

**Lightening the Carbon Load:
Using Management Control Systems to Manage Decarbonization Strategies**

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Abstract

With companies increasingly expected to undertake potentially costly climate-response strategies, we explore the roles of management control systems (MCSs) in how companies simultaneously manage their decarbonization objectives and their financial commitments. Based on research at 19 European chemical, steel, and utility corporations, we extend the concept of “proactive/reactive” response strategies by proposing three additional decarbonization strategies: wholesale green transition, green segmentation, and engagement. Second, we highlight the recursive relationship between MCSs and these strategies. We also postulate a dynamic model of MCSs evolution in the decarbonization context, whereby engagement strategies form the foundation of green segmentation, and *vice versa*. Third, drawing on an integrative model, we propose three antecedents to companies’ response strategies relevant in this context; namely, their framing of decarbonization as an opportunity or a threat, the different perspectives on the availability of green technologies, and the different perspectives on the policy context.

I. INTRODUCTION

Since the signing of the 2015 Paris Climate Agreement, governments, investors, and consumers have stepped up pressure on publicly listed companies to respond to climate risks through decarbonization—that is, by substantially reducing carbon emissions. This pressure is most acute for heavy industries in the European Union (EU), where increasingly stringent climate policies have altered the operating environment of companies with emission-intensive business models. As a result, the price of EU emission allowances increased from €8 in early 2018 to €90 in December 2021, transforming carbon emissions from a hidden liability into a material cost factor (Eccles and Mulliken 2021). And while many European heavy industry companies have historically received free emission allowances, this will be phased down starting in 2026. The most carbon-intensive companies could then find their profits being wiped out unless they can reduce emissions or transfer those carbon costs to customers (Houlder and Livsey, February 03, 2021). Carbon-intensive business as usual is no longer an option for these

companies, forcing them to chart a path balancing commercial viability with substantial emissions reduction. Research suggests that while it may sometimes “pay to be green,” there are contexts—particularly in manufacturing—in which decarbonization may bring losses (Hart 1995; Hart and Dowell 2011; Houlder and Livsey, February 03, 2021).

Drawing on Hahn et al.’s (2015) Integrative Framework, we posit that firms need to pursue economic and environmental performance simultaneously—even if the two goals seem contradictory (Hahn et al. 2015, 299). Thus, achieving decarbonization goals depends on the carbon-intensive firm’s ability to (a) develop and pursue carbon-reducing *environmental capabilities* (Journeault 2016) and (b) promote these with a specific application of management-control systems—*carbon-control*—to measure, control, and disclose their decarbonization performance. This perspective, in turn, requires an understanding of the role of management control systems (MCSs) in pursuing both decarbonization and profitability.

Indeed, the literature suggests a rich array of MCSs applicable to environmental (or sustainability) strategies: cost classification schemes (Parker 2000); environmental dashboards and quantitative performance measures (e.g., Henri and Journeault 2010; Perego and Hartmann 2009), and increasingly sophisticated eco-control packages (e.g., Henri and Journeault 2010; Journeault 2016) that integrate sustainability control systems into traditional MCSs (Ditillo and Lisi 2016). Such systems have been implemented by firms with proactive environmental strategies² (Ditillo and Lisi 2016; Perego and Hartmann 2009). Overall, research has established a strong relationship between firms’ environmental strategic orientation (reactive or proactive) and their use of sustainability management controls (Sharma and Vredenburg 1998; Aragón-Correa and Sharma 2003; Pondeville, Swaen, and Rongé 2013; Ditillo and Lisi

² Perego and Hartman (2009: 42) differentiate between companies “more advanced in the implementation of their environmental strategies (more proactive companies)” and those that lag in their environmental strategies (more reactive companies).

2016). While many survey-based studies have examined the role of MCSs in *implementing* proactive or reactive sustainability strategies, an emerging genre of field studies have examined how management accounting practices are capable of shaping the *formation* of sustainability strategies, too (Rodrigue, Magnan, and Boulianne 2013; Battaglia et al. 2016). In particular, Rodrigue et al. (2013) suggest that environmental MCSs may influence environmental strategies via the performance evaluation process, so that the relationship between a firm's MCSs and its decarbonization strategy may be recursive and dynamically evolving.

In this paper, we investigate the relationship between environmental orientation and MCSs by studying it in the decarbonization context. Building on fieldwork in 19 European heavy-industry firms over 2018–2021, we propose that decarbonization strategies may, as Rodrigue et al. (2013) suggest, co-evolve with MCSs in a dynamic and recursive relationship—specifically, as clients and regulators (policymakers) exert pressure on firms. We posit three explanatory variables for the emergence of various response strategies: companies' *framing* of decarbonization as an opportunity or a threat; their different perspectives on the availability of the requisite green technologies (*technological uncertainty*); and their different perspectives on the relevant policy context (*regulatory uncertainty*).

Our contribution is threefold. First, with respect to environmental strategies and sustainability orientation, we refine the reactive–proactive dichotomy to fit the decarbonization context in Europe, where reactive, defensive responses are becoming incongruent with institutional imperatives, while proactivity may take multiple forms. By exploring the different strategies by which companies address the decarbonization challenge, we suggest a more nuanced classification of proactive decarbonization strategies (green transition, green segmentation, and engagement). Thus, from a conceptual point of view, our paper extends understanding of the term “proactiveness” with respect to decarbonization strategies.

Second, we find that the emerging response strategies have been facilitated by specific management accounting tools (carbon accounting, climate-risk scenarios), which have been integrated into MCSs to varying degrees. While most research explains the presence or lack of environmental controls and their integration into MCS packages with reference to firms' environmental-strategic orientation, we show that the relationship is dynamic and recursive: the different response strategies create the need for specific new MCSs to evaluate relevant strategic alternatives by, for example, monetizing the environmental (carbon) costs or envisioning the risks. Gradually, with the inclusion of such new tools and processes into MCSs, firms may grant new visibilities to the decarbonization landscape and thus shape perceptions of opportunities and threats, and perceptions of technological and regulatory uncertainty, in turn giving rise to new strategies. Thus, we show that over time, response strategies can support each other and have a recursive relationship with the MCSs that facilitate them.

Third, by locating the antecedents of the observed strategies in companies' (a) framing of decarbonization as a threat or opportunity, (b) technological uncertainty, and (c) regulatory uncertainty, we empirically validate Hahn et al.'s (2015) conceptual framework. We also extend it by emphasizing the role of management accounting tools in creating the visibilities necessary for the acceptance and resolution strategies required for sustainability management.

The paper is organized as follows. The next section summarizes the literature, including our theoretical lens. We then introduce our research methods and settings. In the Findings, we outline the response strategies which we classify into three types, along with our insights into the related MCSs. In the Discussion, we adjust the Integrative Framework for the discussion of decarbonization strategies and posit our own process model depicting the recursive relationship between response strategies and MCSs. Viewing proactive decarbonization strategies through this framework, we can see how organizational perspectives on the requisite

change processes and the temporal and spatial context—that is, opportunities, threats, and technological and regulatory uncertainty—are given visibility by MCSs.

II. ORGANIZATIONAL RESPONSES TO THE DECARBONIZATION CHALLENGE

Over the last two decades pressure on publicly listed companies to respond to climate change increased and calls for decarbonization have become ubiquitous (Ansari, Wijen, and Gray 2013; Klein 2014; Klein and Steffo 2021). At the same time, substantial literature has sprung up on organizational responses to the climate (and more broadly, sustainability) challenge. Initial research, pioneered by Naomi Oreskes and her co-authors (Oreskes and Conway 2010, 2013; Supran and Oreskes 2017) mobilized the theory of business capture (e.g., Brown and Fraser 2006) and argued that powerful corporate interests had responded to societal demands for climate action by active resistance strategies (Oliver 1991), manipulating and even discrediting scientific evidence on climate change and deflecting regulation. Defensive strategies sought to maintain the status quo and projected a green façade in climate-change communications. While there was evidence of such strategies, particularly among oil companies (Supran and Oreskes 2017; Bonneuil, Choquet, and Franta 2021), other researchers found that organizational responses were conditioned by companies' framings of climate change as a threat or opportunity to the business (Hart 1995; Hart and Dowell 2011). Managerial cognition and the framing of environmental issues as opportunities (rather than threats) has been identified as affecting firms' abilities to profitably enact environmentally proactive strategies (Sharma 2000; Sharma and Vredenburg 1998; Kolk and Pinkse 2005).

Several studies highlight the role of regulatory policy-infrastructures in influencing these perceptions, with certain regulatory environments incentivizing proactive responses from firms, while regulatory uncertainty has been shown to lead to reactive strategies (Bui and

Villiers 2017; Bryant, Griffin, and Perry 2019; Wright and Nyberg 2017). Although Bui and Villiers (2017) shed light on the role of certain control practices in mediating between corporate perceptions of climate change and (in)action, the appropriate processes and tools require further attention (O'Dwyer and Unerman 2020).

This initial research on corporate climate-response can be usefully complemented by two related bodies of inquiry: (1) the literature on tensions in institutional complexity, and (2) research on the role of MCSs in sustainability strategies. We mobilize these to set up our theoretical lens.

Institutional complexity and the tensions inherent in climate-response strategies

Regulation plays a key role in requiring businesses to decarbonize. The IPCC's scientists tell policymakers that to mitigate the catastrophic impacts of global warming, global anthropogenic CO₂ emissions need to reach net zero³ around 2050 (Millar et al. 2016; IPCC 2022). In line with economists' assessment that every year of delaying climate action makes it harder to reach carbon neutrality (Stern 2011), policymakers have stepped up their efforts of curbing emissions.

Institutional theorists argue that decoupling is a common strategic response to external regulatory pressures (Meyer and Rowan 1977), and in fact, compliance may be just one (not obvious) response by firms who may deploy strategies of overt or covert resistance (Oliver 1991). Indeed, a gap may open between companies' stated intentions to "fight climate change" (to quote Apple CEO Tim Cook's 2017 declaration) and what they do. In practitioner surveys, executives and directors consistently report that the pressures to "produce short-term results" are increasing (Bailey et al. 2014, 1). One market commentary goes as far as declaring, "Under existing market practices... any environmentally oriented CEO must have a death wish to

³ Reaching net zero emissions requires reducing carbon emissions to zero either by removing emitted carbon from the atmosphere (e.g., through emission offsetting or carbon capture and storage) or by eliminating it at the source.

pursue such strategies” (van Gansbeke, March 20, 2021). How, then, do high-carbon-intensity corporations reconcile the growing institutional demands to reduce emissions with the pressure to create shareholder value?

Institutional theory conceptualizes stakeholders’ varying expectations, interests, and demands through the notion of institutional logics (Friedland and Alford 1991; Thornton and Ocasio 2008)—defined as the overarching principles that "prescribe what constitutes legitimate behavior" and provide "taken-for-granted conceptions of what goals are appropriate and what means are legitimate to achieve these goals" (Pache and Santos 2013, 973). Organizations are typically confronted with multiple institutional logics (Reay and Hinings 2009; Kurunmäki, Mennicken, and Miller 2016). The plurality of institutional logics is not always problematic (Carlsson-Wall, Kraus, and Messner 2016), but it may become so when the prescriptions stemming from them are incompatible. In such fields of "institutional complexity" (Greenwood et al. 2011, 318), corporations experience tensions between seemingly conflicting agendas.

