resonate strongly. Firstly, regulations and standards for embodied carbon need to be established to incentivise faster action. Secondly, with emissions coming from construction materials representing the vast majority of embodied carbon in construction, developing low-carbon technologies and alternative materials will be key to reducing the sector's emissions.

Lastly, the assets-owners must play a more active role and demand more low-carbon construction solutions in tenders.

The participants to the report made it clear that although the scale and challenge of decarbonising construction is significant, it can be achieved. I am confident that with a combination of innovative solutions, supportive regulation, and more collaboration across the value chain, we can and will accelerate progress to net zero.

Shell aims to be the partner of choice for decarbonising construction. We look forward to working with the industry to drive faster action. Together, we can meet the ambitions of both today and tomorrow.

* IEA (2020) “[Energy Technology Perspectives](#)”, accessed 15 June, 2022.

REPORT OBJECTIVES

This report reflects the perspectives of nearly 100 executives and experts, representing 84 organisations across almost all segments of the construction ecosystem and three focus regions (see Exhibit 1.). It aims to:

- **Take a comprehensive view over the construction value chain, with a dedicated focus on embodied carbon.** Many decarbonisation studies focus on specific challenges or stakeholder groups in isolation. Given the interdependency of factors, the sector needs a more comprehensive view, which includes economic, regulatory and organisational factors.
- **Clarify a practical way forward.** Construction leaders who participated in this research are at a point where they need to make decisions around decarbonisation. Working with them to converge on a set of solutions and a blueprint can help the sector act now and clarify the path forward.
- **Reflect the voice of the sector.** No one stakeholder group can do this alone, and everyone will have a role to play. It is essential to understand the unique motivations and challenges of different groups and geographies, to develop solutions that will make an impact.

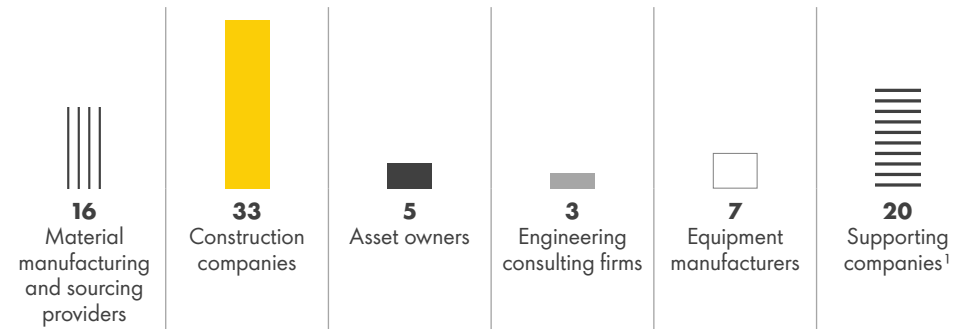
This report reflects the insights industry executives and experts shared with us through interviews and working sessions, not the views of Shell or Deloitte. All engagements with participants were conducted in a manner that respects competition law.

Research participants

95 research participants...



...representing 84 companies across the value chain...



...across the globe

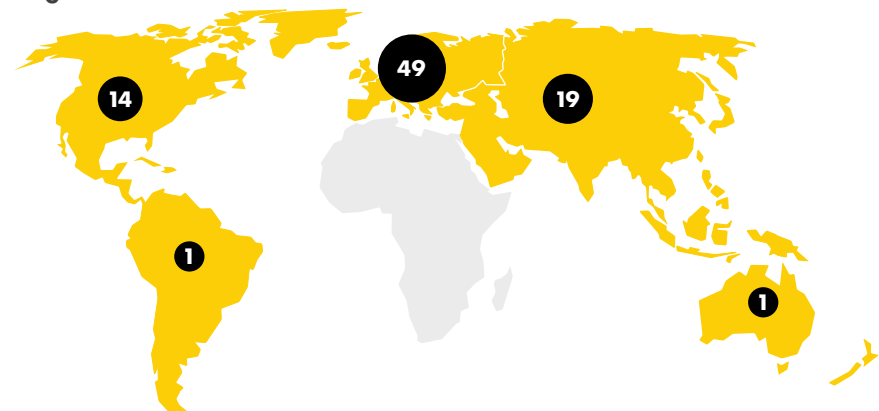


Exhibit 1.

Note: 1) includes e.g. industry associations, financiers

Executive Summary



As a notable contributor to the global economy but also to global carbon dioxide (CO₂) emissions, the construction sector must decarbonise. Historically, the construction sector has been focusing primarily on cost and operational efficiency. If we add to that the complexity of its ecosystem, we will understand better why developing, implementing and scaling low-carbon solutions in construction is so challenging.

