

# Coordinating for net zero: Ecosystem strategies to tackle emissions at the source

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## 1. Introduction

Climate change is one of the most pressing sustainability challenges of our time (Nerini et al., 2019). Although firms' strategic management practices have significantly contributed to this challenge (e.g., Nyberg and Wright, 2022; Bansal et al., 2024), they can also play a crucial role in mitigating it by enabling the development and scaling of low-carbon solutions (e.g., Stern and Valero, 2021; Pinkse et al., 2024; Zobel et al., 2024; Falcke et al., 2024). Since the Paris Climate Agreement in 2015, there has been an increasingly wide recognition that, if the world is to avoid crossing the worst climate tipping points with irreversible impacts on the Earth system (Lenton, 2011), the global economy must achieve net-zero greenhouse gas (GHG) emissions by 2050 (IPCC, 2021; Moeller et al., 2024). Net zero describes a state in which, globally, the amount of emissions released into the atmosphere is balanced by the amount of emissions removed (Joppa et al., 2021). Achieving this state depends primarily on decarbonizing five emission-intensive sectors: (1) electricity & heat, (2) transport, (3) buildings, (4) heavy-industry (including cement, steel, and chemicals), and (5) food & agriculture (Fankhauser et al., 2022).

There is a lot of focus on decarbonizing electricity, which entails several challenges – such as grid balancing or storage solutions (Bumpus and Comello, 2017) – yet remains central to reducing emissions both within the energy sector and across industries through the electrification of fossil-fuel based processes. However, it is the remaining four that are even thornier, as they are considered “hard-to-abate” (Edelenbosch et al., 2024) and thus deserve greater attention from management scholars as well. Despite their major contributions to climate change and the inherent decarbonization challenges they face, many of which are not technological in nature, management research has been surprisingly silent on the role of firms in decarbonizing these high-emission sectors. This is even more astonishing as tackling GHG emissions at the source is the primary way to cap temperature rise and avoid increasingly devastating climate impacts (IPCC, 2021). Therefore, if management research aims to address climate change (e.g., Howard-Grenville et al., 2014; George et al., 2016; Nyberg and Wright, 2022; Bansal et al., 2024), it must advance understanding of how firms can contribute to the net-zero transformation of carbon-intensive, hard-to-abate sectors – those broad groupings of related industries responsible for the vast majority of GHG emissions. This article takes a first step in this direction by developing a new framework that explains how incumbents in these sectors can strategically address emissions at their source.

In developing this framework, the article draws from and extends the ecosystem literature (e.g. Jacobides et al., 2018; Dattée et al., 2018; Hannah and Eisenhardt, 2018; Thomas and Ritala, 2021; Autio and Thomas, 2022). To transform their carbon-intensive offerings into net-zero solutions, focal firms in transport, buildings, heavy industry and food & agriculture must coordinate existing and new participants in their ecosystems. Although these participants are hierarchically independent, they are *interdependent* in their collective efforts to generate more sustainable ecosystem outputs (Thomas and Autio, 2020; Falcke et al., 2024). Consider automotive

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OEMs seeking to transform their mobility offerings. Doing so requires more than shifting from producing internal-combustion-engine vehicles to electric vehicles. It also depends on OEM's ability to orchestrate complementary innovations in charging infrastructure, renewable electricity and grid infrastructure, as well as the sustainable sourcing, production, re-use, and recycling of batteries.

Prior ecosystem research has advanced our understanding of how focal firms orchestrate ecosystems, yet critical gaps remain regarding ecosystem transformation for net zero. First, extant work has shed light on focal firms' strategic choices and orchestration efforts during ecosystem emergence (e.g. Dattée et al., 2018; Hannah and Eisenhardt, 2018; Thomas et al., 2022). However, these insights may not readily transfer to ecosystem transformation aimed at achieving net-zero outcomes, because such transformations are often constrained by heavy assets and physical infrastructure (Selin et al., 2026). Second, while the role of new complementors in shaping ecosystem dynamics is relatively well understood (e.g. Ansari et al., 2016; Adner and Lieberman, 2021; Snihur et al., 2018), incumbents have received less attention. Yet in high-emission industries, they play a central role, as they often *control* heavy assets and physical infrastructure. Nevertheless, we still know surprisingly little about how incumbents coordinate existing and new ecosystem participants to drive ecosystem transformation, especially when transformation is not only directed at growth but at sustainability outcomes, such as reaching net zero. To address this gap in the ecosystem literature, and to advance management research on the role of firms in decarbonizing hard-to-abate sectors, this paper develops a novel net-zero ecosystem framework.

This framework first delineates three interrelated characteristics that pose unique coordination challenges for focal firms seeking to transform their ecosystems to enable net-zero outcomes: (1) legacy assets with physical infrastructure that constrain ecosystem transformation, (2) wickedness of the underlying problems, and (3) temporal imperatives that limit ecosystem experimentation due to the urgent time frame within which net zero needs to be achieved. Second, it proposes a set of ecosystem strategies – *substitution*, *extension*, *looping*, and *build-and-replace* – that outline strategic options for how focal firms can coordinate existing and new ecosystem participants to advance net-zero outcomes.

To illustrate this framework and demonstrate its usefulness for advancing our understanding of ecosystem transformation for net zero, the study leverages examples from the cement and concrete industry. Cement production accounts for 7-8% of global GHG emissions (Li and Unluer, 2025) and is especially difficult to decarbonize, due to the combined emissions from fossil fuel combustion and chemical reactions in cement kilns. It thus serves as an ideal setting to illustrate how incumbents' strategic choices in emission-intensive, hard-to-abate sectors can facilitate net-zero ecosystem transformation. Understanding these strategic choices is important. On the one hand, it enables the tackling of emissions at the source through coordinated ecosystem strategies, thus outlining strategic options for mitigating climate change. On the other hand, the net-zero context offers a fertile ground for advancing our theoretical understanding of ecosystem strategies and how they can facilitate more sustainable outcomes.

The paper is structured as follows. It begins with a conceptual background that draws from prior research on ecosystems and sustainability. Section 3 introduces cement and concrete production as an illustrative context for explaining and demonstrating the usefulness of a net-zero ecosystem framework. Section 4 presents the first part of this framework by detailing the unique challenges incumbents face when coordinating ecosystem participants to achieve net-zero outcomes. Section 5 outlines strategic pathways for responding to these challenges. Section 6 discusses these concepts in relation to prior literature and proposes opportunities for future management research aimed at tackling emissions at the source.

## 2. Conceptual background: ecosystems for sustainability

In high-emission, hard-to-abate sectors, incumbents are under pressure to expand their offerings by providing products or services with similar functionality, while adding net-zero properties. This requires coordination with existing and new ecosystem participants to (re-)align on an integrated net-zero value proposition (Falcke et al., 2024). For example, by coordinating with charging infrastructure providers that deliver renewable rather than fossil-fuel based electricity, automotive OEMs can significantly reduce the emission intensity of electric vehicles. This, in turn, requires grid-balancing technologies and services to address the intermittency of renewable energy, necessitating coordination with actors outside the traditional OEM value chain, such as electric utilities. Extant work (e.g., Ansari et al., 2016; Thomas and Ritala, 2021; Autio and Thomas, 2022; Dattée et al., 2018; Hannah and Eisenhardt, 2018; Jacobides et al., 2018; Stonig et al., 2022; Shi et al., 2024) has begun to shed light on the role of focal firms in ecosystems and can begin to inform our understanding of how incumbents transform their carbon-intensive ecosystems to enable net-zero outcomes.

One stream of research has investigated de novo ecosystem creation around novel technologies like solar PV (Hannah and Eisenhardt, 2018; Szerb and Furr, 2025), platforms (Thomas et al., 2022), or value propositions enabled by general-purpose digital technologies (Dattée et al., 2018). This research proposes different pathways via which focal firms orchestrate de novo ecosystem emergence. First, they can be arranged by a focal firm that promotes a vision or blueprint for the ecosystem and proactively organizes other firms to provide their respective complements (Ozcan and Eisenhardt, 2009). Second, ecosystem emergence can be shaped by firms' decisions about which and how many components to provide themselves, together with the evolving interplay between cooperation and competition (Hannah and Eisenhardt, 2018). Third, under conditions of high uncertainty, a clear ecosystem blueprint may not exist. In such cases, ecosystem emergence becomes more complex. Focal firms may delay their resource commitments to keep their option space open and orchestrate the crystallization of a blueprint via feedback loops and control points (Dattée et al., 2018), or pursue a more collective, bottom-up process of discovery and negotiation with relevant ecosystem participants (Thomas et al., 2022). While this research outlines strategic pathways for de novo ecosystems, it remains unclear to what extent these insights apply to ecosystem transformations, particularly those aimed at net-zero outcomes. Such transformations are likely to significantly differ from de-novo ecosystems, considering that carbon-intensive ecosystems often involve heavy assets and physical infrastructure, such as coal-fired power plants and electricity grids, that constrain transformation (Selin et al., 2026).