The institutional complexity of the climate-risk-response field arises from the competing institutional pressures bearing on carbon-intensive firms. Corporations try to remain profit-focused and maintain short-term economic advantages, but also claim to be “prosocial” (Henderson and Serafeim 2020) and enact climate stewardship. To the extent climate stewardship comes at the expense of profits (Henderson and Ramanna 2015), fallouts follow, as illustrated by the recent woes of the multinational food giant Danone (van Gansbeke, March 20, 2021).

In this context, we draw on Hahn et al.’s (2015) Integrative Framework to analyze the tensions inherent in corporate decarbonization strategies. This integrative view (initially developed for the analysis of corporate sustainability management) allows us to recognize that

firms need to pursue commercial and decarbonization agendas, even if they appear contradictory. This is particularly so in our chosen empirical setting, the EU context.

In 2018, a reform of the EU Emission Trading System⁴ reduced the available supply of emission allowances that grant companies the right to emit greenhouse gases. This was followed by the launch of the European Green Deal in 2019, a comprehensive strategy to make Europe the first climate-neutral continent by 2050. This ambition was subsequently enshrined in the European Climate Law, which set a legally binding target for the EU to reduce greenhouse gas emissions by at least 55 percent compared to levels in 1990. In July 2021, the EU Commission presented a package of legislative proposals to deliver on the Green Deal and the 55 percent emission reduction target, which included, amongst other measures, policy measures to heavily penalize high-emitting companies. Carbon-intensive business as usual is no longer an option for these companies, forcing them to chart a path balancing commercial viability with substantial emissions reduction.

Hahn et al. (2015) postulates that firms may manage such seemingly opposite demands by (1) acknowledging that the tension in question can and should exist and by (2) deploying different strategies to manage these tensions. Offering an alternative to the reactive-proactive dichotomy, Hahn et al. (2015) suggests that responses can be varied. Some opt for *acceptance strategies*, living with the tension, by for example generating constructive dialogue and cooperation among stakeholders, or by deploying experimental solutions. Other firms may find *resolution strategies* and transform the tension into a more manageable situation either by creating a *synthesis* (i.e. introducing a new perspective – or business model - that links or

⁴ The ETS applies a “cap and trade” principle that sets a limit (cap) on the total amount of greenhouse gases that can be emitted in the EU. Within this limit, companies either receive or buy emission allowances, each granting the right to emit one metric ton of carbon. The allowed amount decreases over time (as a matter of policy decisions made by the EU), which constrains the supply and increases the price of emission allowances, making it increasingly expensive for companies to buy them to cover their carbon emissions.

accommodates both opposites) or *by separation* (i.e. addressing the opposing objectives at different locations or at different points in time).

As the antecedents of these strategies, the Framework considers conflicts beyond the ‘traditional triad’ of financial, social and environmental considerations – and directs attention to three specific sources of tension. As these sources are particularly relevant to firms facing the decarbonization challenge, they further underline the relevance of the Integrative Framework to our study. First, Hahn et al. (2015) posit that there are different understandings of the meaning of sustainability across firms and individual decision-makers. Indeed, extant research shows that emissions-reduction can be understood and *framed as an opportunity or a threat* (Kolk and Pinkse 2005; A. Hoffman 2005): depending on this understanding, firms may opt for different response strategies. Second, Hahn et al. (2015) underline the different perceptions that may exist on the requisite change process. In our case, companies controlling predominantly climate-forcing assets – that is, assets associated with substantial carbon emissions (Colgan, Green, and Hale 2021) – may consider the requisite change more difficult than companies with ready access to green technologies or less *technological uncertainty* (Paterson, March 19, 2021). Finally, Hahn et al. (2015) argue that there are different perspectives on the relevant temporal and spatial context – again, some companies may consider climate change and/or associated regulatory clamp-down on emissions imminent in certain geographies, while others may consider these as uncertain and remote. Indeed, perceptions of *regulatory uncertainty* have been found to swing corporate climate-responses from reactive to proactive (and sometimes to regressive) strategies (Bui and Villiers 2017). While Bui and Villiers (2017) underline the role of risk management as a specific management control system that can frame climate change as a regulatory uncertainty, it is likely that firms draw on a whole array of other management accounting tools that shape their framing of the decarbonization challenge as an opportunity or a threat and inform their perceptions about the

availability and cost of green technologies and the relevant regulatory uncertainties. Prior research on the role of management control systems (MCSs) in sustainability management has established a strong relationship between companies' environmental strategic orientation and their use and configuration of MCSs and underlines the importance of MCSs in managing environmental (sustainability) performance. In the context of the pressing need felt by European companies to improve their decarbonization performance, therefore, MCSs are also likely to play an important part.

Strengthening the integrative view: the role of MCS in sustainability management

Corporate sustainability, by definition, “requires firms to address economic *as well as* environmental and social outcomes *simultaneously*” (Hahn et al. 2015, 298, emphasizes in the original). Conceptually, it has been argued that the use of environmental MCSs (and Sustainability Control Systems, SCSs) shapes strategy-making and firms' capacity to enhance simultaneously the elements of triple bottom line performance, particularly when there is a substantial degree of integration between SCSs and more traditional MCSs (Gond et al. 2012). Firms that need to simultaneously attend to triple-bottom-line goals have been shown to provide decision-makers with novel and specific sustainability control systems and eco-controls. On one hand, some studies examined the use of these controls and firm performance, suggesting that there is indeed a direct and positive relationship between the use of these systems and environmental performance (and an indirect positive effect on economic performance) in case of companies pursuing proactive environmental strategies (Henri and Journeault 2010; Journeault 2016). Yet not all companies engage with sustainability issues proactively: there is in fact a continuum between proactive and reactive responses. Focusing on the variation between response strategies and management control systems, we learn elsewhere that firms with a higher orientation towards sustainability tend to deploy SCSs in a way that is more integrated with traditional MCSs. They do this by innovating and upgrading

existing management control tools and processes. For example, such integration may be evident if sustainability performance measures are quantified and sensitive to managerial actions (Perego and Hartmann 2009), or if sustainability performance measures are included within strategic plans, internal reporting and reward systems (Ditillo and Lisi 2016). In contrast, in firms with less sustainability orientation and more reactive strategies, researchers find a lack of formalization or a lack of integration of SCSs, which then “remain peripheral and decoupled from core business activities and fail to reshape strategy” (Gond et al. 2012, 206).

The power of SCSs is twofold: it lies in their ability to (1) inform and improve decision making and (2) enhance environmental performance and, potentially, economic performance. On one hand, Parker (2000) argued that identifying and tracking environmental costs enables managers to screen products for environmental impacts and risks and identify otherwise hidden potential environmental costs and liabilities. Perego and Hartmann (2009) investigated both the system-design characteristics and the measurement-attributes of MCSs that underpinned proactive environmental strategies in their sample of Dutch manufacturing firms, finding that an increase in sophistication (quantification) and sensitivity of performance measurement systems to managerial actions helped align firms with their chosen strategy. Likewise, Epstein and Wisner (2005), on the evidence of a survey among Mexican manufacturers, underlined the importance of integrating environmental information into performance measurement and rewards systems. These results suggest that MCSs such as strategic planning, budgeting, environmental-performance measurement and incentive systems may indeed help companies advance proactive environmental strategies.

On the other hand, Henri and Journeault (2010) find that eco-controls which integrate environmental performance measures into budgeting and incentives lead to a direct positive effect on environmental performance, and an indirect positive effect on the bottom line of their sample of high-polluting Canadian manufacturing firms. This most likely happens due to the

ability of eco-controls to help companies build new capabilities and devise innovative new solutions. In another Canadian survey, Journeault (2016) further observed that eco-control packages contributed positively to the firm's environmental performance - and indirectly to economic performance - by fostering learning, continuous environmental innovation, stakeholder integration, and shared environmental vision capabilities.

Thus, the extant literature on MCSs in sustainability management supports our expectation that MCSs could enhance, and be an integral factor, albeit so far latent, in the framework advanced by Hahn et al.'s (2015), because an important driver of firms' ability to simultaneously attend to triple-bottom-line goals is the upgrade of traditional MCSs with sustainability elements.

Having said that, there are some significant differences between the sustainability or environmental challenges studied by the extant literature cited above, and decarbonization. First, sustainability challenges are generic and entail multiple dimensions, adding social and environmental aspects to economic performance, but enabling firms to voluntarily decide which aspects are most relevant to their strategic pursuits. In fact, empirical evidence suggests that only those sustainability initiatives pay off economically that are the most critical - or material - in their particular business; while misguided choices of misaligned sustainability initiatives do not (Eccles and Serafeim 2013, 5; Khan, Serafeim, and Yoon 2016). The decarbonization challenge does not allow firms whose business model suggests that reducing emissions could be particularly costly for them, to pick alternative initiatives. Decarbonization is focused solely on the emission-reduction capabilities of firms, irrespective of other aspects of their social and environmental performance. While there is no institutionally agreed and legally binding goal on sustainability management in general anywhere in the world, decarbonization has been agreed by policymakers in the European Union, and reduction targets

have been legislated, prompting much higher pressure on companies to fall in line with national targets.

Thus, two issues arise. First, prior research in the environmental management control literature typically distinguishes between proactive and reactive sustainability strategies. As the climate policy environment in Europe has begun to pose an existential threat to the business models of emission-intensive companies, it renders reactive strategies untenable for many heavy industries. With carbon prices reaching close to €100, a reactive strategy that “allow[s] sustainability initiatives to flourish independently of the organization’s business model” (Ditillo and Lisi 2016, 127) is no longer a viable strategic option. Instead, companies need to find climate response strategies that deliver substantial emission reductions – often requiring significant (technological) modifications of carbon-intensive business models – while safeguarding the commercial viability of their business. What then, are the various responses that companies with different inherent and contextual capabilities can deploy in the face of the decarbonization challenge?

Secondly, extant research typically considers environmental-strategic orientation as an antecedent of the use, design, and level of integration of environmental controls into MCS (e.g., Perego and Hartmann 2009; Ditillo and Lisi 2016). Nevertheless, some studies suggest that the relationship may be recursive. For example, Arjaliès and Mundy (2013) found survey evidence in France of the important role that MCSs play in identifying and assessing the threats and opportunities involved in CSR strategies, suggesting that MCSs could play a more active role in the formation of environmental response strategies, too. This notion is supported by both theoretical considerations, highlighting the enabling role of MCSs in strategy formulation elsewhere (e.g., Simons 1990, 1991; Gond et al. 2012) and by field work uncovering the influence of certain environmental controls on environmental strategy, via the performance evaluation process (Rodrigue et al. 2013). In this study, we investigate the relationship between

response strategies and MCSs, leaving open the possibility that related new management accounting practices may shape both the formation and the implementation of companies' response to climate change.

Thus, our research interest is twofold. We ask: (1) What kind of response strategies do companies deploy in the face of the decarbonization challenge and why? and (2) What is the relationship between these response strategies and the management accounting practices that are being implemented along with the strategies?