Deloitte spoke with executives representing companies from the entire value chain of construction. The report “Decarbonising Construction: BUILDING A LOW-CARBON FUTURE” summarises their views on where we are today and what are the biggest barriers to decarbonisation. It also outlines what solutions the industry thinks are needed to help drive decarbonisation and proposes a clear roadmap for reaching net zero.

The consensus among those interviewed for this report is that – while challenging – the decarbonisation of the sector can be achieved. By scaling up the use of existing low-carbon solutions, developing more alternative materials and technologies, adopting supportive policies and extensively collaborating, the sector can achieve net zero.

(e.g. generators or heavy machinery), road freight and shipping.

Research highlights

1	The construction sector accounts for 37% of global carbon emissions , of which 16% represents embodied carbon mainly from material manufacturing. Significant carbon reduction needs decisive action now.
2	Applying a segment view, the infrastructure end market will likely decarbonise first; across the value chain, construction equipment will likely be the first to decarbonise.
3	Several barriers to decarbonisation exist: ineffective procurement practices; a lack of regulation ; production challenges for low-carbon concrete and steel; and no established standards for data, methodologies and tools.
4	Most of the existing carbon reduction efforts have been focused on operational carbon. Creating better visibility for embodied carbon and developing solutions to reduce it will be critical.
5	Asset owners have a leading role to play to generate demand, kickstart collaboration, and increase investors’ confidence to take the leap of faith necessary to invest in emerging technology.
6	Synchronised regulations and standards for embodied carbon will create the conditions required for action, including consistency on how embodied carbon can be measured.
7	Low-carbon cement and concrete are within the sector’s direct influence ; the focus should be on investment in alternative raw material inputs as carbon capture matures.
8	Demand from other sectors, especially automotive, will increase the availability of low-carbon steel and lower the production costs of low-carbon fuels and carbon capture.
9	Improving workforce capabilities around sustainable and digital solutions is needed to drive efficiencies.
10	A system-level approach is needed to optimise trade-off decisions between costs and carbon emissions.
11	Decarbonisation will be a catalyst for embedding efficiency and minimising unnecessary emissions throughout the sector.
12	Sharing learnings will help each region accelerate progress towards net zero.

Exhibit 2.

Where we are today

Construction is one of the largest single-sector contributors to carbon emissions. Emissions from the production of construction materials, construction activities and logistics – called embodied carbon – accounted for 5.4 gigatonnes of carbon dioxide (Gt CO₂) in 2020, or 16% of all global CO₂ emissions. If business continues as usual, these emissions are forecast to remain significant beyond 2050. The sector needs rapid action to decarbonise at scale.

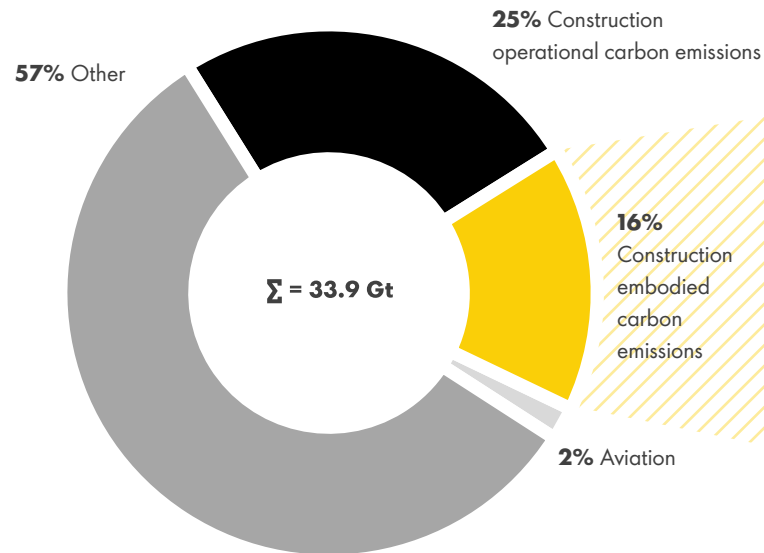
Across the construction value chain, the sourcing and manufacturing of materials represents 92% of embodied carbon emissions, with 43% of these attributable to cement, 25% to steel and 24% to remaining materials, such as glass, aluminium, timber and asphalt. While decarbonisation of cement and steel is a priority, it is made harder by relatively high energy intensity, limited renewable energy supply globally, process emissions (for cement) and long asset lifetimes. Construction activities and logistics together account for 8% of emissions – which mostly come from the use of site equipment

The focus has been and is on operational carbon because the solutions are available. Now is the time to shift focus to embodied carbon, which is bigger than entire sectors like aviation, and will likely be more complex to solve.