Another stream of literature has uncovered how new complementors can disrupt incumbents and thereby shape ecosystem

dynamics (e.g., Adner and Lieberman, 2021; Ansari et al., 2016; Snihur et al., 2018; Björkdahl et al., 2024; Shi et al., 2024). Adner and Lieberman (2021), for example, argue that new complementors may first add value to an incumbent's offering, but may ultimately displace a focal firm or capture a large share of that firm's profitability. For example, while ride-sharing platforms are initially complementary with OEM's main business of selling cars, they could ultimately play a substituting role as vehicles are used more intensively and demand to produce new vehicles decreases (Adner and Lieberman, 2021). While new complementors may initially need to collaborate with incumbents who possess critical complementary assets (Ansari et al., 2016), this research has focused on how new complementors ultimately disrupt incumbents via different ecosystem strategies (Snihur et al., 2018).

While disruption by new complementors that are offering innovative climate-tech solutions plays an important role in the net-zero transformation (Hockerts and Wüstenhagen, 2010) – especially when they collaborate with large corporations (Hakovirta et al., 2022; Hübel et al., 2022) – addressing emissions in carbon-intensive sectors requires, first and foremost, the frontloaded decarbonization of incumbents' products and production processes, so that GHG emissions are halted as quickly as possible. Also, these incumbents may have resources and infrastructure that can potentially be repurposed for net-zero solutions (Mottee et al., 2024). While incumbents face

**Table 1**  
Decarbonization levers for the cement.

| Net-zero levers                                      | Short explanation                                                                                                                                                                 | Sources                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Optimization and electrification of process steps | Optimizing energy use, upgrading process/equipment (e.g. with digital innovations), and electrifying sourcing and transport                                                       | <b>Reports:</b> <ul style="list-style-type: none"> <li>- Technology Roadmap: Low-carbon transition in the cement industry. (2018). A report by the OECD/International Energy Agency and the World Business Council for Sustainable Development. Report of 66 pages.</li> <li>- ECRA (European Cement Research Academy). The ECRA Technology Papers 2022. State of the art cement manufacturing: Current technologies and their future development. Report of 217 pages.</li> <li>- CEMBUREAU (the European Cement Association). (2016). Cement, concrete, and the circular economy. Report of 16 pages.</li> <li>- CEMBUREAU (the European Cement Association). (2024). From ambition to employment – our 2050 roadmap. Report of 31 pages.</li> <li>- International Energy Agency (IEA) and Cement Sustainability Initiative. Technology Roadmap: Low-Carbon Transition in the Cement Industry. Report of 66 pages.</li> <li>- McKinsey et al. (2020). Laying the foundation for zero-carbon cement, by Czigler, T., Reiter, S., Schulze, P., and Somers, K.</li> <li>- Wörner et al. (2025). Cement industry net-zero tracker. Report of 15 pages.</li> </ul> <b>Scientific Articles:</b> <ul style="list-style-type: none"> <li>- Li, N., Unluer, C. (2025). Towards a net zero built environment: decarbonization of the UK cement industry. <i>Npj materials sustainability</i>, 3: 10.</li> <li>- Watari, T., Cao, Z., Hata, S., Nansai, K. (2022). Efficient use of cement and concrete to reduce reliance on supply-side technologies for net-zero emissions. <i>Nature Communications</i>, 13: 4158.</li> <li>- Glenk, Gunther and Kelnhofer, Anton and Meier, Rebecca and Reichelstein, Stefan, Cost-Efficient Pathways to Decarbonizing Portland Cement Production (2023). ZEW - Centre for European Economic Research Discussion Paper No. 23-023, Available at SSRN: <a href="https://ssrn.com/abstract=4495020">https://ssrn.com/abstract=4495020</a> or <a href="https://doi.org/10.2139/ssrn.4495020">https://doi.org/10.2139/ssrn.4495020</a></li> <li>- Barbhuiya, S., Kanavaris, F., Das, B.B., Idrees, M. (2024). Decarbonizing cement and concrete production: Strategies, challenges and pathways for sustainable development. <i>Journal of Building Engineering</i>, 86 (108861).</li> </ul> <b>Expert interviews:</b> <ul style="list-style-type: none"> <li>- Senior manager (A) of large building material company 1 in Europe</li> <li>- Senior manager (B) of large building material company 1 in Europe</li> <li>- Manager (C) of large building material company 1 in Europe</li> <li>- Two interviews with senior manager (A) of medium-sized building material company in Europe</li> <li>- Manager (B) of medium-sized building material company in Europe</li> <li>- Communication and Head of Marketing of carbon removal startup</li> </ul> |
| 2. Alternative fuels                                 | Replacing fossil fuels for kiln heating                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 3. Drop-in clinker substitutions                     | Replacing a portion of clinker with alternative, low-carbon materials                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 4. Re-using and recycling construction waste         | Recovering useable components from buildings for direct reuse in construction + crushing old concrete and using resulting recycled aggregates in new concrete or road base layers |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 5. Carbon capture and utilization or storage (CCUS)  | Capturing CO <sub>2</sub> emissions from cement production at point source and either storing the CO <sub>2</sub> permanently or reusing it in new products                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 6. Novel cement chemistry                            | Developing entirely new types of low-carbon cement that involve fundamentally different chemical reactions and production processes                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

inertia and a strong tendency to conduct business-as-usual (Wright and Nyberg, 2017), they can play an important role in reaching net-zero emissions within a quickly shrinking time window. This calls for more research on how incumbents themselves, rather than new complementors, orchestrate net-zero ecosystem transformation.

Yet only a few studies have so far put the spotlight on incumbent, asset-heavy firms and how they transform their established ecosystems. Stonig et al. (2022) provide insights into how an incumbent machine manufacturer has successfully adapted its product-focused activities to establish itself as a leader in an emerging ecosystem. In the context of the medical sector, Randhawa et al. (2021) highlight the role of cognitive artifacts when incumbents shift from linear value chains to ecosystems that are contingent on collaborations with heterogeneous stakeholders. Falcke et al. (2024) shed light on how incumbent energy utilities experiment with ecosystem realignment and have delineated different pathways via which they can navigate technical interfaces and strategic relations with other actors to achieve positive climate impact. While these studies provide preliminary insights into ecosystem transformation, our understanding of the strategies through which incumbents can transform their ecosystems to deliver more sustainable outcomes remains limited.

Finally, research in more specialized sustainability journals has begun to address how ecosystem strategies can contribute to sustainability outcomes. First, a large stream of research within this area has studied the transition from a linear to a circular economy, focusing on how resource loops can be narrowed, slowed or closed to contribute to sustainability outcomes (e.g., Bocken & Ritala, 2016; Bocken et al., 2021; Kanda et al., 2021; Geissdoerfer et al., 2017; Kuhlmann et al., 2023). While the positive environmental impact of circular strategies through the conservation of resources and waste reduction is clear, the impact on carbon emission intensity is not always straightforward (Driessen and Grönlund, 2024). A second thriving research area focuses on platform-based ecosystems and their potential contributions to sustainability (e.g., Bonina et al., 2021; Ritala, 2023), including their ability to address specific aspects of hard-to-abate value chains, for example, by reducing food waste through open platforms (Hellemans et al., 2022). Third, prior research on sustainable business models and business model innovation has investigated how firms can create and deliver value while at the same time contributing to sustainability outcomes (Bohnsack et al., 2014; Oskam et al., 2020; Snihur and Bocken, 2022; Atkova et al., 2025). While the business model concept takes the firm as the central unit of analysis, it focuses less on the network of interdependent actors that needs to be coordinated.

Taken together, these research streams provide preliminary insights into how ecosystems are created or transformed, and how they can contribute to sustainable outcomes. However, our knowledge of how incumbents can drive the transformation of carbon-intensive ecosystems to deliver net-zero outcomes – a strategic shift critical to decarbonizing the world's highest-emitting sectors – is still radically incomplete. First, while prior research provides insights into the creation of de novo ecosystems, decarbonizing emission-intensive sectors requires a better understanding of how ecosystems are transformed to enable net-zero outcomes. Second, while new complementors can provide novel low-carbon solutions, achieving net-zero requires front-loaded actions by high emitters, calling for a shift of the spotlight from disruptive new entrants to incumbents as the focal firms that orchestrate ecosystem transformation. Third, complementing prior work on the circular economy with a focus on resource conservation and waste reduction, we need a better understanding of how incumbents can orchestrate ecosystem transformations toward net-zero emissions.

To address these gaps, this study proposes a novel framework that centers on incumbent firms in carbon-intensive sectors and develops strategic options for coordinating ecosystem participants to jointly advance towards net-zero outcomes. To support the framework's development and demonstrate its relevance, the article draws on illustrative examples from the cement and concrete industry. The next section introduces this setting and provides the contextual foundation for analyzing coordination challenges and ecosystem strategies for achieving net zero.