III. RESEARCH METHODS

Qualitative methods help researchers gain an improved understanding of practitioners' work realities as experienced in the field (Power and Gendron 2015). Indeed, our aim was to gain a grounded understanding of the varied strategies, tensions and accounting practices implicated in the decarbonization efforts of some of Europe's most carbon-intensive companies. Accordingly, we conducted an exploratory multiple case study of 19 publicly listed European companies in the chemical, steel, and utilities industries.

Sample selection

Our *case selection* was guided by three criteria. First, carbon impact: The three industries are among the largest emitters of greenhouse gas emissions, responsible for close to 50 percent of global greenhouse gas emissions (IPCC 2022). Second, location: we focus on the EU context with its increasingly pressing institutional demands for decarbonization. Third, with respect to the sources of tension emphasized by Hahn et al. (2015), companies in these sectors display significant variation in their perceptions of what decarbonization means (opportunity and/or threat), and different perspectives exist on the requisite change process, innovation paths and policy work (C. Hoffman, van Hoey, and Zeumer 2020; Energy Transitions Commission 2018b, 2018a; World Steel Association 2020). The institutional

complexity is evidenced in the fact that should these companies have to pay (e.g. in the form of EU emission permits) for their calculated carbon costs, many of them – currently shielded from such taxes by exemption policies – would suffer environmental bankruptcy (Houlder and Livsey, February 03, 2021).

To enhance the variation of possible response strategies, we deliberately chose companies in different positions in the value chains of their industries. In the chemical and steel industries, we selected companies with portfolios ranging from commodity to specialty products, the latter generally having higher margins and lower carbon footprints. Likewise, we chose companies with different business models from the utility industry (e.g., power generation portfolios with different proportions of fossil-fuel and renewable energy). Appendix 1 provides an overview of the 19 companies in our case study.

Data sources

Our research drew on two *data sources*: 27 semi-structured interviews, and archival documents⁵. Between May 2019 and November 2020, we conducted 21 semi-structured interviews with the designated sustainability managers from the 19 companies in our sample, each interview lasting between 40 and 80 minutes. Drawing on an interview guideline, participants were asked about their role, how climate risk and response feature in their responsibilities, the organizational functions involved in managing climate response, the accounting and other practices in place for assessing climate challenges, and the ongoing strategic responses. In February 2021, we conducted six face-to-face (online) follow-up interviews (Chemical 3, Steel 2, Steel 3, Steel 5, Utility 1, and Utility 2) to follow up on developments further to our first-round findings.

⁵ The research has been approved by our University's Research Ethics Committee, Ethics Approval Reference: SOGE 1A-19-14

To complement and *triangulate* the interview data, we collected annual reports, sustainability reports, and responses to the CDP⁶ Climate Change Questionnaire. Since 2018, the questionnaire has incorporated questions on the recommendations of the Task Force on Climate-related Financial Disclosure, structured around governance, strategy, risk management, and metrics and targets (TCFD 2017). The responses to the CDP questionnaire were thus particularly useful in verifying and complementing interview data on the management-accounting tools and metrics used by case companies, and to what extent companies saw threats and opportunities in decarbonization⁷. We also used this dataset to compare the carbon-intensity of our sample companies at the outset of our investigation. Carbon intensity metrics - for example, the cost of a firm's carbon emissions as a proportion of its profits - are widely used by investors to assess a firm's exposure to climate risk: many carbon-intensive companies would see their earnings wiped off, should they have to pay for the carbon they emit (Houlder and Livsey, 2021). We further reviewed annual and sustainability reports to gain a deeper understanding of business models, strategies, and how companies perceived their business environment.

Analysis

We conducted a comparative case study of our 19 sample companies, following a four-stage abductive approach to data analysis. We used the QSR Nvivo software to build a case database to combine data from different sources in a central repository and facilitate the data processing and analysis. In the first stage, we combined interview transcripts, corporate reports, and CDP responses to construct individual case studies of our sample companies. The second stage involved a detailed within-case analysis of this subset of cases to cluster information that

⁶ CDP is a nonprofit organization that operates a corporate environmental disclosure system and gathers data on corporate action on climate change.

⁷ The TCFD questionnaire asks companies to list the threats and opportunities they see in climate risk (possible climate events and regulatory response).

addressed primary questions such as what, why, who, how, and when (Lofland 1976). Starting with an analysis of interview transcripts, this clustering allowed us to identify emergent themes in the interviewees' comments without introducing premature analytical biases (Battilana and Dorado 2010, 1421). In particular, we noted our interviewees' professional backgrounds and experiences (who), the diverse ways in which they described climate risks (e.g. opportunities, threats), how and with whom they discussed these risks at work, why these risks entered their agendas, and what actions were taken in response and when. We subsequently triangulated the interviewees' accounts with corporate disclosures (annual and sustainability reports) and CDP responses. Based on our research question, three major categories of codes were used at this analytical stage (see Figure 1): (a) perceptions of decarbonization (threat or opportunity); (b) MCSs and practices (tools, processes, and functions involved in identifying and assessing decarbonization strategies and projects); and (c) climate-risk response (actions taken).

-----INSERT FIGURE 1 AROUND HERE-----

In the third stage, we moved from within-case analysis to cross-case analysis, using techniques proposed by Eisenhardt (1989) and Miles and Huberman (1994). We used tables as analytical devices to identify patterns of similarities and differences among cases (Cloutier and Ravasi 2021). During this stage, we realized that the perceptions emerging from our data reflected companies' entanglement in complex webs of institutional expectations, to which they responded differently (an inductive step). Iteratively going back and forth between our data and extant theory, we found Hahn et al.'s (2015) framework for analyzing tensions in corporate sustainability helpful with understanding the emerging patterns in our data (a deductive step). The fourth stage of our analysis applied these preliminary findings to the full set of case studies, which confirmed the validity of our associations.

IV. FINDINGS – RESOLUTION STRATEGIES

Acknowledgement of tensions

In line with Hahn et al. (2015), our interviewees and their companies acknowledged the tensions in the decarbonization challenge. Particularly, two of the tensions cited by Hahn et al. (2015) featured prominently: the tension between corporate short term versus long term orientation, and isomorphism (legitimate business as usual) versus technological change, both suggesting that decarbonization required long-term, costly commitment. The following quotes are typical in illustrating carbon-intensive companies' view that decarbonization comes at a cost. Table 1 provides additional supportive evidence.

Speaking on behalf of a chemical company, this sustainability manager highlighted the tension arising from business -as-usual versus technological innovation, particularly when providing a lower-carbon alternative product was costly to the firm, yet customers who seemed to have “cared about the climate” were not necessarily ready to pay a premium for it; in fact norm of business as usual seemed to have prevailed in their price expectations:

“...many consumers say yes, climate is important, and companies must also do something about it. But if you as a company say, yes, we offer a corresponding product, as the customer wants it, but the customer has to pay 5 percent more for it, then you suddenly find that the customer says, ‘no, that's not how we imagined it’.”
(Chemical 6, IP7)

Another example of the tension between technological innovation and expectations of business as usual was steel companies' nervousness about undertaking costly “green steel” projects, while high-emitting competitors outside the EU continue to provide low-cost steel:

“We're not afraid to take steps to decarbonize, but if we have to do it, but our competitors don't, we're out of business.” (Steel 2, IP5)

Decarbonization required a much longer time orientation than the typical time horizon of firms, which has been evident as another source of tension. Short-term financial imperatives had been acknowledged as delaying decarbonization investments:

“...sometimes you have to say: ‘I don’t have the investment money right now to do this, so I regret I can’t do it.’”(Chemical 2, IP3)

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Overall, companies recognized that these tensions existed and the pressures that caused them were intensifying. So, defensiveness was no longer enough: they had to assess green (that is, low-carbon) alternatives in order to be able to estimate the time, technologies and cost involved in their respective decarbonization challenges. How they responded (and what control tools and processes underpinned these responses) becomes our next focus.

Strategies to manage tensions

The companies in our sample deployed tension-management strategies that echoed those conceptualized by Hahn et al. (2015).

Synthesis by Wholesale Green Transition

Synthesis strategies “introduce a new element that links or accommodates both poles” (Hahn et al. 2015, 300). They involve substantial structural and technological change that result in the firm shaping institutional expectations in favor of its newly found business practices.

Indeed, we find that five companies were able to engage in such substantive “institutional change” by a wholesale shift in their business model, by growing or acquiring carbon-light business units and shredding carbon-intensive ones. In the decarbonization context we call this strategy “*wholesale green transition*.” The five companies came from the chemicals and utilities industry, which offered a wider variation in technological and customer-pass-on options than the steel industry. These companies were the first adopters of innovative low-carbon business models in their industry, achieving transition by bold portfolio-management moves: divestitures and acquisitions. Their transition was accelerated by their perception of the ready availability of specific low-carbon alternatives (renewable technologies for utilities and/or low-carbon specialty products in chemicals). Another driver of this strategy

was companies' perception of opportunities in the sustainability space. All of these companies had leadership who advocated the "integrative logic" (Hahn et al. 2015) of sustainability: internally, and externally they advocated "climate stewardship" instead of privileging the economic over the non-economic objectives. They committed their companies to the most stringent decarbonization targets (guided by the Paris Agreement and the Science-Based Target Initiative⁸).

In Table 2, we highlight leadership's advocacy of the opportunities inherent in decarbonization, the MCSs and salient actions we found associated with companies pursuing green transition strategies. Perceptions of decarbonization opportunities and targets were communicated vocally by CEOs and/or CFOs, with top management often being long-standing, vocal advocates for sustainability in the public realm (e.g. Chemical 2, Utility 7, Utility 8). Green Transition strategies focused on providing solutions to the climate crisis and position companies in such a way that they stood to benefit from the energy transition. In companies enacting green transition strategies, MCSs reflected ambitious decarbonization targets (Scope 1-3, science-based), and introduced the internal carbon pricing and carbon-footprinting of the entire value chain. In addition, MCSs applied carbon-adjustment in strategic investment appraisals and performance evaluation.

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At Chemical 2, for example, the CEO was a long-time vocal champion of sustainability and the CFO strongly engaged in the Accounting for Sustainability (A4S)⁹ initiative on advancing the integration of sustainability into performance measurement. Accordingly,

⁸ Science Based Targets initiative (SBTi) is a collaboration between the CDP, the United Nations Global Compact, World Resources Institute and the World Wide Fund for Nature. The SBTi provides companies with „sector-specific guidance and requirements“ to reduce emissions in line with either the Paris Agreement goals („below 2-degree scenario“) or with the more ambitious „1.5-degree scenario“. For a fee, the SBTi provides a service to „validate“ companies' targets.

⁹ Initiated by the then Prince of Wales in 2004, A4S works with the finance and accounting community to embed environmental and social issues into financial decision-making.

Chemical 2 introduced ambitious science-based targets and implemented carbon pricing in its internal investment appraisals and performance reports, applying a hypothetical carbon “penalty” to the P&L of business units.