Executive, engineering firm

Global CO₂ emissions (2020)

Total global CO₂ sector emissions = Σ =100% | 33.9 Gt¹



Construction embodied CO₂ emissions (2020)

Total global CO₂ sector emissions = Σ =16% | 5.4 Gt

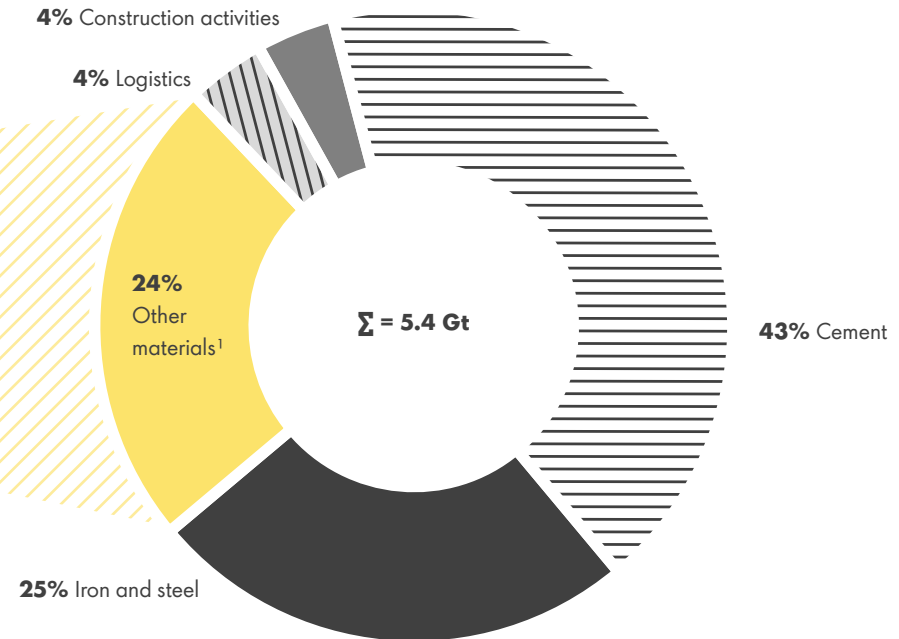


Exhibit 3.

Note: 1) Including sourcing and manufacturing
Source: IEA and Deloitte analysis

The construction sector can be broken down into three end markets – buildings, infrastructure and industrial projects – all likely to decarbonise at different speeds.

Infrastructure construction projects

are likely to decarbonise soonest as they are generally publicly owned and have centralised budgets. The large scale of these projects also makes it easier for them to absorb the higher cost of low-carbon solutions. The **buildings** end market is likely

to follow. The drive to decarbonise here is expected to come from large corporations with net-zero emissions strategies and demand from public and residential buyers, who are increasingly aware of the need to decarbonise. The **industrial** end market is expected to be the slowest to change. Large carbon emission footprints from this market's own operations, push embodied carbon lower on its priorities list. Still, some industrial end markets, like big technology firms, are showing signs of being first movers.

Geographically, construction emissions are highest in countries such as **China** and **India**, where economies are rapidly developing and therefore construction volumes are higher. Regulation around embodied carbon in these markets is nascent. More developed economies, such as **the Western and Northern European countries** and the **USA**, have smaller construction volumes on a per capita basis and here regulators are starting to act to restrict embodied carbon. Measures like the

Emissions Trading System (ETS) in Europe and new subsidies introduced through the Inflation Reduction Act in the USA show clear signs of progress. There is also a growing sense of optimism in major markets like China, as noted by one interviewee: “China may not have significant regulation around construction today, but like they have shown in other sectors, when they choose to move, they can do so much faster than most western markets.”

Barriers to decarbonisation

Research participants identified a range of barriers currently inhibiting the sector from decarbonising more quickly (see Exhibit 4.) with four highlighted as priorities to tackle:

- **Limited market and customer demand:** procurement practices operate in a fragmented market which typically prioritises cost and speed over reducing embodied carbon.
- **Insufficient regulatory incentives:** regulations for construction sub-sectors (e.g. cement and steel manufacturing) and end markets (i.e. buildings, infrastructure and industry) are neither aligned, nor adequate to incentivise action across the value chain.
- **Significant breadth and scale of technology implementation required:** steel and cement are the largest drivers of emissions. Technologies to decarbonise them are available, but require significant capital investment to mature and scale.

- **Lack of harmonised standards:** the lack of consistent definitions, data, methodologies and tools to account for carbon, as well as of a single regulatory body, results in varying interpretations, limiting the ability of market participants to claim outcomes consistently.

Barriers vary according to end market and their intensity is determined by differences in geology, climate, customer preferences, project size and technologies used.

These and other barriers are explored in greater detail in this report.