### 3. Decarbonizing cement: an illustrative setting for ecosystem strategies aimed at net-zero outcomes

Cement is one of the most extensively used materials in the world, and demand continues to rise due to population growth and urbanization (Watari et al., 2022). At the same time, cement is responsible for roughly 7-8% of global CO<sub>2</sub> emissions (Li and Unluer, 2025). Combined, the industry's growth rate and emission intensity make it a particularly appropriate setting for illustrating how incumbents can contribute to decarbonizing emission-intensive sectors via their ecosystem strategies. These illustrations are grounded in a compilation of industry reports, scientific articles, and expert interviews with managers in the cement and concrete industry (see Table 1).

In a first step, the material was systematically analyzed to understand incumbents' activities and their contributions to carbon emissions. Fig. 1 shows how discrete activities contribute to overall emissions in the production of cement, which is then mixed into concrete. Abatement is particularly challenging because emissions stem from two major sources: (1) the combustion of fossil fuels in the kilns that reach temperatures of around 1450°C, and (2) the chemical process of calcination, when limestone breaks down in the kilns, releasing CO<sub>2</sub>. Each ton of high-clinker Portland cement produced emits approximately 0.9-1 tons of CO<sub>2</sub> equivalents (Li and

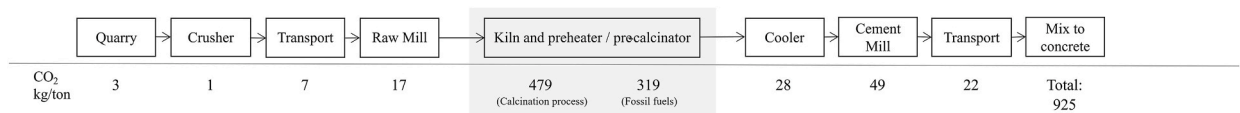


**Fig. 1.** The carbon-intensive, hard-to-abate process of producing cement/concrete (own visualization based on McKinsey et al., 2020; Li and Unluer, 2025).

Unluer, 2025).

In a second step, the material was analyzed to delineate key decarbonization levers. Multiple innovative decarbonization options are emerging and studies reveal that it is technically possible to achieve net-zero emissions in cement and concrete by 2050 (e.g., Watari et al., 2022). For example, optimizing and electrifying process steps (see Lever 1), using alternative fuels to fire the cement kiln (see Lever 2) or partially replacing carbon-intensive clinker with drop-in clinker substitutions such as supplementary cementitious materials (see Lever 3) can significantly reduce the emission intensity of cement production. However, there is no “silver bullet” (Watari et al., 2022) that can provide sufficient emission abatements on its own; instead, it requires the combination of different decarbonization levers in the limited time remaining. Table 1 lists these levers and Fig. 2 illustrates how they interact with and transform the cement and concrete production process.

In a third step, decarbonization levers were analyzed more deeply to develop an understanding of whether and in which ways they require coordination in ecosystems. This step revealed that producing cement/concrete with net-zero properties requires focal firms to (1) coordinate with new and existing ecosystem participants (e.g., Thomas et al., 2022), and to (2) navigate bottlenecks (e.g., Baldwin, 2015) within the ecosystem that can constrain net-zero outcomes. These characteristics demonstrate the usefulness of advancing a net-zero ecosystem framework to better understand how coordination can be enacted, and bottlenecks be prevented.

First, unlocking the net-zero value proposition requires **coordination with new actors** that span multiple industries and qualify as complementors (Thomas and Autio, 2020). For instance, new participants from the tech industry – such as AI-native firms delivering process optimization solutions – can enhance the efficiency and sustainability of incumbents’ energy-intensive cement production processes if these solutions run on renewable electricity (Lever 1). Lever 5 (Carbon Capture and Utilization or Storage - CCUS) requires the orchestration of an entirely new set of ecosystem participants. These include not only providers of technologies that allow focal firms to capture CO<sub>2</sub> from cement flue gases, but also infrastructure or transport providers that move the captured CO<sub>2</sub> to permanent storage sites or to manufacturing facilities where it can be utilized in new applications. Moreover, new market structures, such as contracting models for carbon utilization and verification mechanisms for long-term storage are required to unlock the value of CCUS.

At the same time, unlocking decarbonization levers can require **coordination with existing ecosystem participants**. For example, the use of alternative fuels (Lever 2) has a long-standing tradition in the cement and concrete industry, where waste has been co-processed in cement kilns for decades. In the context of the net-zero transformation, however, ecosystem participants linked to alternative fuels – such as waste producers and processors or municipalities – become strategically more important to incumbents, as substitution targets rise, fuel mixes grow more complex, and suitable waste material becomes scarce.

Furthermore, unlocking decarbonization levers is subject to **coordinating multilateral interdependencies** between ecosystem participants. For example, changes in cement or concrete composition, such as drop-in clinker substitution (Lever 3), require coordination with standardization bodies that ensure the safety and durability of the material following such compositional changes. Re-using and recycling construction waste (Lever 4) calls for the concerted action of multiple stakeholders, including architects, urban planners, constructors, general consumers and waste processors. The value of recycled cementitious materials depends on the configuration of demolition practices, sorting infrastructure, certification regimes, architectural specifications, construction capabilities and regulatory acceptance. This requires coordination effort from focal firms that goes far beyond “formal, one-to-one supplier contracts that define delivery obligations and possible sanctions should the supplier fail to deliver” (Autio and Thomas, 2022, p.13).

Second, cement manufacturers require ecosystem strategies since the above outlined interdependencies can result in **bottlenecks** – i.e., components that constrain the overall growth or performance of the ecosystem due to poor quality, weak performance, or scarcity (Baldwin, 2015; Hannah and Eisenhardt, 2018; Agarwal and Kapoor, 2023). Novel cement chemistries (see Lever 6), for example, hold the potential to produce cement with very low or near-zero process emissions. However, it remains highly uncertain whether these approaches can be scaled to meet industry-wide demand. Another example is the use of alternative fuels (see Lever 2) – such as biowaste. Demand for biogenic waste is projected to increase substantially (IRENA, 2024), as it can be used for various net-zero applications, such as the production of energy through waste incineration or biofuels. This could pose challenges for future needs in the form of increased prices and shortages, thus constituting a bottleneck in focal firms’ ambition to transform their ecosystems to

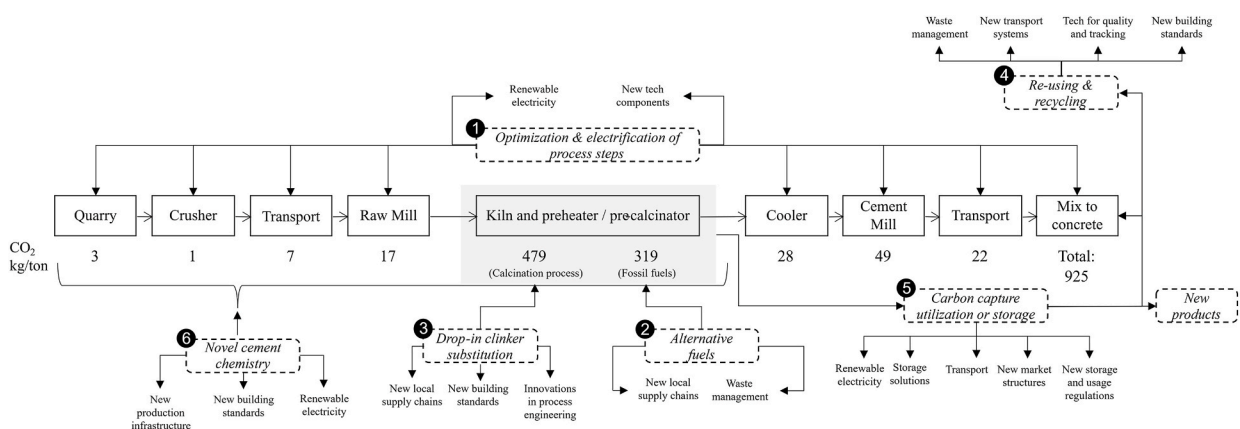


Fig. 2. How decarbonization levers interact with the cement/concrete production process.

deliver net-zero outputs.

In sum, the investigation of incumbents in the cement and concrete industry illustrates how delivering net-zero outcomes is an ecosystem game. Net-zero solutions rely on complementary offerings from multiple actors across industries and sectors, which can become bottlenecks to value creation and must thus be coordinated by focal firms. Such coordination comes with a unique set of challenges that call for new research on ecosystem strategies. Throughout the manuscript, most illustrations will adopt the perspective of incumbent cement producers as the focal firm. However, selected examples will also involve technology providers or materials firms whose activities demonstrate the interdependencies that cement producers must engage with.

#### 4. Coordination challenges associated with net-zero ecosystem transformation

The following delineates three coordination challenges associated with net-zero ecosystem transformation: (1) incumbents' boundedness by legacy assets and physical infrastructure, (2) the wickedness of the problem(s), and (3) temporal imperatives of achieving net zero on specific timelines. Examples from the cement and concrete industry illustrate.