Another case in point is Utility 3. Ahead of the curve, Utility 3 decided in 2015 to divest its large-scale fossil power-generation portfolio and, in 2018, instead acquired a renewables company. The company committed to science-based targets and internally, in its management accounting systems deployed a carbon price to “carbon-adjust” its internal investment decisions, and strategic planning processes. The application of internal carbon prices was an important element in these analyses and “influenced [their] strategy to sell the full portfolio of fossil fuel power plants” (Utility 3, CDP Response 2019). With the help of its carbon-adjusted MCSs, the company pledged to reduce its customers’ carbon emissions by 50 percent by 2030. This required Utility 3 to measure emissions not just in its own operations and energy consumption (Scope 1, Scope 2), but also in the value chain (Scope 3). Here we see a recursive relationship between the Wholesale Green Transition strategy and accounting: the former was facilitated by accounting, but also put pressures on the development of more comprehensive and accurate accounting (“carbon footprinting” the entire value chain). Utility 3’s response was characterized by an understanding that the “opportunities on our side are greater than the risks”.

Overall, the five companies we classified as pursuing a wholesale green transition strategy saw decarbonization more as an opportunity than a threat. They developed extensive carbon accounting processes, setting emission targets across the value chain (Scope 1, 2 and 3), in order to capture decarbonization opportunities in their acquisitions, divestitures and product launches. These carbon costs were integrated into their investment appraisal, product appraisal and (increasingly) performance measurement systems.

As for the antecedents of this strategy, the three factors suggested by Hahn et al. (2015) are relevant: (1) perceiving decarbonization as an opportunity rather than a threat; (2) a perception that change processes were technologically feasible and achievable (3) by a wholesale transition across geographies, relatively fast (first-movers).

Separation by Green Segmentation

Separation strategies address the two poles of the tension at different locations or at different points in time. Companies deploying such strategies, according to Hahn et al. (2015, 304) would typically “concentrate established business in markets where traditional institutional expectations prevail while launching innovative solutions and novel business models in market segments where institutional change has already taken place.” Indeed, in our sample seven companies (chemicals and utilities) enacted this resolution strategy, which we call *green segmentation*. The goal of it was to decarbonize the business portfolio *selectively*, by introducing specific low-carbon product segments, and charging a premium for these. At the time, these companies did not assess the demand for carbon-light products in their value chain high enough to justify a wholesale green transition.

In Table 3, we highlight the sustainability leadership, the MCSs and the salient actions we found associated with companies pursuing green segmentation strategies. At Chemical 4, the sustainability manager explained the tensions inherent in sectors where innovation was costly, and the carbon-intensive business as usual was hard to change:

“Not everyone is moving towards the low carbon economy at the same time or with the same intensity. So, you have your own reduction obligations, but then you have to make sure that the markets you supply are developing.” (IP5, Chemical 4)

Their focus was on developing new markets for more and more niche products with environmental and climate benefits (“solutions”), and they sought to legitimate green products by evoking accounting processes to measure their decarbonization effects, measuring Scope 1

and 2 emissions – but not extending carbon footprinting across the value chain (as did companies we classified as pursuing wholesale green transition).

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In fact, green segmentation companies retained a significant carbon-heavy legacy business. This tended to preclude them from committing to ambitious decarbonization targets and/or from applying carbon-adjusted performance measurement across the portfolio. They tended to deploy emission targets, internal carbon prices and carbon-adjusted appraisal vis-à-vis the “solutions”, but not the whole business. Those with already developed portfolios of low-carbon “solutions” also developed customer-accounting systems to market the benefits of carbon-light products towards customers, and “product sustainability screens” to be used by sales teams (Chemical 1, Chemical 4).

For example, Chemical 1 internally defined and designated certain products as climate “solutions”; that is, products “*that we consider having a positive impact on the planet.*” These were also “high-margin materials,” which the business strategy prioritized. However, the company’s green transformation was far from complete. It aimed to have 63 percent of its portfolio sustainable by 2030, implying that it was prepared to keep over one-third of its product portfolio emission-intensive, due to a carbon-intensive legacy business that it was not prepared to divest and not (yet) able to abate. Chemical 1 developed a “sustainability screen” – a carbon-adjusted product and customer accounting tool—initially used in decisions related to mergers and acquisitions, capital appraisal, and new product assessment, but later also deployed in marketing, to help salespeople articulate to clients the environmental benefits of their products.

Considering the generally rising emissions prices in carbon markets, Chemical 1’s accountants chose prices from the higher end of the annual range in order to demonstrate the

carbon-cost savings achieved by “green” projects and investments, also ensuring that competing (benchmark) carbon-intensive proposals carried a significant cost of the negative externalities they imposed, “especially in China, Brazil, and America,” where the market carbon price was zero at the time. This allowed innovative technologies (such as “light-weighting auto and aircraft”) and renewable energy proposals to be prioritized. However, the use of EUR 50 as a carbon price, a figure intended to incentivize innovation and decarbonization efforts, was still well below the USD 100 carbon price promoted as more effective (and possibly the market price by 2030¹⁰), suggesting that Chemical 1 also intended to maintain a non-green portfolio segment. In this way, the company reached partial (though significant) compliance with the decarbonization purpose. Notably, Chemical 1’s ability to differentiate with green strategies and pass the cost on to customers enabled it to do so without government subsidies. The breakthrough technologies for its carbon-light projects (renewables for electricity generation, “light-weighting solutions” for transport) were considered as given or imminent, however, additional climate-saving technologies were seen as distant.

Overall, the seven companies we classified as pursuing a green segmentation strategy saw decarbonization pressures both as an opportunity (for new business development) and a threat (to legacy businesses). They developed emission targets focused on their own boundaries, but not the entire value chain (Scope 1 and 2), in order to capture decarbonization opportunities in their new business and product launches. These carbon costs were integrated selectively into the appraisal and customer-accounting systems of the new segments, but not in the legacy business. Organizationally, sustainability was advocated by various staff functions

¹⁰ The carbon price in Europe breached the \$100 (~€88) threshold in December 2021: <https://ember-climate.org/data/carbon-price-viewer/>. Note that the interview took place 2.5 years before the European carbon price reached this level – back then, in June 2019, the carbon price in Europe stood at ~€25.

(ranging from the CFO to HR), suggesting a lower level of organizational integration with MCSs and weaker institutionalization, relative to the green transition firms.

As for the antecedents of this strategy, the three factors suggested by Hahn et al. (2015) are relevant: (1) perceiving decarbonization both as an opportunity and a threat; (2) a perspective that change processes are technologically feasible in certain product areas, but not all; and (3) by a selective transition across geographies and a gradual decarbonization of operations over a longer time horizon.

Acceptance by Engagement

Acceptance strategies try to maintain legitimacy for their well-established businesses, by launching (sometimes costly) experimental practices in line with the integrative logic, and / or instigating cooperation between stakeholders with opposing interests (Hahn et al. 2015). Indeed, in our sample seven companies (all steel companies and a utility) enacted this strategy. Without access to readily available climate-saving low-carbon technologies, these companies deemed it impossible to decarbonize: “*with the technologies available today, we are not getting much further down in CO2 emissions*” (Steel 1, IP8). Decarbonizing by themselves was deemed to be compromising their financial viability. Under growing pressures to decarbonize, the companies reached out to policy makers and industry associations to undertake the policy work needed to gain support (subsidies and requisite green infrastructure-development) from governments. For example, much corporate activism aimed at public-private partnerships that would create hydrogen infrastructure in specific regions of Europe. Companies also lobbied the EU to level the playing field *vis a vis* foreign competitors (green border tax). In this context, we call these strategies – accepting hard realities and trying to manage it by corporate activism – *engagement*.

In Table 4, we highlight leadership’s delayed and cautious advocacy of the opportunities inherent in decarbonization, and the MCSs and salient actions we found associated with companies pursuing engagement strategies.

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The seven companies enacting engagement framed climate change as a serious existential threat. These companies perceived their industries as extremely hard-to-abate, so they asked for support from governments, customers, and patience from investors. They assessed the viability of different decarbonization pathways by scenario planning considering various policy and market constellations, and they utilized the output of these analyses in negotiations with policy makers and governments. The scenario work underpinned the companies’ emissions targets, which were less ambitious than in the other two clusters and were conditional on new technologies and government subsidies (e.g., Steel 1, Steel 4), applied only to specific business units (e.g., Steel 2).

The case of Steel 2 illustrates. Here climate risk did not feature much in internal managerial discussions until 2018, when Climate Action 100+, a climate-focused investor group, challenged the company to respond to climate-related stakeholder expectations. The Head of Sustainability, having overseen Steel 2’s sustainability reporting, realized that this external requirement started to “*drive internal conversations: We’ve got to respond to these stakeholder expectations.*” (Steel 2, IP10). In response to stakeholder (and CDP) questions about climate risk, the sustainability department considered climate-related regulatory risk as a threat. A plan by EU policymakers to turbocharge decarbonization in the steel industry by the gradual phasing out the ETS allowances for steelmakers was a shock: the policy would effectively levy a growing carbon tax on the industry. Having identified this policy risk, the Head of Sustainability was able to grab the attention of the CFO and the Head of Strategy. Internal documents calculated that the sector would need a carbon price over EUR 100 a ton to

make breakthrough technology viable. But this imposed an existential risk to the current business model, because with steel being a commodity, producers could not pass the increased cost on to customers.

Steel 2 rallied the industry to lobby European regulators to level the playing field across steelmakers by introducing green-border adjustment. Yet the EU's carbon border levy could face years of delay due to opposition from China and the US. Steel 2 stepped up its policy-oriented work. Lobbying in Europe—both directly and through the World Steel Association—for a carbon tax and for government subsidies required analysis combining sustainability, operations, and business expertise. Steel 2 now had a full-time analyst undertaking such calculations, producing, for example, “a carbon abatement curve” as part of its scenario planning to show the carbon prices at which lower-carbon products could become viable. The analyses also investigated various radical technological options for decarbonization and the investment needed to bring them about. Steel 2 sought a voice in the policy space (and in the World Steel Association) to lobby governments to help these innovations.

Overall, the seven companies we classified as pursuing engagement saw decarbonization pressures as a threat. They developed emission targets focused on their own boundaries, but not the entire value chain (Scope 1 and 2), to capture the cost of regulatory changes and potential green investments. Carbon accounting was less developed in this cluster, much of it being work-in-progress; in some cases, the work was undertaken as part of an industry-level network. The accounting calculations also made it clear that decarbonization necessitated government subsidies and cooperation between various parties (to form innovation consortia). The costs and benefits of decarbonization, including the reduction in carbon costs, were considered in the investment appraisal of these experimental businesses, to foster mutual understanding with governments and consortia-partners of the tensions and challenges involved (Hahn et al. 2015), but carbon pricing was not integrated into their regular product

and performance appraisals. Instead, sustainability concerns featured in separate, qualitative reports: risk assessments and ESG reports.

As for the antecedents of this strategy, the three factors suggested by (Hahn et al. 2015) are again relevant: (1) perceiving decarbonization as a threat; (2) a perspective that change processes are technologically barely feasible (risky, experimental at best) and require government subsidies (3) by a selective transition across geographies and time.