Construction sector decarbonisation readiness

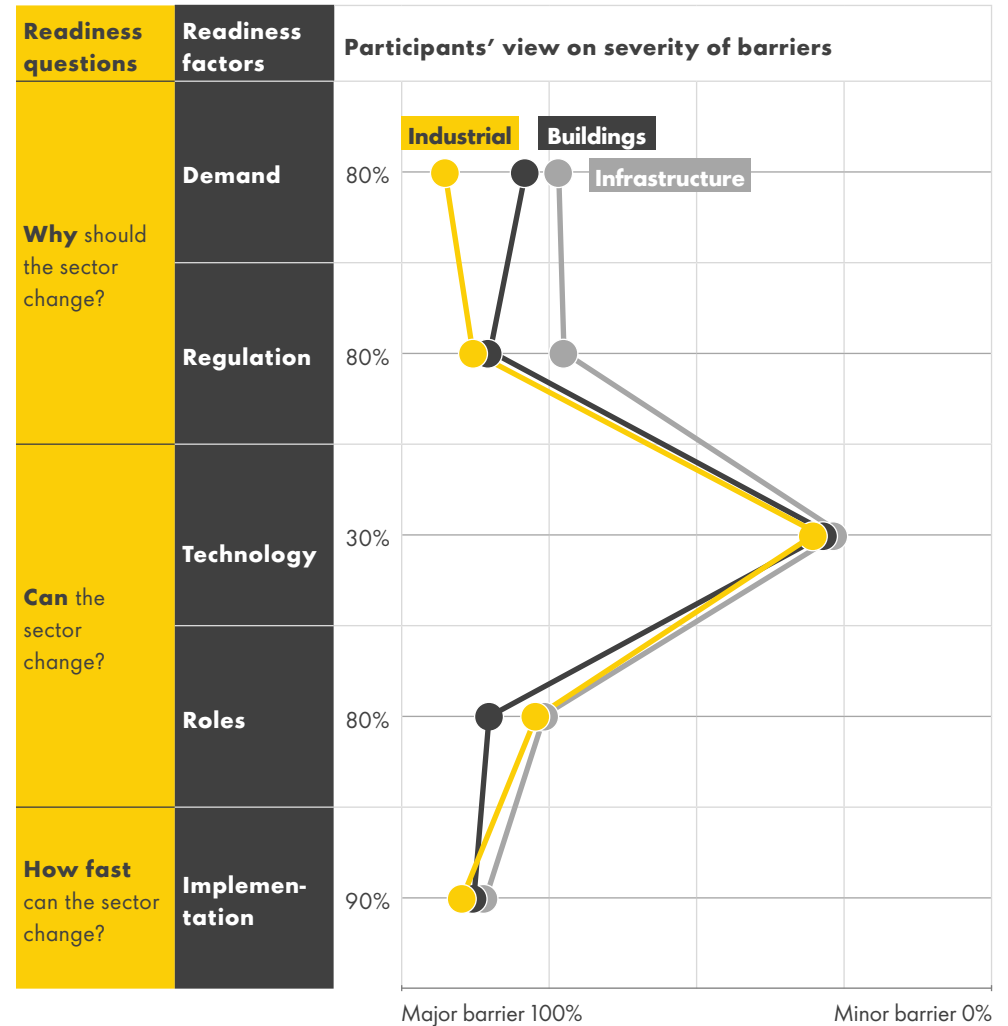


Exhibit 4.
Source: Interviews; Deloitte analysis

Potential Solutions for Decarbonising Construction

The interviews conducted showed that despite multiple barriers, thanks to early adopters, innovators and sustainability-driven asset owners, the global construction sector is already showing early signs of the change needed for decarbonisation.

Governments and financiers are pushing the need to reduce emissions higher up the agenda. Customers are starting to demand more low-emissions projects and construction companies are responding by making commitments and exploring new technologies. More than 80% of interviewees identified decarbonisation as a top three business priority and large construction businesses have committed to reducing emissions. These positive signs are gradually coalescing to accelerate the pace of decarbonisation, but more decisive action is needed to reach net zero.

Construction executives need to define and implement clear decarbonisation strategies, but the road ahead is unclear. What solutions are available already and what is their decarbonisation impact? Which are the easiest to implement? How can companies who have been focusing on operational efficiency turn their attention to instilling a decarbonisation mindset?

We are seeing new initiatives all over the place, but it feels like there is too much to do, and we don't really know what matters most and where to start.

CEO, building contractor

This research aims to guide the sector's progress on decarbonisation and has resulted in 15 solution themes. While no single solution will be enough, in combination they reinforce each other and create the conditions required for change.

Demand

Activating and aggregating demand for low-carbon products through joint sourcing and coalitions can encourage investment. Increasing awareness around embodied carbon and defining a common language will be foundational to create the momentum for more decisive action. Financiers can also incentivise low-carbon construction by recognising embodied carbon and extending financing schemes that currently certify only operational carbon. Creating scale in customer demand through coalitions and partnerships will give financiers and construction companies the confidence to make investments. Coalitions of financiers would also help these institutions better manage risk and unlock earlier investments.