##### 4.1. Incumbents' boundedness by legacy assets and physical infrastructure

Firms aiming to decarbonize are not building de novo ecosystems from scratch (e.g., [Hannah and Eisenhardt, 2018](#); [Dattée et al., 2018](#)), nor do they move from products to platform-based ecosystems by adding digital innovations (e.g., [George et al., 2021](#); [Ritala, 2023](#); [Björkdahl et al., 2024](#); [Randhawa et al., 2024](#)). Instead, they need to transform existing production processes ([Mottee et al., 2024](#)), which are often asset-intensive and characterized by long asset lifetimes. Think of cement kilns that typically produce 0.9–1.1 million tons of clinker annually and have a lifetime of 30–50 years ([Cembureau, 2025](#)). The emission intensity of the physical infrastructure can be reduced via digitally enabled sustainability strategies ([Falcke et al., 2026](#)) but ultimately requires more fundamental reconfiguration of physical assets and process steps. This typically entails high switching costs from path-dependent, asset-heavy, and emission-intensive systems to low-carbon alternatives ([Stern and Valero, 2021](#)). This underscores the need for focal firms to coordinate not only actors and activities in their ecosystem, but also physical artifacts ([Granstrand and Holgersson, 2020](#)).

At the pilot level, [Falcke et al. \(2024\)](#) show that legacy infrastructure plays a critical role for net-zero ecosystems. The study uncovers configurations through which incumbents – who control physical infrastructure – can realign with new complementors for positive climate impact. However, what remains unaddressed is how incumbents can move beyond the pilot stage to develop a comprehensive strategy for net zero. Pursuing multiple ecosystem configurations simultaneously seems prohibitively costly. Yet, delaying actions prolong emissions and make it more costly to change later ([Stern and Valero, 2021](#)), especially when focal firms are subject to emission trading schemes that cause a progressively increasing price on carbon. Given the inertia and costs associated with replacing physical infrastructure, as well as the multiple ways in which physical infrastructure can be combined with novel complements (see [Fig. 2](#)), incumbents face substantial challenges in transforming ecosystems for net-zero outcomes.

##### 4.2. The wickedness of the problem(s)

Climate change and the transition to a net-zero economy are wicked problems ([Rittel and Webber, 1973](#)). Following [Dentoni et al. \(2018\)](#), wicked problems are characterized by knowledge uncertainty, dynamic complexity, and value conflict. First, knowledge uncertainty refers to both the formulation of the problem(s) and the potential solutions, requiring firms to make strategic decisions in an incomplete information setting. Uncertainty derives from limited availability of information due to gaps in scientific knowledge – e.g., can new cement chemistries scale to ultimately replace the carbon-intensive production process? – and cognitive limits of decision-makers to adequately deal with, process and put available information to use – e.g., how to become knowledgeable and make strategic decisions across all decarbonization levers? There are multiple rapid technological developments and uncertainties regarding which combinations of low-carbon technologies will succeed ([Bumpus and Comello, 2017](#); [Zobel et al., 2024](#)). Thus, for firms, there is not one clear ecosystem blueprint ([Dattée et al., 2018](#)) for reaching net zero. Instead, it requires experimentation with multiple possible pathways ([Falcke et al., 2024](#)).

Second, dynamic complexity refers to volatile interdependencies and non-linear changes that are difficult to predict ([Dentoni et al., 2018](#)). For example: Will new cement chemistries scale, potentially rendering other levers like CCUS obsolete? And if so, when? And will the necessary regulations and market mechanisms be and stay in place to make CCUS feasible and economically viable?

Third, multiple stakeholders are affected by wicked problems, each with their own set of values, frames, perceptions, and interests, which may not only diverge but clash with one another ([Dentoni et al., 2018](#)), raising concerns around legitimacy ([Thomas and Ritala, 2021](#); [Randhawa et al., 2024](#)). The scaling of CCUS, for example, risks conflicts with relevant stakeholders ranging from (1) society that is concerned about the safety of CCUS, (2) NGOs that may frown upon cement manufacturers that collaborate with oil and gas firms which can store carbon in depleted oil fields but are often considered the “bad guys”, or (3) governments that are concerned that CCUS will be used as an excuse to continue to emit.

Given the uncertainty, dynamic complexity and contestability surrounding the realization of a net-zero ecosystem, firms may struggle to find relevant stakeholders to support it and make the required resource commitments (e.g. [Ozcan and Santos, 2015](#); [Dattée et al., 2018](#); [Randhawa et al., 2024](#)). This calls for further research on how focal firms can effectively orchestrate ecosystems that

deliver net-zero outcomes.

#### 4.3. Temporal imperatives

A final challenge is the urgency of achieving net zero within a limited time frame to avoid crossing severe climate tipping points and to prepare for tightening policy regimes, such as the EU Emissions Trading System. Decarbonization trajectories that are scientifically aligned with the Paris Climate Agreement require frontloading emission reduction, approximately halving emissions by 2030, and achieving net-zero emissions by 2050 at the latest (Fankhauser et al., 2022; Comello et al., 2021). The front loading and urgency challenges assumptions in prior ecosystem literature, which suggests that ecosystem creation and transformation under conditions of uncertainty requires experimentation, feedback loops, and learning (e.g., Ansari et al., 2016; Dattée et al., 2018; Stonig et al., 2022). Faced with urgent decarbonization timelines, firms may not be able to afford the same degree of experimentation or may be unable to keep their options open.

Beyond urgent timelines, other temporal dynamics add complexity to the orchestration of net-zero ecosystems. While the time window within which net zero must be achieved is shrinking, net-zero goals still extend decades into the future, far beyond the usual strategic time horizons (Slawinski and Bansal, 2015; Feuls et al., 2024). Such distant future goals often require imagining qualitatively different worlds that are subject to uncertainty and ambiguity (Augustine et al., 2019). For example, new cement chemistries could replace conventional cement production. However, imagining how such processes could replace cement kilns in thousands of facilities around the world requires efforts to translate this future into realizable courses of action (Feuls et al., 2024). While incumbents may see the potential for future benefits generated from a net-zero ecosystem, they also perceive more immediate threats to their current emission-intensive business model (Ansari et al., 2016). Combined with the wickedness of the problem, this tension is particularly threatening to incumbents, as it creates significant uncertainty about how and when value will be distributed across participants of the ecosystem. Whereas future benefits are uncertain and distant, the threat of disruption perceived by industry incumbents is much more imminent (Ansari et al., 2016).

Arguably, each of the above outlined characteristic – (1) legacy assets and physical infrastructure, (2) wickedness of the problem, and (3) temporal imperatives – is perhaps not novel itself and not uniquely tied to the net-zero setting. However, the severity and interplay of these characteristics in the context of net-zero ecosystem transformations pose exceptional challenges to incumbents. Existing approaches to ecosystem orchestration, such as blueprints, experimentation, and disruption by complementors, are likely insufficient.

### 5. Strategies for net-zero ecosystem transformation

While the legacy assets and physical infrastructure constrain ecosystem transformation, the wickedness of the problem calls for exploration of multiple solution pathways. This exploration is, however, further constrained by temporal imperatives requiring both front-loaded emission reduction as well as more radical, long-term low-carbon solutions to reach net zero by 2050. To address these challenges, this section develops a set of four strategies – substitution, extension, looping, and build-and-replace – that constitute strategic options for focal firms to orchestrate net-zero transformations of their ecosystems. The starting point for these strategies is an ecosystem-based value system – visualized in Fig. 3 – that takes the focal firm as the unit of interest and defines the ecosystem as the network of ties linking the firm to other ecosystem participants that affect, or are affected by, its activities (Jacobides et al., 2018; Shipilov and Gawer, 2020). The four strategies – shown in Figs. 4–7 – are aimed at transforming this ecosystem-based value system to enable net-zero outcomes.

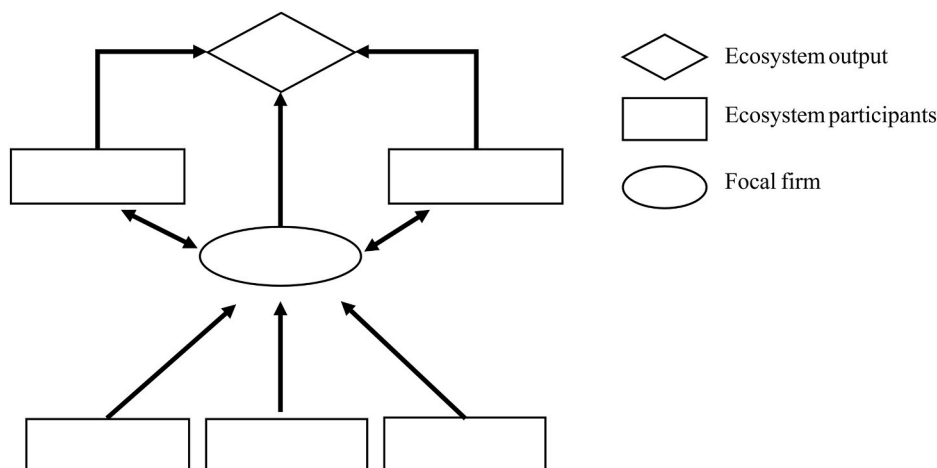


Fig. 3. A generic ecosystem-based value system (adapted from Jacobides et al., 2018).