Recursive developments

By carrying out follow-up interviews and a review of recent developments in our case companies, we see that over time, the response strategies take on a dynamic aspect. Green segmentation companies are now actively engaged with policy makers, and engagement strategies are followed (once government support is gained) by green segmentation. Table 5 offers evidence. Here we see that companies previously creating green segmentation (under continuing pressures to decarbonize) are now raising their climate ambition while simultaneously engaging with governments and other stakeholders to negotiate what these goals ought to be, given commercial and technological constraints. Conversely, we find companies, previously actively pursuing engagement strategies, now having gained sufficient concessions from governments to declare select technological innovation projects and to launch reduced-carbon products. These initiatives enjoy subsidies (from governments) and a higher price premium (from customers), demonstrating the success of the companies' engagement strategies to build collective decarbonization strategies – by helping stakeholders reach their climate goals.

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Overall, the cases suggest that few companies have the strategic freedom (and resources) to divest carbon-intensive businesses and transition into a carbon-light business

model. Following Hahn et al. (2015), we argue that for most, the path to decarbonization involves tensions and the requirement to attend to costly decarbonization objectives while maintaining financial viability. Our analysis finds empirical evidence that companies indeed are developing new environmental capabilities for green segmentation and engagement strategies. In addition, the acceptance and resolution strategies that we observed were facilitated by MCSs, which were characteristic to the specific strategies and the tensions involved. Table 6 summarizes our findings.

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Apart from extending the concept of strategic orientation in the decarbonization context, Table 6 also puts some empirical flesh on the bone of the antecedents postulated by Hahn et al. (2015). First, the *perceptions of decarbonization as an opportunity or a threat* (or both) mattered and varied with the associated response strategies, as explained before. Second, we found different *perspectives on the requisite change* (particularly in relation to technological uncertainty). Companies controlling predominantly climate-forcing assets considered the requisite change more difficult than companies holding relatively more climate-saving assets with less carbon-emissions. We triangulated these insights by two measures. First, based on companies' CDP disclosures, the average Asset Carbon Intensity¹¹ of these companies at our starting point (2019 data): companies associated with green transition strategies had more climate-saving assets, whereas companies with engagement strategies had the most climate-forcing assets. Second, looking at the average Carbon Cost Intensity¹² of the clusters (again, based on their 2019 CDP disclosures), the data shows that companies pursuing engagement strategies had the highest carbon cost intensity, whereas companies pursuing green transition strategies had the lowest carbon cost intensity. Accordingly, we find different perspectives on

¹¹ A higher asset carbon intensity indicates a higher share of climate-forcing assets. A lower asset carbon intensity indicates a higher share of climate-saving assets.

¹² The metric is calculated as follows: (Scope 1 & 2 carbon emissions * carbon price of EUR 100)/EBITDA. It measures the carbon cost as a percentage of EBITDA.

the relevant temporal and spatial context too – green transition companies appear to be able to decarbonize their business faster, while green segmentation companies do this gradually and in select product areas only, and engagement companies intend to decarbonize over an even longer time horizon and at different pace in different geographies.

V. DISCUSSION AND CONCLUSION

We set out to investigate the relationship between companies' decarbonization strategies and management control systems. Our contribution is threefold.

First, with respect to environmental strategies and sustainability orientation, we refine the reactive–proactive dichotomy to fit the decarbonization context in Europe, where reactive strategies are no longer available to carbon-intensive firms. Proactivity, however, may take various forms, which we uncovered by drawing on Hahn et al.'s (2015) categorization of strategies for managing the tensions inherent in decarbonization; namely, strategies of resolution by synthesis, of resolution by separation, and of acceptance. These correspond, in the European decarbonization context, to what we call strategies of wholesale green transition, of green segmentation, and of engagement. Adapting Hahn et al.'s recursive integrative framework (Figure 2), we suggest that a proactive orientation to decarbonization is best thought of as a journey, not a destination.

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This journey requires voyagers to first acknowledge the inevitable conflicts between the short-term financial imperatives and the longer-term, costly innovation challenge inherent in decarbonization. Better decarbonization performance can improve economic performance in some contexts (Henri and Journeault 2010; Journeault 2016), but not in this context—not, at any rate, in the short term. The seemingly most proactive response—wholesale green transition—is the hardest to bring about, as it is conditional on ready availability of low-carbon

technologies and business models and on a favorable policy environment that allows the bold portfolio moves involved in getting rid of carbon-intensive businesses and acquiring low-carbon alternatives. No wonder, then, that the examples we encountered involved either partly state-owned companies or private companies with governmental support. For most other firms, acceptance strategies (engagement with stakeholders to negotiate compromises) and resolution strategies by separation (green segmentation) are, considering the growing pressures for decarbonization, likely to be necessary and to be adopted sequentially. These pressures are channeled into companies' decision making by an array of management control practices increasingly able to monetize the negative and costly consequences of regulatory and policy penalties (effectively, carbon tax) and institutional expectations in order to embrace even more ambitious decarbonization targets. An important gap in Hahn et al. (2015) is the means by which the perceptions of opportunities and threats and of technological and policy uncertainties are translated into the language of decision making.

Our second contribution is to address this gap by suggesting that the integrative framework should take into consideration the role of MCSs in facilitating the initial choice of and subsequent shifts in response strategy. To express this, we suggest the inclusion of Hahn et al.'s (2015) model into the following process model (Figure 3). As per the original theory, we suggest that companies may choose and shift between strategies depending on their framing of climate change as an opportunity or a threat and on their perceptions of the difficulties of the change and of time/space considerations. In the decarbonization context, these perceptions are created by MCSs assessing (a) policy and technological uncertainties (scenario planning) and (b) product, business, and technological investment opportunities (carbon-adjusted investment appraisals, due diligence, and product profitability analyses). Having pursued a given response strategy, companies continue to be scrutinized by stakeholders for their decarbonization performance, as was evident in the rise of carbon-intensity metrics now widely

used by investors and by companies themselves (Houlder and Livsey, 2021). Such feedback prompts companies to reassess their decarbonization performance, change their emissions targets, and consider further developments in the policy environment and the effect of, for example, increasing carbon prices on their profitability once regulatory penalties start to bite. Such calculations spur additional plans for divestment or acquisition (green transition strategies) or for capital investment in emerging green technologies and low-carbon products (green segmentation) or for corporate activism (engagement).

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Although research is still needed on these recursive developments, they are—at least conceptually, in the context of Hahn et al. (2015)—expected. Acceptance strategies feed resolution strategies and vice versa, illustrated in the decarbonization context by the green segmentation strategies that underlie engagement strategies and the engagement strategies that underlie companies' willingness to try green segmentation.

Our process model extends previous understanding of the relationship between decarbonization strategies and MCSs. Much research has focused on how a proactive environmental orientation drives more sophisticated, more formal (Pondeville, Swaen, and Rongé 2013), and more quantified and action-sensitive (Perego and Hartmann 2009) environmental measures than reactive strategies do and has noted the enhanced integration of such measures into MCSs by proactive companies (Ditillo and Lisi 2016). Yet, due to the nature of their cross-sectional survey methodologies, these studies have tended to take a snapshot view which did not take in recursive effects. Even so, our qualitative study concurs with pioneering field-based evidence by Rodrigue et al. (2013) suggesting that the environmental strategy—MCS relationship is recursive. Although the choice of initial environmental strategy may determine the use and design of internal environmental control systems (as survey-based research would have it), eco-controls further influence environmental strategy via the

performance evaluation process imposed by stakeholders (Houlder and Livsey, 2021). In our case, too, such recursive relationships are brought about by firms' engagement with important stakeholders: firms adopting green segmentation got feedback from customers about the viability of green products; those engaging with government got feedback from policymakers about the extent of regulatory uncertainty; and all companies were under the scrutiny of investors, who monitored the firms' carbon intensity and likely exposure to continuing decarbonization pressures. Such pressures and feedback were then incorporated into MCSs, leading to additional MCS changes (upgrading decarbonization targets; reassessing opportunities and threats) and further strategy adjustment.

Third, by locating the antecedents of the observed strategies in companies' framing of decarbonization as a threat or opportunity, their technological uncertainty, and their regulatory uncertainty, we illustrate and empirically validate Hahn et al.'s (2015) conceptual framework. We also add to it by emphasizing the important role of management accounting tools in creating the visibilities necessary for crafting the strategies required for sustainability management. Thus, our findings extend Hahn et al.'s (2015) Integrated Framework with accounting as a facilitator of acceptance and resolution strategies and of the shifts among them. The antecedents we uncovered complement research that had already uncovered them in isolation; in particular, studies on management's framing of environmental imperatives as an opportunity or a threat (Sharma 2000; Sharma and Vredenburg 1998; Kolk and Pinkse 2005) and on regulatory uncertainty as a key driver of reactive and defensive climate-response strategies (Bui and Villiers 2017; Bryant, Griffin, and Perry 2019; Wright and Nyberg 2017). We also complement the MCS literature on environmental strategies by observing variation in the type of MCSs associated with these strategies. While wholesale green transition strategies were predicated on more ambitious (science-based) emissions-target setting and the use of the most sophisticated carbon accounting tools (footprinting the entire value chain, including measuring

Scope 3 emissions), green segmentation strategies were associated with less-sophisticated carbon measurements (Scope 1–2 only). Among the three strategies, engagement was associated with the least-sophisticated carbon-accounting and the least-ambitious emissions-target-setting practices, which is not surprising, given the looming technological and regulatory (policy) uncertainties.

While green transition companies typically used carbon accounting in their internal performance measurement reports and in the evaluation and due diligence of M&A projects, green segmentation companies integrated carbon costs into the appraisal of specific low-carbon “solutions.” Companies pursuing engagement strategies did not integrate carbon calculations into their traditional MCSs and focused on scenario planning by risk or sustainability specialists to assess the extent of regulatory (existential) risk, supporting their corporate activism.

We believe that our study is among the first to generate rich descriptions of the strategies and MCSs used in decarbonization, paving the way for future quantitative studies (Kaplan 2011) on the determinants and evolving relationships of these phenomena. As carbon accounting is a still evolving and controversial practice (Kaplan and Ramanna 2021), further research - and technical accounting work - are necessary to find and finesse the particular accounting practices that can provide decision makers with less controversial and more reliable information on their decarbonization progress. Finally, future work can usefully investigate the extent and types of integration between new carbon-accounting practices and traditional accounting. Building on Gond et al. (2012), integration is most typically envisioned and carried out at *technical* level; as was the case of single carbon-accounting practices being used within a broader MCS at green transition and green segmentation companies. However, integration could be *organizational*, requiring management accountants to become specialists not only in the carbon-pricing but also the sustainability-engineering aspects of decarbonization and, *vice versa*, requiring the hybridization of sustainability expertise with accounting skills. And

additional research is needed to uncover the possibility and extent of *cognitive* integration between accounting and sustainability experts, who typically bring very different expertises, mindsets, and practical viewpoints to the decarbonization challenge. Cognitive integration has been deemed crucial for sustainability integration (Gond et al. 2012; Battaglia et al. 2016) and is likely just as important for decarbonization. We therefore call for the continuing study of MCSs and other managerial practices that facilitate discussion, knowledge-sharing, and understanding between these expert groups.