Regulation

Policies will be key to accelerating low-carbon construction and must address demand and supply simultaneously. On the demand side, policies must incentivise the adoption of low-carbon assets while on the supply side they have to support the investment in more low-carbon construction solutions and technologies. Interviewees agreed that incentives and coercive policies will both be necessary to reduce embodied carbon emissions.

Technology

Technology innovations including renewable energy solutions, energy efficiency solutions and alternative materials are already being deployed in the construction sector.

For example, the vast emissions coming from cement and concrete production can be reduced by investing in low-carbon cement and concrete pathways, such as using more sustainable energy solutions to power the cement and concrete production processes, developing cleaner technologies to produce clinker or reducing the amount of clinker used in cement. To further this effort, carbon capture utilisation and storage (CCUS) is a technology that will need to be developed, and at scale, to further support the industry to achieve net zero.

Solutions to cut emissions coming from alternative materials are also emerging, such as low-carbon asphalt. In the asphalt production phase, the key technologies used to reduce emissions are low-carbon energy to power the asphalt plant and heat the asphalt mixture, replacing the hot-mix asphalt with warm-mix asphalt, or incorporating bio-based binders that have a lower carbon footprint.

Emerging technologies such as more energy efficient methods of creating iron, have proven that low-carbon steel production can be scaled. Scaling up production for low-carbon steel will need financiers, governments and asset owners to invest in processes and infrastructure.

The sector should also develop and adopt more alternative and circular materials, like advanced timber and recycled asphalt. This can be done through investments in R&D, both within the sector, and with adjacent sectors looking to improve circularity.

The roll-out of low-emission equipment is already happening, albeit with a shortage of low-carbon energy supply. Careful planning is needed to create high capacity grid connections and enable construction companies to connect to energy infrastructure onsite.

Roles

New skills, such as carbon data analysis and the development of low-carbon materials, will be needed to advance the technologies required to support decarbonisation. The sector needs to expand and develop new mechanisms to develop talent and increase knowledge and best practice sharing around carbon emissions.

More collaborative decision making across the construction value chain will also improve the adoption of new technologies. Collaboration and public-private partnerships will enable the sharing of both knowledge and risk.

Implementation

Making design and execution more efficient will minimise waste, reducing costs, and lower construction emissions at the same time. Modular design can reduce waste

by more than 80% through standardised and repeatable construction methods. By monitoring the execution of projects, construction companies can ensure that planned carbon reductions are being realised in practice.

An update to existing standards for design and materials would release the industry from traditional working practices and allow low-carbon practices to be implemented. This would also enable companies to become agile enough to quickly adopt new innovations as they arise.

The sector also needs to secure an adequate supply of renewable energy. This can be achieved through power purchase agreements with producers or co-investment in new renewable projects. Energy transportation, supply and storage infrastructure needs to be built. Those manufacturing materials or involved in construction processes should consider their location according to the availability of low-carbon energy.

The sector needs to increasingly encourage more systems thinking: a way to consider the trade-offs between emissions, cost, operations, maintenance, and demolition. These systems should include the second-life of assets, components and materials and focus on the re-use and re-purposing of materials, limiting demand for virgin materials.



The Roadmap: Accelerating Decarbonisation in Construction

The 15 solutions identified through this research will all contribute to decarbonising the construction industry and require a phased, incremental approach (see Exhibit 5.).

- **The short term (2023 – 2030)** is about rapidly adopting and expanding the ready-now solutions and creating the conditions required for investment in longer-term low-carbon alternatives.
- **The medium term (2030 – 2040)** is about taking maturing low- and zero-carbon alternatives like low-carbon cement and steel and beginning to use them in commercial applications across the sector to make meaningful change.
- **The long term (2040+)** is about rapidly increasing adoption and scale of all solutions being deployed by the sector to accelerate towards net zero.

The value chain as a whole must move forward together but different parts of the chain can lead on different solutions. For instance, construction companies can drive efficiency gains, skills and contract models, while manufacturers can make low-carbon materials and equipment available.

The solutions outlined in this report can create the conditions required to start reducing the sector's emissions immediately and gradually

accelerate the decarbonisation pace. While progress against this blueprint is likely to move at a different pace across geographies, with Western Europe already putting more strict regulation in place and beginning to invest in low-carbon materials, the industry should capture learnings from these efforts and use them to accelerate progress in slower moving regions.

Based on the views shared by the participants in this research, decarbonising a sector of such scale and complexity will not be easy. However, those we spoke to were optimistic that a net-zero future is possible, with low-carbon solutions increasingly available. Construction leaders recognise the

urgency, the opportunities for those who take the lead and the need for more collaboration across the value chain.