### 5.1. Substitution strategy

Focal firms can deploy low-carbon solutions as modular *plug-ins* that partially replace emission-intensive components in the ecosystem. These plug-ins may originate from existing or new ecosystem participants and often require multilateral adjustments elsewhere in the ecosystem. However, they do not fundamentally overhaul the ecosystem's underlying value system. Instead, this strategy reduces the ecosystem's emission intensity by selectively substituting high-emission-intensive process steps with low-carbon alternatives. Of the six decarbonization levers listed in Table 1, (1) optimization and electrification of process steps, (2) alternative fuels, and (3) drop-in clinker substitution can be leveraged as substitution strategies. Enacting these strategies requires focal firms' coordination with ecosystem participants.

On the one hand, substitution strategies may require renewed coordination with existing ecosystem participants. Consider the example of leveraging drop-in clinker substitutes (Lever 3) which requires access to supplementary cementitious materials (SCMs) that replaces clinker in cement. Clinker is produced by heating limestone, a process that triggers chemical reactions releasing CO<sub>2</sub>. Cement producers often already have long-standing relationships with firms from other industries that supply SCMs. Utilities, for example, provide fly ash from their coal-fired power plants, while steel manufacturers supply granulated slag as a substitute for emission-intensive clinker. In the context of the net-zero transformation, however, these ecosystem participants become strategically more important, as substitution targets increase and availability of these SCMs decline (Li and Unluer, 2025). Fly ash production is decreasing as coal-fired power plants are being phased out. Similarly, granulated blast furnace slag is becoming scarcer due to the transition to cleaner steel production technologies, such as electric arc furnaces. This may create bottlenecks in the transformation of a cement producer's ecosystem – elevating the role of SCM providers to a strategic level. As such, participants that used to be at the periphery of the ecosystem move closer to its center and require more intensive or renewed coordination by the ecosystem's orchestrator.

On the other hand, substitution strategies can also rely on coordination with new ecosystem participants. Calcined clay, for example, offers an alternative pathway for substituting emission-intensive clinker. Although clay is a rather abundant natural resource that is geographically widespread, realizing this pathway requires coordination with new ecosystem participants that can provide novel minerals resources and specialized geological expertise.

While substitution strategies do not fundamentally transform the legacy ecosystem-based value system, they require coordination of multilateral interdependencies. For example, changes in cement or concrete composition through drop-in clinker substitution require coordination with standardization bodies that ensure the safety and durability of materials following such compositional changes. Similarly, because SCMs can alter the characteristics and behavior of concrete, coordination with design and specification actors, such as architects or engineers, becomes more critical. This example illustrates that interdependencies induced by substitution strategies are not only bilateral (e.g. between cement manufacturers and SCM suppliers) but often involve multilateral interdependencies, requiring coordination across multiple ecosystem participants (e.g. with standardization bodies, architects, and engineers).

Fig. 4 visualizes the ecosystem substitution strategy, whereby a focal firm strategically coordinates with existing (see half-shaded rectangle) and/or new ecosystem participants (see fully shaded rectangle) to plug in low-carbon components (e.g., SCMs) that partly replace emission-intensive ones (e.g. clinker in cement). These plug-ins require focal firms to strategically enhance coordination with these existing and/or new ecosystem participants (see bidirectional dashed arrows between the focal firm and these participants). They also require managing multilateral interdependencies (see dashed arrows across ecosystem segments) that extend beyond directly affected ecosystem components (e.g. standardization bodies or engineers), as well as navigating emerging bottlenecks. Because substitution strategies require neither a major overhaul of the existing ecosystem's value system nor the creation of entirely new structures, they can be considered comparatively accessible near-term measures of the net-zero transformation. However, incumbents relying on

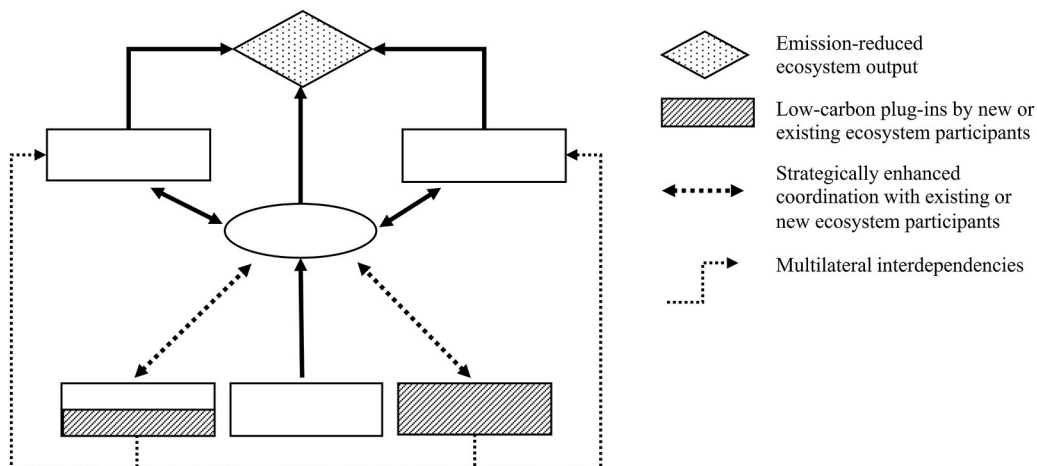


Fig. 4. Substitution strategy for net-zero ecosystem transformation.

substitution strategies only, risk exposing themselves to bottlenecks and are unlikely to reach net-zero emissions within the limited time frame remaining.

## 5.2. Extension strategy

With an extension strategy, incumbents expand their ecosystem-based value system by integrating new participants and activities that enable net-zero outcomes beyond incremental substitution. This introduces novel interdependencies and fundamentally reshapes the value system. Whereas substitution replaces emission-intensive components within the existing ecosystem's value system, extension introduces entirely new activities that were previously absent. Lever 5 – Carbon Capture Utilization and Storage (CCUS) – helps to illustrate.

When incumbents engage in CCUS, they must coordinate with new ecosystem participants that provide technologies for capturing the CO<sub>2</sub> emitted from cement flue gases. However, realizing the value proposition of CCUS requires not only access to the core technology of CO<sub>2</sub> separation (e.g. amine-based absorption or oxyfuel combustion), but also coordination across a broader set of novel complements, including transport and storage infrastructure, as well as new regulatory and market structures. These complements expand the ecosystem's value system horizontally by integrating participants from other industries (e.g. pipelines and shipping operators) and sectors (e.g., policymakers regulating carbon storage). Rather than “plugging in” low-carbon components, extension strategies therefore require the orchestration of more complex interdependencies.

An example that illustrates this complexity is “The Peak Cluster Project” (The Peak Cluster Project, n.d.) – an innovative collaboration between Holcim and Progressive Energy, Tarmac, Breedon, and Sigma Roc intended to capture, transport and permanently store CO<sub>2</sub> emissions from neighboring industries and across Derbyshire, Staffordshire, and Cheshire. The project aims to capture and store over 3 million tons of CO<sub>2</sub> annually by 2030. Achieving this goal requires ecosystem extension through a joint effort to build an underground pipeline transporting CO<sub>2</sub> emissions from industrial plants in the Peak District to a permanent storage facility underneath the eastern Irish sea. To enable this, the project partners with Morecambe Net Zero – a joint venture involving Spirit Energy, Centrica plc, and Stadtwerke München GmbH – which is planning to convert its depleted Morecambe Bay gas fields under the eastern Irish Sea to create storage capacity of approximately one billion tons of CO<sub>2</sub>. The consortium also actively engages in shaping regulations and policies in support of CCUS.

Fig. 5 illustrates the ecosystem extension strategy. With this strategy, focal firms extend their existing ecosystem by adding a new carbon-reducing technology or process step (see dashed rectangle with round edges), such as CO<sub>2</sub> separation technologies to enable carbon capture at source point. While the integration of such technologies may require substantial modifications to cement plant operations, this addition does not fundamentally alter the ecosystem's value system. Instead, it augments it with a carbon-reducing component or process that lowers the emission intensity of the ecosystem's outputs. Achieving more sustainable outputs, however, requires coordination with a new set of complementors (e.g. providers of transport or storage infrastructure, see additional dashed rectangles), thereby broadening the ecosystem horizontally. While some complements may be more readily available – e.g., storage sites in abandoned oil fields – others need to be developed from scratch, including new underground pipelines or novel regulatory