An important limitation of our study is that it is “frozen in time”; our data collection took place in a time window we could now call “pre-COP 26.” Recent developments—especially the added geopolitical tensions, policy changes in the US, such as the Inflation Reduction Act of 2022¹³, and the unfolding energy crisis in Europe—are outside the scope of our study. We will need ongoing research to explicate the implications of these added tensions, although we can expect Hahn et al.’s (2015) Integrative Framework, as deployed and extended in this study, to remain a relevant lens. Finally, our time horizon did not allow us to assess the consequences (economic and environmental) of various response strategies; further research must ascertain that companies are indeed acting in the social interest. The danger is that, due to geopolitical and economic upheavals and to less-understood institutional, system-level constraints and incentives, ambitious decarbonization goals may fall prey to capture by stakeholders with conflicting, short-term priorities.

¹³ Outcompeting the EU on climate-progressiveness, the US Inflation Reduction Act contains a \$369 billion package of subsidies and tax breaks aimed at luring companies to invest in low-carbon technologies in North America. The protectionist Act puts pressure on Europe to work out a rival plan (Campbell, 2023).

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FIGURE 1

Overview of data structure

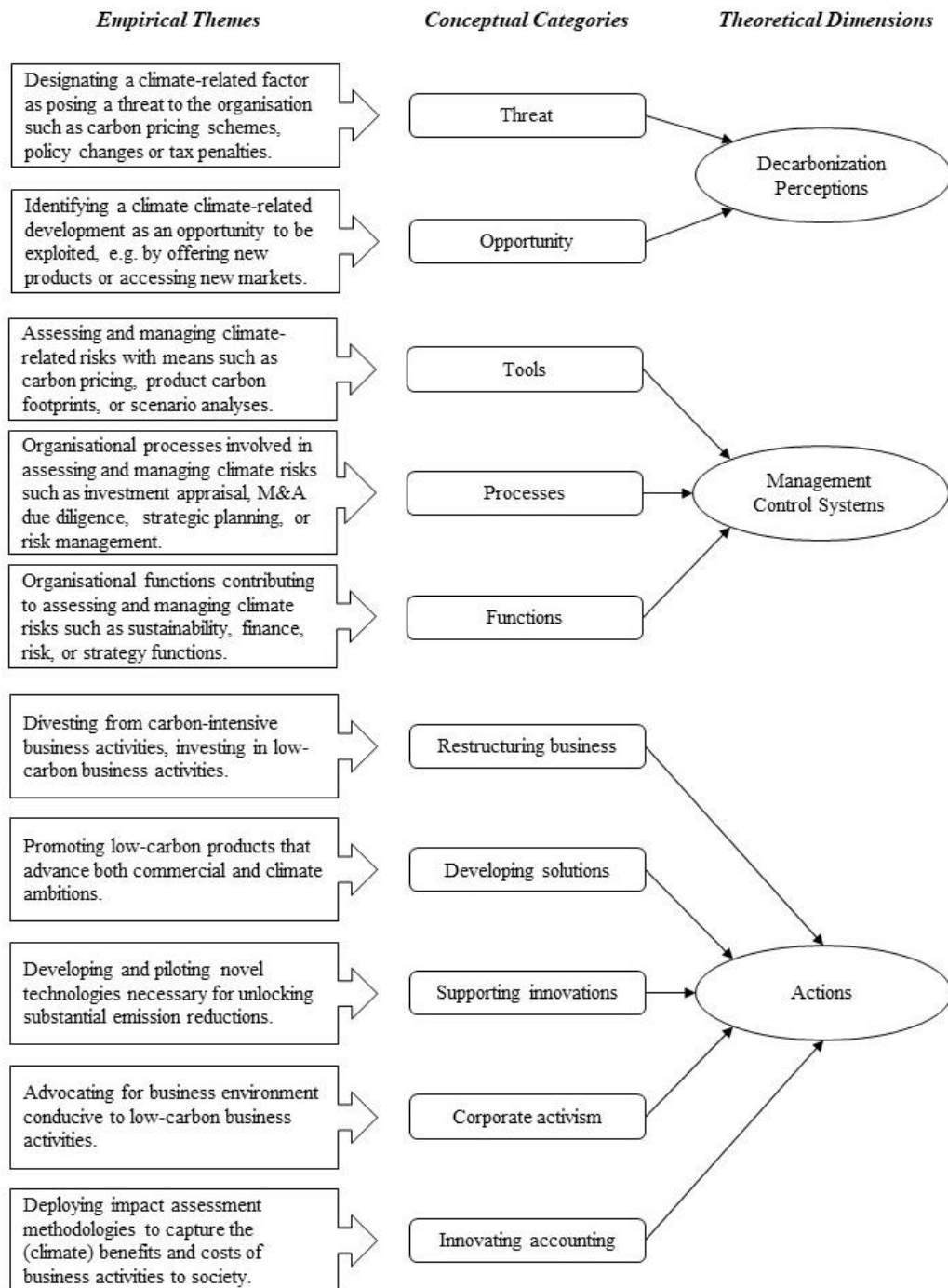


FIGURE 2

Acknowledging and managing tension in decarbonization. Adapted from Hahn et al. (2015).

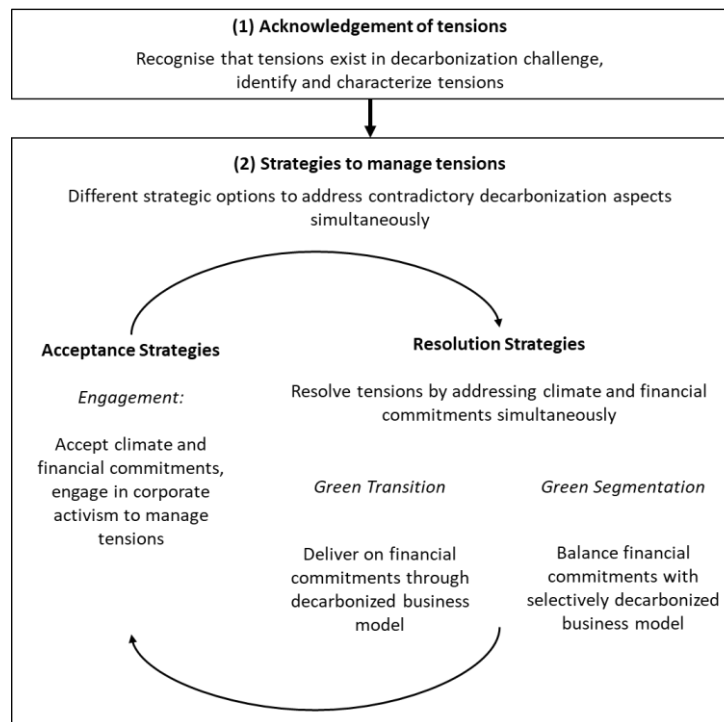


FIGURE 3

MCS enabling—and being shaped by—proactive decarbonization strategies.

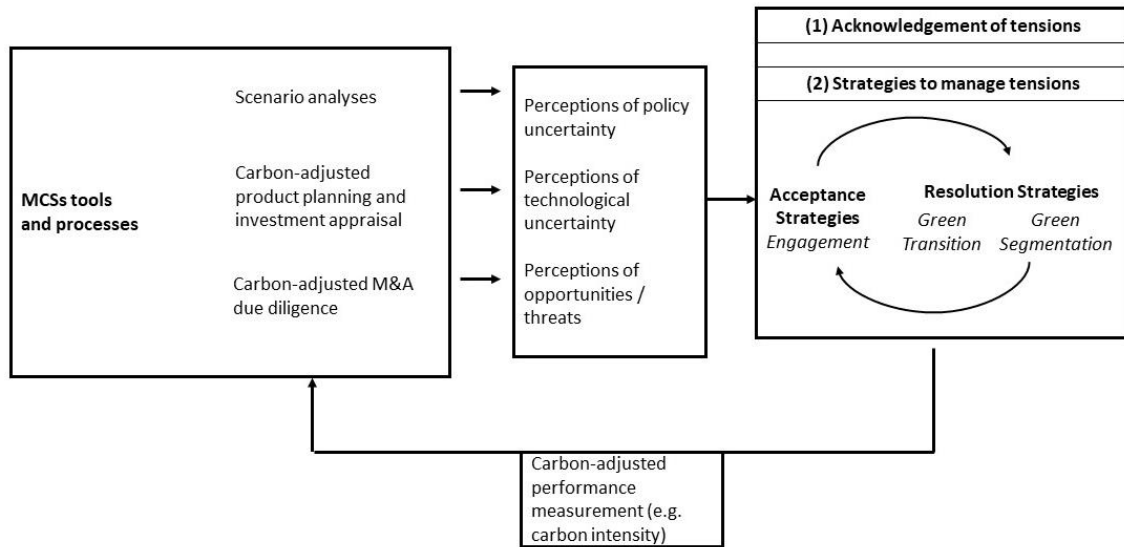


TABLE 1

Acknowledgment of tensions in decarbonization (representative quotes)

Company	Source of tension	Tensions
Chemical 1	Profitability vs. costly low-carbon innovation Technological innovation vs. current norms of production	“Sustainability includes the financial sustainability, meaning that we need to exit from coal in a profitable way [...] Now I am not saying that it is easy. Basically, this is part of the challenge of the Sustainable Development and Energy function – to be able to find a profitable way out of coal. [...] in some cases we are going out of gas to go to renewables or to biomass for example. So it's part of the challenge to make it work from an economic standpoint. Now I will not say that all the investments we are doing in terms of sustainability are the most profitable investments, but we do our best to generate good opportunities.” (IP1)
Chemical 2	Short term profitability vs. long term innovation	“If I spend money on lowering emissions, it goes either from my investment budget or from my bottom line. But I think in the target setting we have always been trying to create room for these kind of long-term trends. And we are flexible. If really need be, I think we can be flexible here and there with the speed to implement and I think we always balance in the dialogue, we try to balance people, planet, profit every time. And yes sometimes you have to say: ‘I don’t have the investment money right now to do this, so I regret I can’t do it, but I don’t change my long-term ambition.’” (IP3)
Chemical 3	Short term profitability vs. long term innovation Technological innovation vs. current norms of production and customer relations	“It is also embedded in our investment decisions, a qualitative statement on sustainability is required and it is quantified, as much as it is possible. But you have to say, of course, that in the last few years it has still often been the case, that the financial aspect has been weighted more strongly. Well, it's not like it has been said we don't care at all. Location decisions were also made, where people said 'ok only coal works here, we don't do that'. But in the end - and this is the crux of the matter - we are also measured externally by our quarterly figures and they are purely financial. And when costs arise due to the environment, then you have something tangible, but we are measured by - if our EBIT is not in order, then we just get to notice it. And in this case – to put it bluntly – it doesn't matter at all whether we've saved CO ₂ or not.” (IP4) “Customers are asking for low-carbon products but they don’t want to pay for them.” (IP4)
Chemical 4	Technological innovation vs. current norms of production and customer relations	“So the fundamental challenge now is that not everyone is moving towards the low carbon economy at the same time or with the same intensity. So you have your own reduction obligations, but then you have to make sure that the markets you supply are developing. And there's a lot of unrest right now. So when you say an automobile industry has not been able to decide for a long time where they want to go, something like that, you can definitely see that now – because our products would also go into electric cars – that there is a nervousness that a chemical company could notice as well.” (IP5)
Steel 1	Technological innovation vs. current norms of production Profitability vs. costly low-carbon innovation	“we don't use carbon for our processes because we like to emit CO ₂ , but because – seen from a global perspective – it is the most economical process for producing our special range of products. And if we leave this path – or, to put it the other way round, we would have left it long ago if the other path had been cheaper. That means it's not possible, it's up to the market. And in this respect, it doesn't help us if the CO ₂ price becomes more expensive, if the certificates become scarcer and scarcer, because this doesn't stimulate new investments and new processes in our economic sector, because we have to compete with the products - or we