This report provides a blueprint to help guide progress and **build a low-carbon future**.

Decarbonisation pathway – sector sentiment

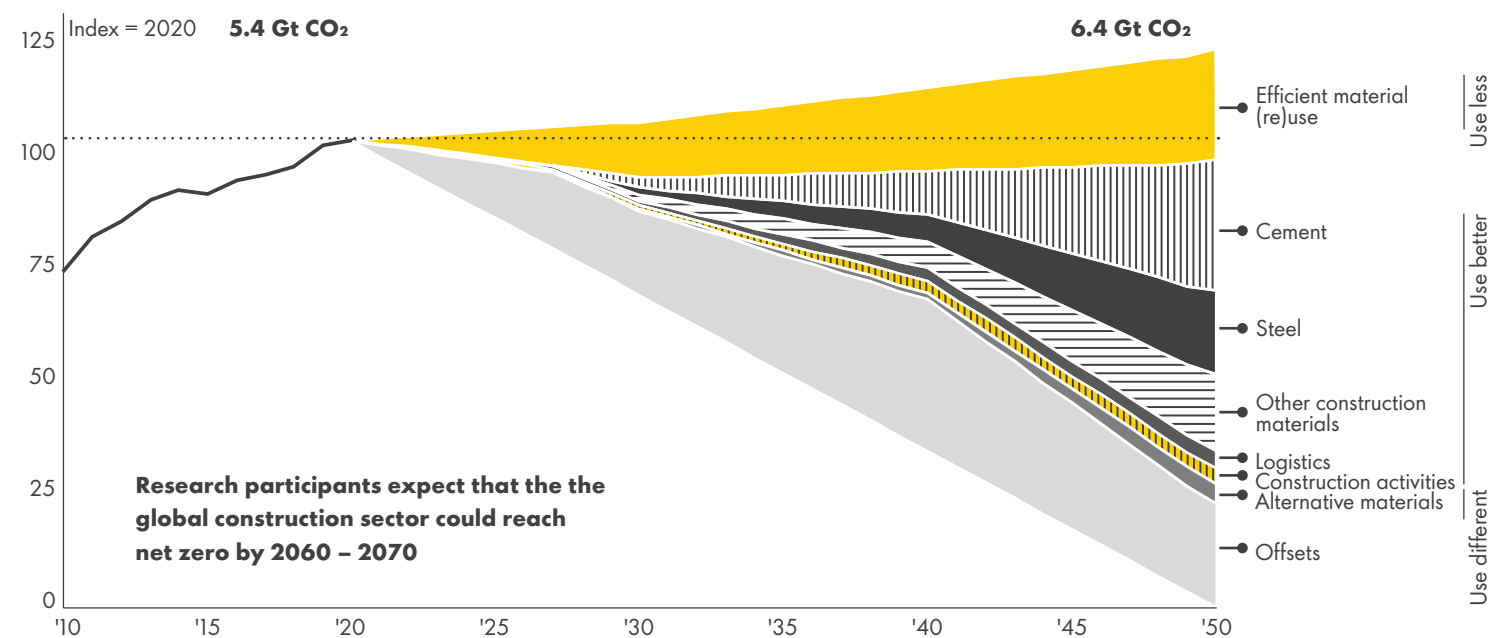


Exhibit 5.
Source: Interviews, Deloitte analysis