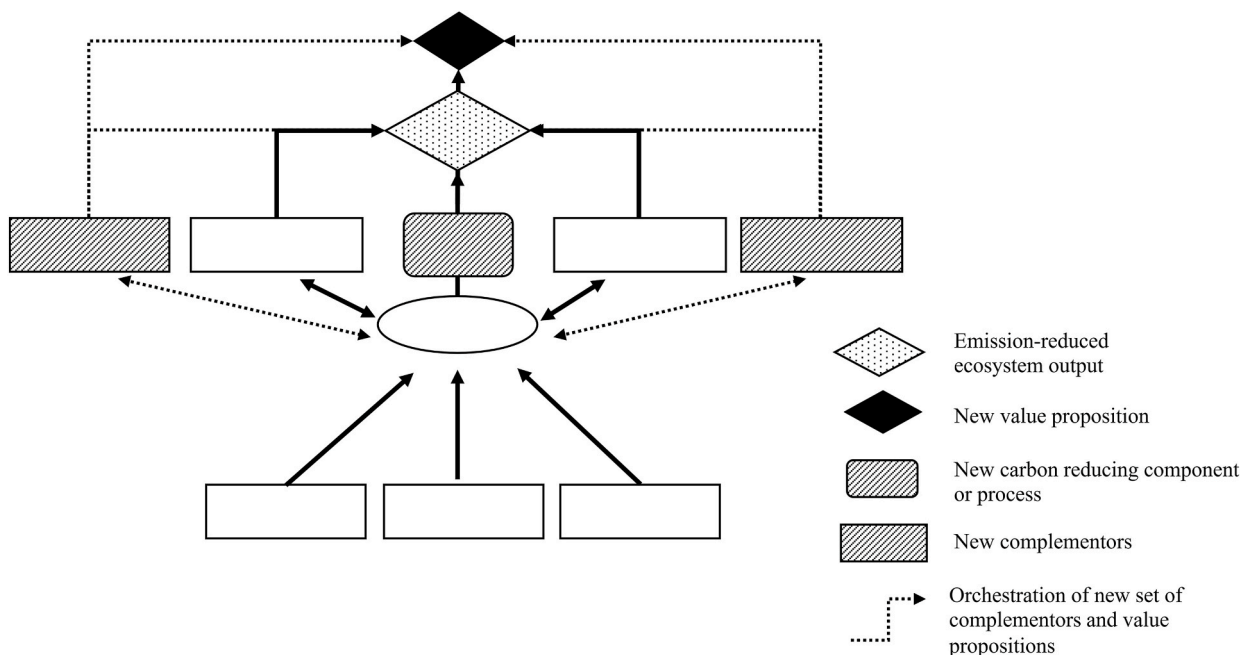


Fig. 5. Extension strategy for net-zero ecosystem transformation.

frameworks. At the same time, ecosystem extensions can unlock new value propositions for the focal firm, creating opportunities for vertical ecosystem extension (see new diamond added to the value system). For example, rather than permanently storing the captured CO<sub>2</sub> underground, it could be used as an input in other applications, such as a feedstock for the chemical industry. While this opens up new business opportunities for the focal firm, net-zero benefits depend on the application's lifecycle and the duration of CO<sub>2</sub> retention. Consequently, extension strategies require greater orchestration and coordination effort from focal firms (see dashed arrows in Fig. 5) but also create opportunities to unlock new value propositions.

### 5.3. Looping strategy

Looping strategies have been covered in prior work on the circular economy which has extensively studied how firms can transition from linear to circular value chains (e.g., Bocken et al., 2016; Bocken and Ritala, 2021; Geissdoerfer et al., 2017; Kuhlmann et al., 2023; Wörner et al., 2025). Bocken et al. (2016) distinguish between (1) narrowing – reducing resource use associated with the production process –, (2) slowing – prolonging the use and reuse of goods over time –, and (3) closing resource loops – reusing material through recycling. Focal firms can use all three to transform their carbon-intensive ecosystems into more sustainable ones. Specifically, focal firms can reshape resource flows within the existing ecosystem by narrowing, slowing, and closing material loops to create circular structures that aim to reduce resource use and emission intensity. While circular strategies conserve resources and reduce waste, their impact on carbon emission intensity needs to be evaluated more carefully, as circular economy scenarios might increase the need for more transport and processing. Nonetheless, recent studies in the cement context suggest positive impacts of circular economy approaches in both resource and climate impact categories (e.g., Barbhuiya et al., 2024; Driessen and Grönlund, 2024).

An example of a looping strategy is incumbents' shift from landfilling to the re-use and recycling of construction waste<sup>1</sup> Sika – a multinational chemical and materials company serving the construction sector – has developed a process, called reCO<sub>2</sub>ver to separate and reuse components of demolished concrete and increase the recycled aggregates' quality (Sika, n.d.). This process breaks down old concrete into aggregates, sand, and fine powdered material, while also sequestering CO<sub>2</sub> by carbonation of cement stone powder. However, fully unlocking the value of this process requires coordination with complementors, such as waste management companies and recycling players to create a closed-loop system (Barbhuiya et al., 2024), as well as with certifiers who can document the resulting climate benefits. Sika has, for example, entered a partnership with global climate consultancy South Pole to develop a climate-protection program for documenting and certifying the CO<sub>2</sub> benefits of reCO<sub>2</sub>ver facilities. In addition, Switzerland's Climate Cent Foundation is guaranteeing the purchase of CO<sub>2</sub> certificates from the program for an initial amount of CHF 10 million by the end of 2030 (Sika, 2023).

Fig. 6 illustrates how focal firms can use looping strategies to transform their ecosystem by reducing its environmental impact – and, depending on lifecycle assessments, its emission intensity – through lower resource use, reduced demand for virgin cement and concrete, and the diversion of waste from landfills. Thinner arrows in Fig. 6 (compared to Figs. 3–5) between the focal firm and other ecosystem participants, as well as the emission-reduced ecosystem output, represent the “narrowing” of resource flows. An illustrative

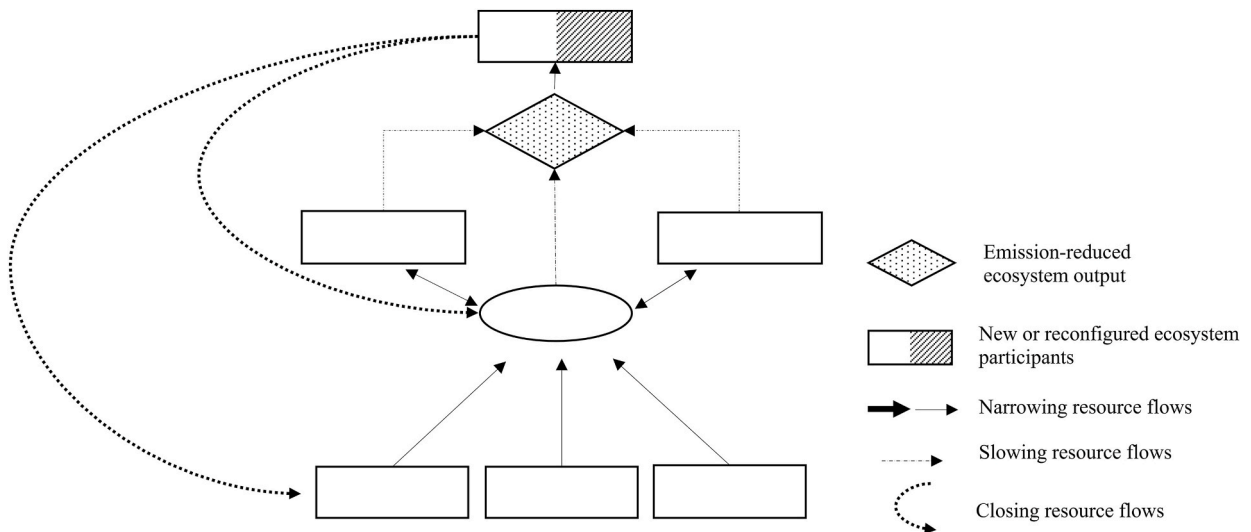


Fig. 6. Looping strategy for net-zero ecosystem transformation.

<sup>1</sup> Technically, decarbonization levers 2 (alternative fuels) and 3 (drop-in clinker substitutions) are also part of a circularly economy, since they entail the incorporation of industrial by-products into the production process, reducing the need for extracting new raw materials and diverting waste from landfills (Barbhuiya et al., 2024).

mechanism is a focal firm's coordination with partners that provide digital quality control solutions to reduce cement use per cubic meter. Dashed arrows between the focal firm and the emission-reduced ecosystem output represent the “slowing” of resource flows. For example, a focal firm may coordinate with partners to provide high-durability concrete formulations that extend the lifespan of buildings and infrastructure. Finally, closing loops (see dashed looped arrows) often requires adding new ecosystem participants or reconfiguring relationships with existing ones. For example, waste managers or recyclers need to provide collection logistics and material-processing capabilities (see partly dashed rectangle) and thus become strategic partners of the focal firm. These changes and coordination requirements extend beyond the life cycle of the original value proposition. They enable new loops into other parts of the ecosystem (e.g. re-use and recycling of demolished concrete), creating feedback flows that initiate new life cycles. Thus, if focal firms coordinate across participants and product life cycles effectively, they can establish novel circular structures within their legacy ecosystem-based value system with the potential to reduce emission-intensity of the ecosystem's outputs.