		<p>compete with those - that are offered worldwide. And in our case, these are all products that are made on the blast furnace route. That means - I'll put it bluntly now - either we die now from having to bear too high costs for ourselves because CO₂ prices are rising, or we die from introducing a process that is lower in CO₂ but significantly higher in production costs. So something else has to happen than just high CO₂ prices so that we have a chance to bring these processes into the market." (IP9)</p>
Steel 3	Technological innovation vs. current norms of production and customer relations	<p>"The unfortunate thing is that our competitors from China, India and other countries do not have this component of energy and CO₂ in their prices. And of course that makes it difficult for us [...] So to give you the dimension why we are always fighting for special permits as an energy-intensive industry, because we compete worldwide and our product has the same price worldwide. We can't say that we're going to put a premium on the on the product." (IP11)</p>
Steel 5	Technological innovation vs. current norms of production and customer relations	<p>"we did a survey last year among our customers and they don't want to pay for it. Especially high-end customers are asking for low carbon steel, but they won't pay for it." (IP15)</p>
Utility 1	Profitability vs. costly low-carbon innovation	<p>"CO₂ and climate responsibility must first of all be properly established on the board level. Once we've done that – I think we're on the right track to get there – I think that SbT [science-based targets] will be the next step, because SbT will automatically mean that we have to work against the business to achieve climate targets. This is of course a paradigm shift, if you want to see it this way – especially for companies like us, that's where it burns the most." (IP16)</p>

TABLE 2

Synthesis by Wholesale Green Transition

Company	Leadership advocating sustainability	MCSs (“Targets” denotes “emissions targets”)	Salient Climate Actions
Chemical2	CEO: long-time, vocal champion of sustainability. CFO: strongly engaged with Accounting for Sustainability (A4S). “[W]e are in the lucky position that we have a CEO and also a CFO, and an ExCo and a strategy that is all really about sustainability.” (IP3)	1) <i>Targets</i> : Scope 1-3, science-based 2) <i>Internal carbon pricing</i> : used in investment and acquisition processes 3) <i>Internal reporting</i> : hypothetical internal carbon “penalty” applied to P&L of business units 4) Carbon-footprinting of value chain	Decarbonising Operations by – Divestiture – Mergers and acquisitions – Supporting innovations – Lobbying stakeholders – Innovating accounting
Chemical5	Executive committee: working with the CISL (Cambridge Institute for Sustainability Leadership) on strategy and 2030 targets aligned with UN Sustainable Development Goals. CFO: “Our CFO has been heavily involved in our sustainability target setting with KPIs, he has been really-really involved in that work.” (IP6)	1) <i>Targets</i> : Scope 1-3, science-based 2) <i>Internal carbon pricing</i> : used in investment processes 3) <i>Internal reporting</i> : energy use and carbon emission on quarterly basis 4) Carbon-footprinting of value chain	Decarbonising Operations by – Mergers and acquisitions – Supporting innovations – Lobbying stakeholders
Utility 3	CEO vocal and high-profile advocate of low-carbon transition. Establishment of Sustainability Council: led by CEO and attended by top executives.	1) <i>Targets</i> : Scope 1-3 1) <i>Internal carbon pricing</i> : used in strategy, business development, and investment processes 2) <i>Internal reporting</i> : regular reports on progress on climate issues to Sustainability Council 3) <i>Carbon-footprinting</i> of value chain 4) <i>Scenario analysis</i> : decarbonization scenarios are used to identify “business opportunities offered by the low-carbon transition” (2019 CDP Response)	Decarbonising Operations by – Investments in green assets – Divestiture – Mergers and acquisitions – Lobbying stakeholders
Utility 7	CEO vocal and high-profile advocate of low-carbon transition Company has changed a lot since 2014 and this was linked with the arrival of the new CEO in 2014, who was the former head of [Utility 8]’s renewable business line. In particular, it was mentioned that the new CEO was key for changing the mind-set within the company.	1) <i>Targets</i> : Scope 1-3, science-based 2) <i>Internal carbon pricing</i> : used in strategic planning 3) <i>Scenario analysis</i> : building a larger team for developing and conducting scenario analyses, shifting from analysis of historical weather patterns to building future projections.	Decarbonising Operations by – Investments in green assets – Mergers and acquisitions – Supporting innovations – Lobbying stakeholders

Utility 8	CFO strongly engaged in Accounting for Sustainability (A4S) and at forefront of integrating sustainability into finance processes.	1) <i>Targets</i> : Scope 1-3, science-based 2) <i>Internal carbon pricing</i> : used in operational and capital investment decisions 3) <i>Scenario analysis</i> : Scenario analysis is at the heart of Utility 8's climate risk management. Importantly, climate risks are assessed holistically, e.g. linkages and knock-on effects of climate risks are considered	Decarbonising Operations by <ul style="list-style-type: none"> – Investments in green assets – Mergers and acquisitions – Lobbying stakeholders – Innovating accounting
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TABLE 3

Separation by Green Segmentation

Company	Leadership advocating sustainability	MCSs (“Targets” denotes “emissions targets”)	Salient Climate Actions
Chemical 1	CFO in charge of sustainability.	1) <i>Targets</i> : Scope 1-2, not science-based 2) <i>Internal carbon pricing</i> : used in investment and product development processes 3) <i>Product sustainability screening</i> : used to measure performance against sales target 4) <i>Internal reporting</i> : integrated performance dashboard with climate-related KPIs	– Gradually decarbonising operations by developing and marketing Low-Carbon “Solutions” – Innovating accounting
Chemical 4	Board advocates for sustainability: “the topic has moved very close to the board of directors in order to really build up the organizational pressure.” (IP5)	1) <i>Targets</i> : Scope 1-2, not science-based 2) <i>Internal carbon pricing</i> 3) <i>Scenario analysis</i> 4) <i>Internal reporting</i> : energy use and carbon emission on quarterly basis	– Gradually decarbonising operations by developing and marketing Low-Carbon “Solutions” – Innovating accounting
Chemical 6	Chief Human Resource Officer is also the most senior climate officer.	1) <i>Targets</i> : Scope 1-2, not science-based 2) <i>Internal carbon pricing</i> : applied in investment appraisals 3) <i>Product sustainability screening</i> : used to measure performance against sales target	– Gradually decarbonising operations by developing and marketing Low-Carbon “Solutions” – Innovating accounting
Utility 2	CFO replaced CEO – who was perceived as a bit of a “dinosaur” (IP18) – in April 2021; new CEO (former CFO) sees sustainability as an opportunity to improve reputation → sustainability team moved into Strategy.	1) <i>Targets</i> : newly set Scope 1-3, science-based target, previously only Scope 1-2 2) <i>Internal carbon pricing</i> : used to steer portfolio of operating power plants subject to ETS 3) <i>Scenario analysis</i> : used in strategic planning	– Gradually Decarbonising Operations by developing and marketing Low-Carbon “Solutions”
Utility 4	CEO initiated TCFD implementation in 2018 and published book on potential of hydrogen economy in 2021. ESG Committee: Newly created in May 2019, this Board-level committee reviews company’s response to climate change and “evaluates the sustainability risks in the medium-/long-term.” (CC Report 2019)	1) <i>Targets</i> : Scope 1-2, not science-based 2) <i>Internal carbon pricing</i> : used in cost-benefit analysis of investments 3) <i>Scenario analysis</i> : building on sophisticated scenarios modelling gas demand, company has developed climate-related scenarios to inform strategy 4) <i>Internal Reporting</i> : Non-financial data is reported internally to the board in six months intervals (mid-year and end-of-year).	– Gradually decarbonising operations by developing and marketing Low-Carbon “Solutions”

Utility 5	CFO has long been leading proponent of climate-related disclosure and has been inaugural member of TCFD.	1) <i>Targets</i> : Scope 1-2, not science-based 2) <i>Internal reporting</i> : climate-related KPIs integrated into performance management system (CO ₂ intensity and installed output of renewable energy assets) 3) <i>Scenario analysis</i> : used to assess robustness of business model in transition to low carbon economy	– Gradually decarbonising operations by developing and marketing Low-Carbon “Solutions”
Utility 6	CEO receives direct reports from Head of Corporate Responsibility.	1) <i>Targets</i> : newly set Scope 1-3, science-based target, previously only Scope 1-2 2) <i>Internal reporting</i> : climate KPIs used in investment appraisal and regularly reported to executive board 3) <i>Scenario analysis</i> : used in strategic planning	– Gradually decarbonising operations by developing and marketing Low-Carbon “Solutions” – Innovating accounting

TABLE 4

Acceptance by Engagement

Company	Leadership advocacy	MCSs (“Targets” denotes “emissions targets”)	Salient Climate Actions
Chemical 3	<p>Delay in switching from instrumental to integrative logic.</p> <p>“Climate risks issues have moved closer to CFO” and “articles and new developments on climate risks are now landing directly on the CFO’s desk.” (IP4)</p> <p>“The issue of sustainability and climate change is on the minds of board members; some of them really believe in it and push it”. (IP4)</p>	<p>1) <i>Targets</i>: Scope 1-2, not science-based</p> <p>2) <i>Internal carbon pricing</i>: used in investment appraisals of European projects</p> <p>3) <i>Product carbon footprinting</i>: implemented in 2020 to generate product-level emission data, but coverage is patchy and no group-level aggregation</p> <p>4) <i>Internal reporting</i>: starting to include sustainability KPIs in business steering, but decarbonization targets are not linked to PMS</p> <p>5) <i>Scenario analysis</i>: used for modelling low-carbon transition and assessing implications for product portfolio</p>	<ul style="list-style-type: none"> – Engagement with policymakers on creating conditions allowing company to decarbonise. – Experimental decarbonization project under way.
Steel 1	<p>Delay in switching from instrumental to integrative logic.</p>	<p>1) <i>Targets</i>: no emissions targets</p> <p>2) <i>Internal carbon pricing</i>: Partially applied, but not across the whole production portfolio.</p>	<ul style="list-style-type: none"> – Engagement with policymakers on creating conditions allowing company to decarbonise. – Lobbying governments for subsidies in exchange for investment in decarbonization projects. – Experimental decarbonization project under way.
Steel 2	<p>Delay in switching from instrumental to integrative logic.</p> <p>“CFO eventually backed TCFD implementation...” (IP10)</p> <p>Step-change in CEO office in early 2021: “They elevated this issue: stakeholder expectations, we want to be a leader in this space. So the CEO asks what would it take for us to lead on this?” (IP10)</p>	<p>1) <i>Targets</i>: only for Europe, Scope 1-2, not science-based</p> <p>2) <i>Scenario analysis</i>: used to assess decarbonization policy scenarios</p> <p>2) <i>Internal carbon pricing</i>: used in investment processes</p>	<ul style="list-style-type: none"> – Engage policymakers on creating conditions allowing company to decarbonise. – Lobbying governments for subsidies in exchange for investment in decarbonization projects. – Engagement with industry networks: Working out carbon accounting for steel companies as part of an industry network. – Engagement with investors: “Over the last year, the percentage of questions on climate as opposed to other ESG questions went from 25% to 75% over the last 4 years.” (IP10)