The roadmap for decarbonising construction

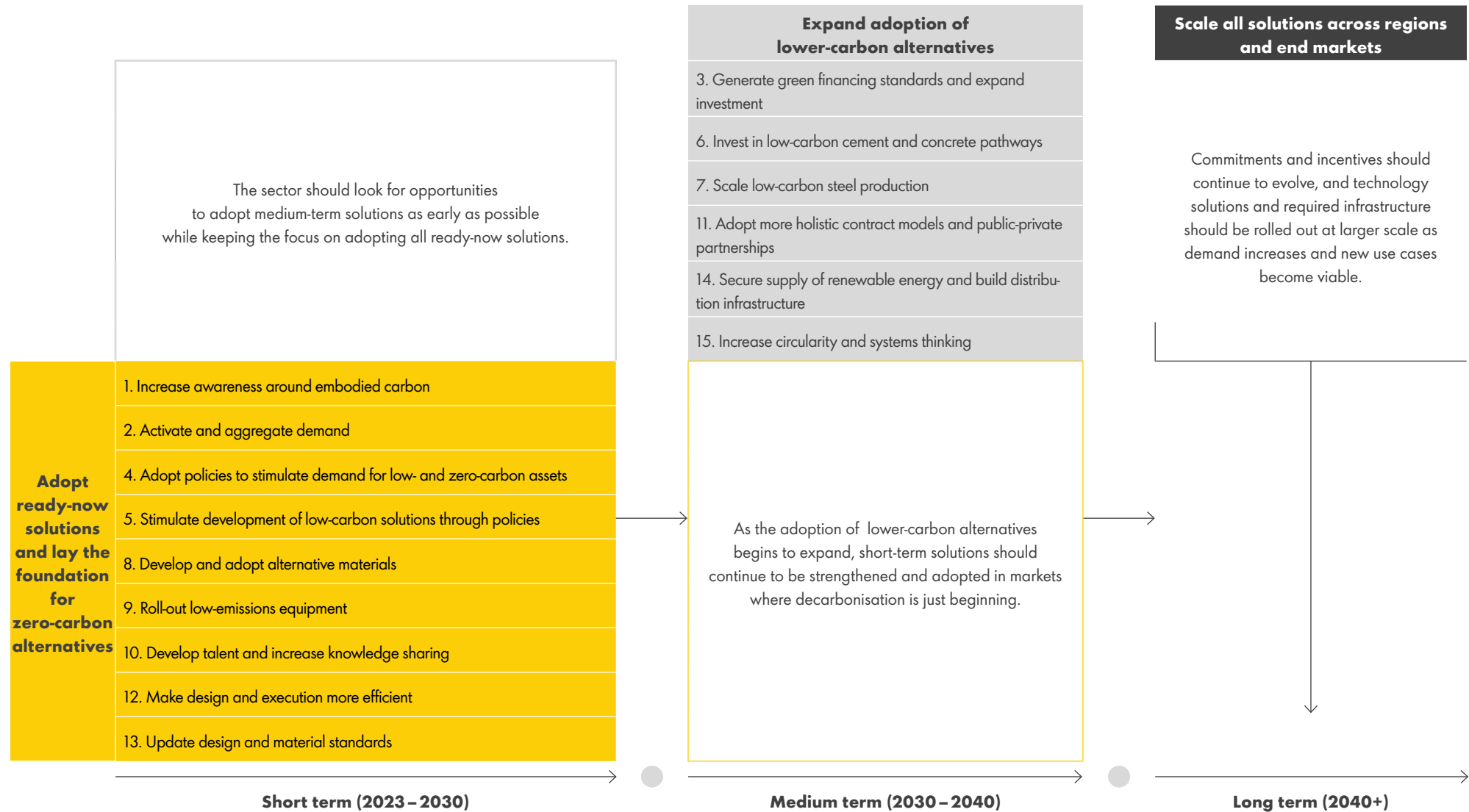


Exhibit 6.

Moving towards low-carbon construction in the short term (2023–2030): a comprehensive industry view on what needs to happen