#### 5.4. Build-and-replace strategy

Leveraging build-and-replace strategies, focal firms develop a parallel ecosystem-based value system based on radically new production processes and complementary actors, with the intention that this new system eventually replaces the existing emissions-intensive one. This strategy requires incumbents to engage with new ecosystem participants that provide radically novel production processes which, if successfully scaled and combined with new complements, could give rise to an entirely new net-zero ecosystem-based value system. Because this nascent value system does not integrate easily with the existing one, incumbents need to divide their investments and attention between both systems and develop them in parallel.

Experimentation with novel cement chemistry (Lever 6), such as electrochemical cement production based on alternative materials, illustrates a build-and-replace ecosystem strategy. The U.S. startup Sublime Systems, spun out of MIT, provides a technology that reinvents the full cement manufacturing process (Sublime Systems, n.d.). Its novel approach cuts across the entire production chain, ranging from the use of clean electricity to carbon-free raw materials and novel electrochemical processes. In 2024, incumbent Holcim entered a partnership with Sublime, including a co-development agreement to scale up and commercialize the technology, as well as binding offtake reservation securing a large share of Sublime Cement produced at its Massachusetts facility (Holcim, 2024). Scaling this new ecosystem-based value system requires multilateral coordination with both new and existing ecosystem participants. For example, novel cement types may require coordination with new feedstock providers (e.g. non-limestone input) as well as with renewable power developers or grid operators when production relies on electrochemical rather than fuel-based processes. At the same time, renewed coordination with existing ecosystem participants may be necessary, for example, to obtain certification for the new material.

If the new value system scales, it could reach near-zero cement production, rendering the legacy ecosystem-based value system as well as other ecosystem strategies, such as extension through CCUS, obsolete. However, firms pursuing only build-and-replace strategies risk failing to achieve net zero within the required time frame, as the uncertainty and time needed to develop, scale, and coordinate the new value system may delay its maturity and readiness to replace the existing system. Yet, if they are not investing into this novel ecosystem-based value system, incumbents may risk disruption through complementors (Adner and Lieberman, 2021; Shi et al., 2024), where ultimately the new system may be mature enough to replace the old one, allowing new entrants to displace incumbents' core offerings. This might be an explanation for Holcim's equity investment into Sublime, securing access to and partial ownership of this new approach (Holcim, 2024).

Fig. 7 illustrates the build-and-replace strategy for net-zero ecosystem transformation. With this strategy, a new low- or zero-carbon technology or production process gives rise to an alternative ecosystem-based value system (see parallel value system with shaded elements). Because such novel approaches may ultimately disrupt the focal firm's legacy business, incumbents often manage these investments separately from their core operations (Christensen and Raynor, 2003), for example through partnerships with external technology providers. This implies that the focal firm orchestrates two ecosystem-based value systems – the legacy and the emerging one – in parallel and needs to make strategic decisions about resource allocation between them (see bilateral dashed arrow connecting

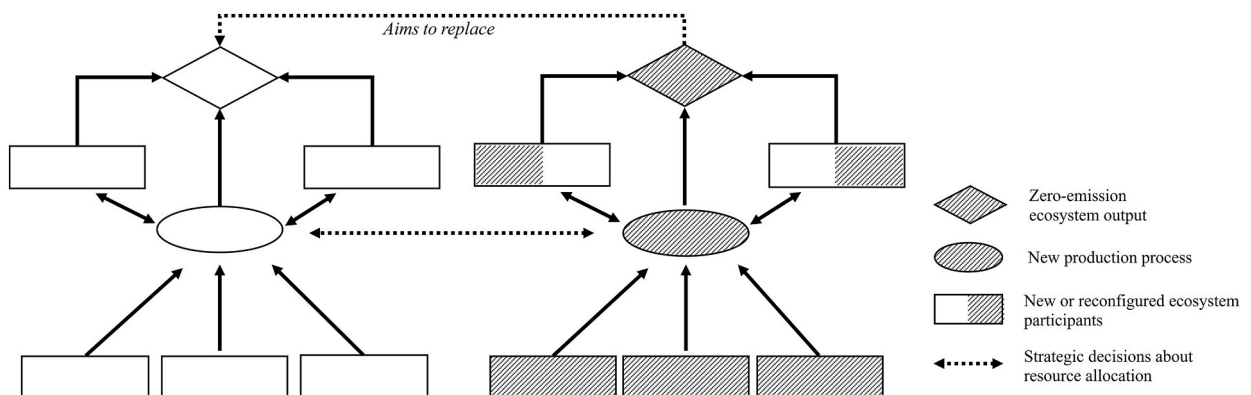


Fig. 7. Build-and-replace strategy for net-zero ecosystem transformation.

the two systems). As the above example illustrates, the emerging value system entails entirely new participants (see completely dashed rectangles) as well as the reconfiguration of relationships with existing ones (see partly dashed rectangles). The prospect is that the emerging ecosystem-based value system, delivering zero-emission outputs (see dashed diamond), will ultimately replace the legacy one. However, the likelihood, scope, and timing of this replacement remain highly uncertain.

## 6. Discussion: How focal firms coordinate net-zero ecosystem transformations

This study is motivated by the need for management research to provide greater insight into how firms in carbon-intensive, hard-to-abate sectors – causing the majority of global GHG emissions – can orchestrate net-zero ecosystem transformations. While prior research has shed light on how ecosystems are created in the first place (e.g. [Hannah and Eisenhardt, 2018](#); [Dattée et al., 2018](#); [Thomas and Ritala, 2021](#); [Thomas et al., 2022](#)), it has not yet sufficiently addressed how focal firms can transform ecosystems to enable net-zero outcomes, especially when these firms (1) are bounded by legacy assets and physical infrastructure, (2) face wicked problems, and (3) are subject to temporal imperatives. This study conceptualizes and illustrates these coordination challenges, drawing from examples in the cement and concrete industry, and proposes a set of four strategies – substitution, extension, looping, and build-and-replace – that focal firms can leverage to orchestrate the net-zero transformation of their ecosystems. These strategies have important implications for our understanding of how ecosystem transformation could help tackle the root causes of climate change by facilitating emission reductions and, ultimately, net-zero solutions in carbon-intensive, hard-to-abate industries. They thus complement prior work on the circular economy (e.g. [Bocken et al., 2016](#); [Bocken and Ritala, 2021](#); [Geissdoerfer et al., 2017](#)), sustainable business models (e.g., [Oskam et al., 2020](#); [Snihur and Bocken, 2022](#)), and digital platform-based ecosystems for sustainable development (e.g. [Bonina et al., 2021](#); [Ritala, 2023](#)). While each of the proposed strategies aims at reducing the emission intensity of ecosystem outcomes, no one can achieve net-zero outcomes on its own with certainty.

Therefore, the proposed concepts have important strategic implications for firms that are exposed to increasing institutional pressures to reach net-zero emissions ([Falcke et al., 2024](#)) and that need to position themselves in this changing landscape. In line with prior work (e.g. [Kapoor, 2018](#); [Jacobides et al., 2018](#); [Hannah and Eisenhardt, 2018](#)), a focal firm pursuing any of the proposed strategies must decide which and how many components of the ecosystem to provide itself, which components to coordinate actively with partners, and which components to approach more passively, for example, by waiting for other actors to put them in place. For instance, when *extending* its ecosystem to include CCUS, a focal firm must decide whether to focus on testing and implementing CO<sub>2</sub> separation technologies or to also become actively involved in coordinating solutions for transportation and storing the captured CO<sub>2</sub>.

Importantly, the proposed framework extends prior work by introducing a portfolio-level dimension of strategic decision-making: whether, to what extent, and when a focal firm should pursue multiple ecosystem strategies by combining substitution, extension, looping, and building-and-replacing. Each of these strategies entails distinct modifications to the focal firm's original ecosystem-based value system, ranging from relatively minor changes through substitution, to more substantial extension, shifts from linear to closed loops, and ultimately, to complete replacement of the legacy value system. Combining multiple strategies therefore introduces a new level of ecosystem complexity as it requires firms to envision ([Dattée et al., 2018](#)) and realign ([Falcke et al., 2024](#)) multiple configurations of their existing ecosystem and, when pursuing a build-and-replace strategy, to manage the relationship between the legacy and an emerging ecosystem-based value system.

By conceptualizing ecosystem transformation as a portfolio of strategies, the proposed framework highlights how the combination of these strategies is shaped by interdependencies and complementarities *within* individual strategies and *across* different strategies. Focal firms must consider interdependencies and complementarities not only among actors involved in a given single ecosystem strategy, but also among actors involved in different strategies. Rather than selecting a single strategy in isolation, focal firms thus need to strategically consider how to best combine and sequence them, recognizing that actions associated with one strategy could enable, constrain, or amplify those associated with another. They must therefore account for how the strategies jointly modify the focal firm's existing ecosystem-based value system and, in the case of build-and-replace, how an emerging parallel value system relates to the legacy system that is simultaneously being modified.