			– Experimental decarbonization project under way.
Steel 3	Delay in switching from instrumental to integrative logic. “Supervisory board raised climate risk management with company”	1) <i>Targets</i> : Scope 1-2, not science-based 2) <i>Scenario analysis</i> : used to assess decarbonization policy scenarios 3) <i>Internal carbon pricing</i> : used in investment committees	– Engagement with policymakers on creating conditions allowing company to decarbonise – Lobbying governments for subsidies, and ETS allowances in exchange for positive externalities and investment in decarbonization projects. – Experimental decarbonization project under way.
Steel 4	Delay in switching from instrumental to integrative logic. CEO receives direct reports from Head of Strategic Environmental Management	1) <i>Targets</i> : long-term target conditional on availability of “yet to be developed break-through technologies” (2019 CDP Response) 2) <i>Scenario analysis</i> : used to assess decarbonization policy scenarios 3) <i>Internal carbon pricing</i> : used in investment processes	– Engagement with policymakers on creating conditions allowing company to decarbonise. – Engagement with policymakers and “show which framework - which conditions - are necessary for us or for the steel industry to be able to manage this decarbonisation process.” (IP14)
Steel 5	Delay in switching from instrumental to integrative logic. New CEO in early 2021 with stronger focus on sustainability. Sustainability Manager is now at the top table – reports directly to the CEO, part of the top management team.	1) <i>Targets</i> : newly set Scope 1-3, science-based target, previously only Scope 1-2 2) <i>Scenario analysis</i> : used in strategic planning to assess risks from policy changes (EU ETS) 3) <i>Internal carbon pricing</i> : used in risk assessments, impact studies and in an internal carbon trading scheme	– Engagement with policymakers on creating conditions allowing company to decarbonise – Experimental decarbonization project under way.
Utility 1	Delay in switching from instrumental to integrative logic. Since corporate takeover in 2020, Utility 1 has Board-level engagement on climate change; Chief Operating Officer is now officially acting as a Chief Sustainability Officer.	1) <i>Targets</i> : No emissions targets 2) <i>Internal reporting</i> : quarterly reports to the Board about sustainability and climate risks 3) <i>Scenario analysis</i> : used in strategic planning to assess risks from policy changes (EU ETS) 4) Project assessments: sustainability screening of new projects, also reported to the Board.	– Engagement with policymakers on creating conditions allowing company to decarbonise

TABLE 5

Recursive Developments

Company	Initial strategy (2018-2021)	Additional emerging strategy (2022)
Chemical 1	Green Segmentation	<i>Engagement:</i> New chief sustainability and government affairs officer appointed to focus the group's advocacy on its decarbonization ambitions and to “accelerate and scale-up our internal sustainability journey.”
Chemical 4	Green Segmentation	<i>Engagement:</i> Chemical 4 joins World Business Council for Sustainable Development.
Utility 2	Green Segmentation	<i>Engagement:</i> Utility 2 “expressly supports Dutch CO ₂ reduction target”, but files for arbitration and requests arbitration against the Netherlands at the International Centre for Settlement of Investment Disputes. Utility 2 joins new European Clean Hydrogen Alliance with ambitious aims on the deployment of hydrogen technologies by 2030; bringing together renewable and low-carbon hydrogen production, demand in industry, mobility and other sectors, as well as hydrogen transmission and distribution. The alliance was established by the EU Commission in order to support the EU’s commitment to reach carbon neutrality by 2050.
Chemical 3	Engagement	<i>Green Segmentation:</i> Chemical 3 launches and increases sale of reduced-carbon “Accelerator” products. It calculates CO ₂ footprint of all sales products – and deploys a new digital application to help customers better measure and reduce their own CO ₂ footprint of their activities and end products.
Steel 1	Engagement	<i>Green Segmentation:</i> Steel 1 adds low CO ₂ steel grades to its product range and delivers green strip steel to an auto industry customer. Steel 1 also obtained third-party verification of the lower carbon footprint for producing strip steel “in line with TÜV SÜD’s VERIsteel procedure”. The process provides proof of product-specific CO ₂ emissions in steel production.

TABLE 6

Summary case comparisons

	Green Transition Strategies	Green Segmentation Strategies	Engagement Strategies
Strategic response's salient climate actions	Decarbonizing operations by portfolio management: <ul style="list-style-type: none"> – Divestitures – Mergers and acquisitions – Low-carbon product innovations 	Gradually decarbonizing operations by developing and marketing Low-Carbon “Solutions”	Engagement with policymakers on creating conditions allowing company to decarbonise. Lobbying governments for subsidies in exchange for investment in decarbonization projects. Experimental decarbonization projects
Firms	2 chemical companies, 3 utilities	3 chemical companies, 4 utilities	1 chemical company 5 steel companies 1 utility
Average Asset Carbon Intensity ⁽¹⁾	194	459	807
Average Carbon Cost Intensity ⁽²⁾	28%	91%	283%
Perception of decarbonization (threat or opportunity)	Decarbonization is an opportunity to transform the business.	Decarbonization offers opportunities but also poses threats to parts of the business.	Decarbonization is seen as an existential threat to the business.
Perception of requisite change	Attainable	Partially attainable	Hard to attain
Perceptions of temporal and spatial context	Wholesale transition	Partial, selective transition over time	Gradual and slow transition in select geographies
Decarbonization objectives	Science-based emission-reduction targets for own operations (Scope 1+2) and for supply chains/customers (Scope 3).	Emission reductions targets for own operations (Scope 1+2) only (but not the entire value chain).	Typically, no science-based targets. Emission-reduction targets contingent on breakthrough technologies varying across companies and within companies, across business units.
Carbon price and carbon-adjusted MCSs	On average €28 per ton of carbon. Used in CAPEX and M&A appraisal, and performance evaluation (PMS).	On average €38 per ton of carbon Used in product planning and investment appraisals, and performance evaluation (PMS) at product level.	On average €58 per ton of carbon Used in scenario analysis to support policy work (corporate activism).

(1) Calculated as tons of CO₂ emission (Scope 1 & 2) divided by total assets (in \$ million), 2019 data

(2) Carbon cost as % of EBITDA, calculated as carbon emissions (Scope 1 & 2) multiplied by hypothetical carbon price of \$113.95 (€100) divided by EBITDA (in \$ million); 2019 data from CDP, S&P's CapIQ

VII. APPENDIX 1 COMPANY CHARACTERISTICS AND DATA SOURCES

Case	Business activities	Interview partners (function)	Data (27 interviews, archival data)	Interview duration
Chemical 1	Speciality chemicals, commodity chemicals	IP1 (finance), IP2 (strategy)	2 interviews (initial), corporate reports, CDP data	60 min, 60 min
Chemical 2	Speciality chemicals	IP3 (risk)	1 interview, corporate reports, CDP data	50 min
Chemical 3	Commodity chemicals, speciality chemicals	IP4 (finance), IP29 (finance)	2 interviews (initial & follow-up), corporate reports, CDP data	60 min, 60 min
Chemical 4	Speciality chemicals, commodity chemicals	IP5 (sustainability)	1 interview, corporate reports, CDP data	50 min
Chemical 5	Speciality chemicals	IP6 (sustainability)	1 interview, corporate reports, CDP data	50 min
Chemical 6	Speciality chemicals, commodity chemicals	IP7 (sustainability)	1 interview, corporate reports, CDP data	60 min
Steel 1	Commodity steel	IP8 (sustainability), IP9 (technology)	1 interview, corporate reports	50 min
Steel 2	Commodity steel	IP10 (sustainability)	2 interviews (initial & follow-up), corporate reports, CDP data	75 min, 75 min
Steel 3	Speciality metals	IP11, IP12, IP30 (all sustainability); IP13 (risk)	2 interviews (initial & follow-up), corporate reports, CDP data	50 min, 50 min
Steel 4	Commodity steel	IP14 (sustainability)	1 interview, corporate reports, CDP data	50 min
Steel 5	Specialty steel & metals	IP15 (sustainability)	2 interviews (initial & follow-up), corporate reports, CDP data	60 min, 60 min
Utility 1	Energy generation (fossil fuels) & trading	IP16 (sustainability); IP17 (sustainability)	3 interviews (2 initial & 1 follow-up), corporate reports, CDP data	80 min, 70 min, 70 min
Utility 2	Energy generation (fossil fuels, renewables) & trading	IP18 (sustainability)	2 interviews (initial & follow-up), corporate reports, CDP data	60 min, 70 min
Utility 3	Energy transmission & distribution; customer services	IP19 (sustainability); IP20 (sustainability)	1 interview, corporate reports, CDP data	50 min
Utility 4	Energy infrastructure (gas)	IP21 (sustainability)	1 interview, corporate reports, CDP data	60 min
Utility 5	Energy generation (fossil fuels, renewables); trading, transmission & distribution	IP22 (finance), IP23 (sustainability)	1 interview, corporate reports, CDP data	40 min
Utility 6	Energy generation (fossil fuels, renewables); transmission & distribution; water services	IP24 (sustainability)	1 interview, corporate reports, CDP data	50 min
Utility 7	Energy generation (fossil fuels, renewables); transmission & distribution; customer services	IP25 (strategy), IP26 (strategy), IP27 (strategy)	1 interview, corporate reports, CDP data	65 min
Utility 8	Energy generation (fossil fuels, renewables); transmission & distribution	IP28 (finance)	1 interview, corporate reports, CDP data	65 min

VIII. APPENDIX 2 SEMI-STRUCTURED INTERVIEW GUIDE

A. Personal background

1. Please describe briefly your background (e.g. education, training, career stations)

B. Current role

1. Please describe your current role and how climate-related aspect feature in it

C. Organisation

1. Which functions are involved in managing climate-related aspects?

D. How are climate change issues integrated into management processes?

1. How are climate-related risks and opportunities assessed?
 - a. Which organisational units are involved?
 - b. Which climate-related aspects are assessed?
 - c. How are climate-related aspects assessed?
 - i. Are climate related-aspects quantified/monetised?
 - ii. Are specific tools used, e.g. scenario analyses?
 - d. What are the key challenges in assessing climate-related risks/opportunities?
2. Which organisational processes are informed by these climate risks/opportunities assessments? And how?
 - a. Strategic processes?
 - b. Investment processes?
 - c. Others?
 - d. Can you give specific examples of how climate-related aspects influence decision-making in these processes?
3. Are there any processes in which climate-related aspects should be integrated but they are currently not? If so, why is that?