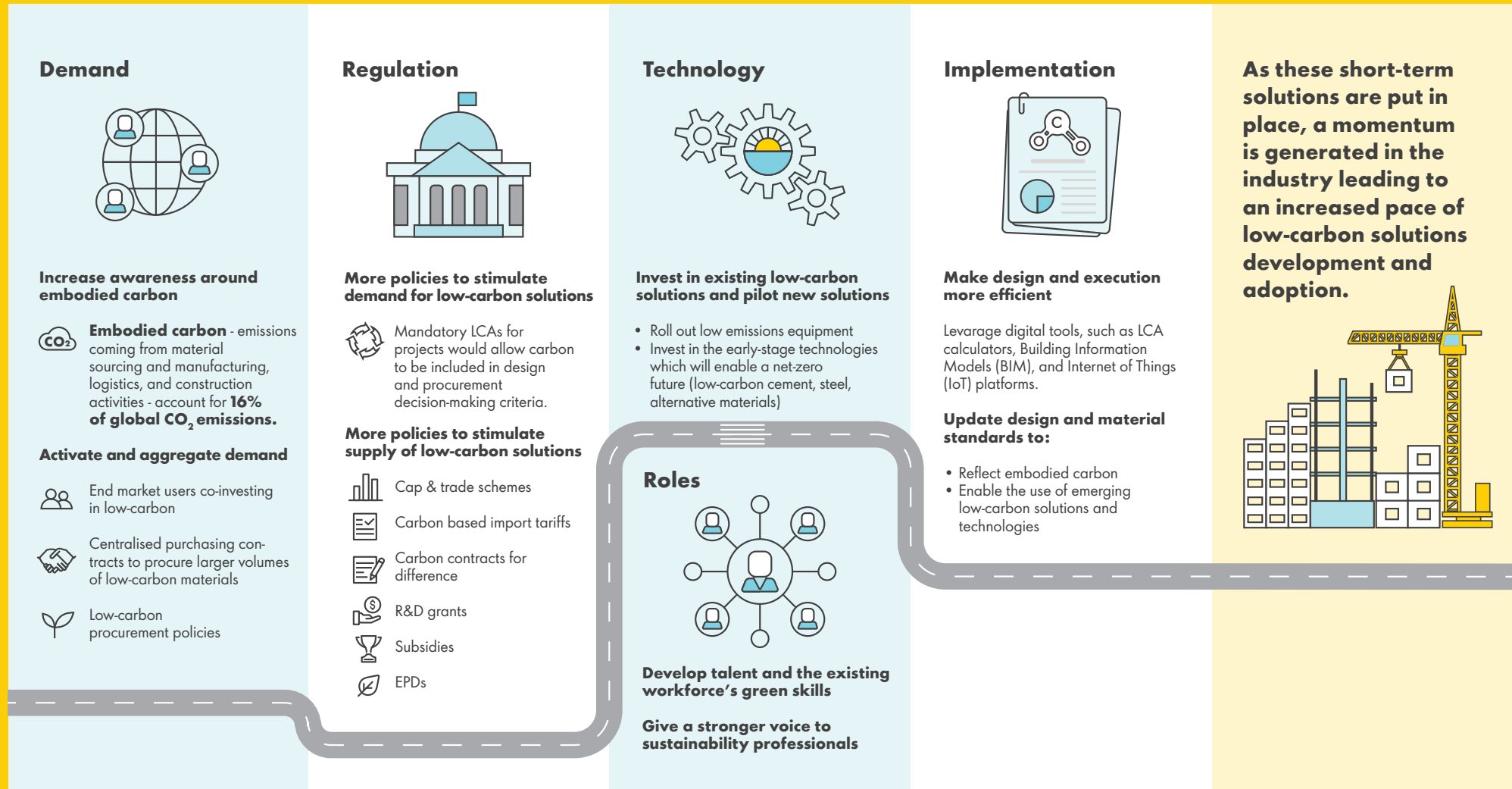


Exhibit 7.

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The companies in which Shell plc directly and indirectly owns investments are separate legal entities. In this report “Shell”, “Shell Group” and “Group” are sometimes used for convenience where references are made to Shell plc and its subsidiaries in general. Likewise, the words “we”, “us” and “our” are also used to refer to Shell plc and its subsidiaries in general or to those who work for them. These terms are also used where no useful purpose is served by identifying the particular entity or entities. “Subsidiaries”, “Shell subsidiaries” and “Shell companies” as used in this report refer to entities over which Shell plc either directly or indirectly has control. Entities and unincorporated arrangements over which Shell has joint control are generally referred to as “joint ventures” and “joint operations”, respectively. “Joint ventures” and “joint operations” are collectively referred to as “joint arrangements”. Entities over which Shell has significant influence but neither control nor joint control are referred to as “associates”. The term “Shell interest” is used for convenience to indicate the direct and/or indirect ownership interest held by Shell in an entity or unincorporated joint arrangement, after exclusion of all third-party interest.

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Also, in this report we may refer to Shell’s “Net Carbon Intensity”, which include Shell’s carbon emissions from the production of our energy products, our suppliers’ carbon emissions in supplying energy for that production and our customers’ carbon emissions associated with their use of the energy products we sell. Shell only controls its own emissions. The use of the term Shell’s “Net Carbon Intensity” is for convenience only and not intended to suggest these emissions are those of Shell plc or its subsidiaries.

Shell’s net-Zero Emissions Target

Shell’s operating plan, outlook and budgets are forecasted for a ten-year period and are updated every year. They reflect the current economic environment and what we can reasonably expect to see over the next ten years. Accordingly, they

reflect our Scope 1, Scope 2 and Net Carbon Intensity (NCI) targets over the next ten years. However, Shell’s operating plans cannot reflect our 2050 net-zero emissions target and 2035 NCI target, as these targets are currently outside our planning period. In the future, as society moves towards net-zero emissions, we expect Shell’s operating plans to reflect this movement. However, if society is not net zero in 2050, as of today, there would be significant risk that Shell may not meet this target.

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This report may contain certain forward-looking non-GAAP measures such as cash capital expenditure and divestments. We are unable to provide a reconciliation of these forward-looking Non-GAAP measures to the most comparable GAAP financial measures because certain information needed to reconcile those Non-GAAP measures to the most comparable GAAP financial measures is dependent on future events some of which are outside the control of Shell, such as oil and gas prices, interest rates and exchange rates. Moreover, estimating such GAAP measures with the required precision necessary to provide a meaningful reconciliation is extremely difficult and could not be accomplished without unreasonable effort. Non-GAAP measures in respect of future periods which cannot be reconciled to the most comparable GAAP financial measure are calculated in a manner which is consistent with the accounting policies applied in Shell plc’s consolidated financial statements.

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