On the one hand, relationships among ecosystem strategies can be complementary. The relationship between Holcim and the Swiss start-up Neustark illustrates how a cement producer can capture complementarities between looping and extension strategies. By collaborating with Neustark and other ecosystem participants, Holcim can connect the reuse of demolished concrete (i.e. looping through re-using and recycling construction waste) with the durable mineralization of biogenic CO<sub>2</sub> (i.e., extension with carbon dioxide removal and storage). Neustark's solution links biogas plants, where biogenic CO<sub>2</sub> is separated during biogas upgrading, with concrete recyclers and other construction-material firms, where the captured CO<sub>2</sub> is mineralized in demolished concrete that is subsequently reused ([Neustark, n.d.](#)). From Holcim's perspective, this configuration of combined looping and extension creates joint value by reducing demand for virgin materials whose production is emissions-intensive while durably storing biogenic CO<sub>2</sub> in recycled aggregate. The combination can therefore reduce lifecycle emissions and generate carbon-removal benefits, thereby contributing to both the emission reduction and carbon removal aspects of net zero.

On the other hand, ecosystem strategies can be substitutive ([Granstrand and Holgersson, 2020](#)). For example, when an emerging value system centered on novel cement chemistry can produce large amounts of cement with near-zero emissions, it could ultimately replace the focal firm's legacy cement value system, and thereby render other ecosystem strategies less important or even obsolete. This example illustrates how some ecosystem strategies can create joint value when combined, as in the case of looping and extension, whereas others may operate as substitutes (e.g. build-and-replace vs. looping and extending). The framework therefore highlights the need to combine and sequence multiple strategies rather than treating them as isolated choices. This insight extends prior ecosystem theorizing which has predominantly focused on firms' strategic efforts to align interdependencies within the boundaries of a single

focal offer or ecosystem-based value system (e.g. [Jacobides et al., 2018](#); [Kapoor, 2018](#); [Ranganathan et al., 2025](#)).

Moreover, the temporal imperatives of achieving net-zero outcomes further complicate the combination of ecosystem strategies. Some strategies may be better suited for front-loading emission reductions – for example, substituting emission-intensive components with low-carbon alternatives (e.g. alternative fuels) – while others, such as ecosystem extension (e.g. with CCUS), may be more effective for achieving midterm targets by 2030. Build-and-replace strategies hold the potential to reach near-zero emissions in the long term (e.g. with novel cement chemistry), though it may be highly uncertain whether the emerging value system can fully replace the legacy value system before 2050. Thus, in addition to adding a new level of strategic decision making, the portfolio of strategies introduces a novel temporal dimension to the discussion of ecosystem transformation for sustainable outcomes.

### 6.1. Implications for future research

The concepts proposed in this study call for future research to examine how incumbents can transform their carbon-intensive ecosystems into ones that can deliver net-zero outputs. Considering potential complementary and substitutive relationships between different ecosystem transformation strategies, to what extent and under which conditions should firms focus on one or two strategies versus pursuing them all simultaneously? While the notion of complementarity has been central in extant ecosystem research (e.g. [Jacobides et al., 2018](#); [Shipilov and Gawer, 2020](#); [Agarwal and Kapoor, 2023](#)), substitutive relationships have been largely neglected ([Granstrand and Holgersson, 2020](#)) but could play a critical role in ecosystems with net-zero value propositions. In addition, it is critical for this research to take the temporal imperative of reaching net zero into account. Considering the sense of urgency and the planetary penalties of delaying any short-term emission reductions ([Bansal et al., 2024](#)), how can firms best combine different ecosystem transformation strategies? Prior work suggests that a system strategy (i.e., doing it all) is only viable when integrative synergies are high and the pace of innovation is manageable ([Hannah and Eisenhardt, 2018](#)). Both are unlikely to be true in a net-zero context. However, focusing on only one or a few strategies risks delaying emission reduction or jeopardizing the achievement of net zero by 2050, with detrimental impacts on the climate as well as the focal firm's long-term viability under increasingly tightening emissions regulations. Hence, future research should combine aspects of complementarity, substitution, and temporality to uncover ecosystem strategies that are most effective for net-zero progress.

At the same time, studying sustainability contexts, such as the pursuit of net-zero emissions provides a fruitful setting for generating new insights into ecosystem strategies under conditions of high uncertainty and value-ladenness ([Dentoni et al., 2018](#)). For example, future research could examine how firms redesign their business models (e.g., [Snihur et al., 2018](#)), alignment and governance structures (e.g., [Paavola et al., 2025](#)), or investment logics ([Eklund and Kapoor, 2019](#)) when net-zero outcomes are subject to regulatory uncertainty and contested by diverse stakeholders.

Another promising avenue in this context is to examine the role of open innovation for ecosystems with net-zero outcomes ([Kennedy et al., 2017](#); [McGahan et al., 2021](#); [Randhawa et al., 2021](#); [Holgersson et al., 2022](#); [Zobel et al., 2024](#)). Future research could shed light on how the division of labor between ecosystem players across different strategies and the management of knowledge flows could leverage complementarities within the quickly shrinking time window of reaching net zero. This also raises the question of whether and how firms' customers of carbon-intensive products could contribute to their decarbonization. Scientifically validated net-zero targets do not only include firms' direct emissions – emissions caused on site by the burning of fossil fuels and through process emissions – but also indirect scope 2 (emissions generated through the purchase of electricity and heat) and scope 3 emissions (emissions generated upstream and downstream of the supply chain) ([Rogelj et al., 2021](#)). This raises the question of whether – and how – firms that rely on inputs from high-emission, hard-to-abate sectors (i.e., contributing to the focal firms' scope 3 emissions) can contribute to decarbonizing these upstream sources of GHG emissions through collaborative approaches.

Finally, advancing our understanding of net-zero ecosystems calls for empirical studies that introduce and operationalize new outcome variables ([Snihur and Bocken, 2022](#); [Falcke et al., 2024](#)). However, this is not easy to achieve since metrics and data are often not available. Studying how ecosystem strategies contribute to net zero requires assessing an outcome variable that has yet to be achieved – reaching net-zero emissions by 2050. Using short-term progress in emission reduction is likely to give an unfair advantage to lower-hanging-fruits (e.g. substitution strategies) which may reduce emissions in the short term but, on its own, fail to achieve net-zero by 2050. Hence, future research must become more creative in proposing novel approaches to studying and measuring progress toward net zero. Waiting to assess this outcome retrospectively may be too late, given the looming risk of crossing critical climate tipping points.

### 6.2. Practical implications

Recent attribution studies in climate science indicate that GHG emissions from so-called “carbon majors”, such as cement producers, are significant contributors to climate change, causing extreme weather events to become more likely and more intense (e.g. [Quilcaille et al., 2025](#)). These findings highlight the growing exposure of corporations to institutional, regulatory, and societal pressures to adapt and transition to net-zero emissions. Against this backdrop, this study informs strategists in high-emitting industries by offering new ways to navigate the net-zero transformation of their ecosystem-based value systems.

It proposes a strategic choice set from which managers can draw to make progress towards net zero, with strategies differing in their coordination and resource requirements. Managers may opt for the lowest-hanging fruit first by substituting carbon-intensive components in their ecosystem with low-carbon alternatives while keeping the original value system largely unchanged. However, even this lower-intensity strategy requires enhanced strategic coordination with ecosystem participants, may necessitate adjustments in other parts of the ecosystem, or can create bottlenecks that must be navigated. Extension strategies become viable when firms possess

orchestration capabilities or can credibly build them. With these capabilities, firms can not only expand their ecosystem horizontally through low-carbon complements but also explore new value propositions. Looping strategies require coordination across product lifecycles and therefore introduce a novel temporal dimension, as managers must account for resource flows beyond the product's initial lifetime. Finally, build-and-replace strategies allow managers to deal with complexity by managing interdependencies across two separate systems. However, they also require the strategic allocation of substantial resources between the two systems under conditions of high uncertainty. In sum, these unique characteristics and coordination challenges associated with the four strategies can inform managers' strategic choices among them.

Importantly, these strategies should not be viewed as alternatives but as elements of a broader strategic portfolio. Such a portfolio combines ecosystem strategies to achieve net-zero emissions as quickly as possible while maintaining strategic viability. Although this study cannot yet specify the optimal portfolio mix or the best sequencing of strategies, it offers initial guidance for managers. The proposed framework encourages managers to examine potential complementarities and substitutive effects across strategies and to assess their implications for the coordination efforts that the focal firm must invest in its ecosystem. Moreover, it highlights the importance of aligning strategic assessment of the focal firm's ecosystem-based value system – or systems, when building-and-replacing – with the temporal demands of reaching net-zero in ways consistent with the Paris Agreement. This requires managers to think beyond traditional strategic time horizons and design strategic pathways that integrate near-term emission reductions, medium-term targets such as halving emissions by 2030, and long-term transformation toward net-zero emissions by 2050. Together, these insights suggest that net-zero transformation is less about choosing a single pathway and more about orchestrating a temporally layered portfolio of ecosystem strategies.

### Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author used ChatGPT 4 & 5.5 in order to edit individual sentences for grammar, clarity, and sentence structure as well as to assess the clarity and consistency of selected conceptual arguments. In addition, it was used to critically assess and add nuance to the illustrative examples from the cement and concrete industry by prompting it to adopt the perspective of an industry expert. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

### Data availability

The data that has been used is confidential.

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