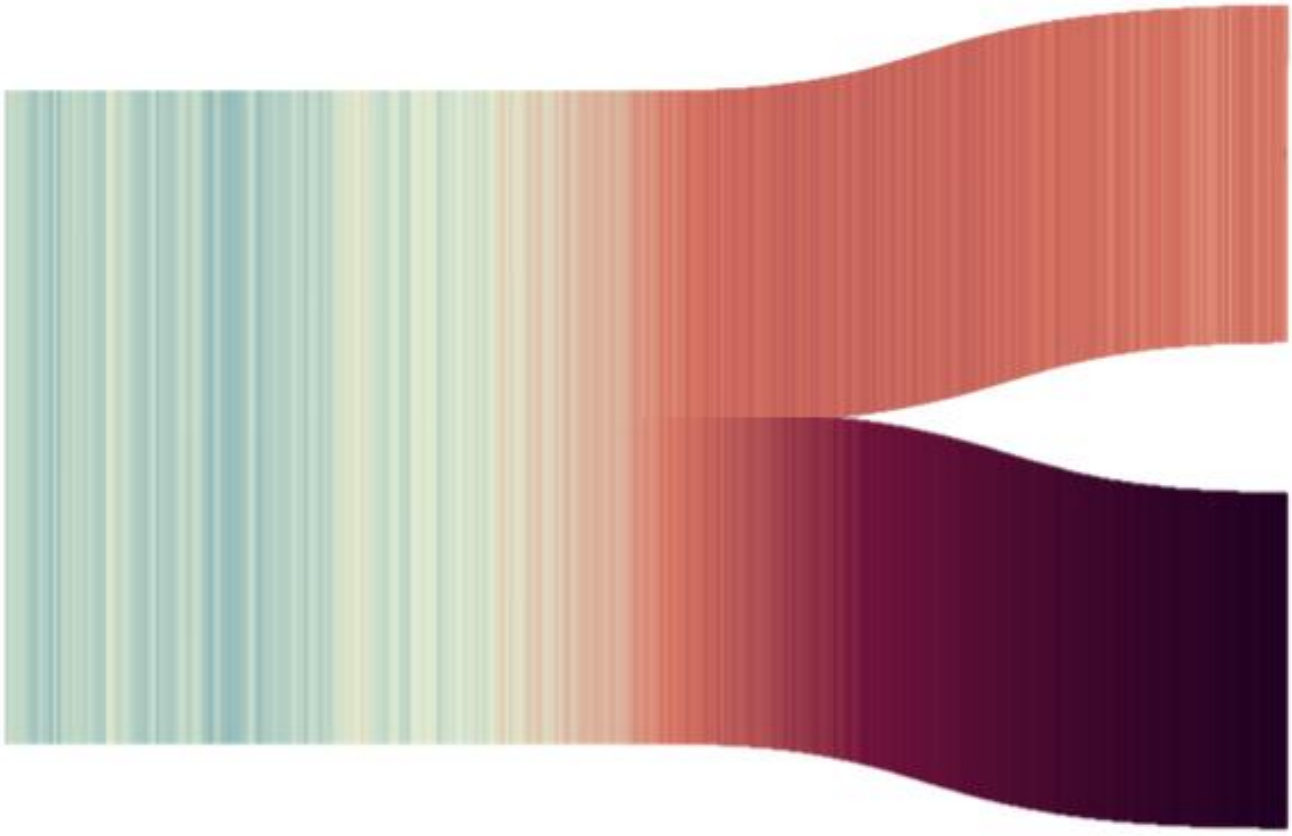
Anticipating the Heat

USING SCENARIOS TO MAKE FUTURE CLIMATE CHANGE IMPACTS TANGIBLE



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ABSTRACT

The TCFD-guidelines were created to support companies, investors and other financial service providers in better identifying and addressing climate-related risks and opportunities. They differ from current disclosure practices by addressing the impact of climate change on business rather than the impact of businesses on the climate. They also aim to address a long-term time horizon by using scenario analysis. The current adoption rate of scenario analysis, however, is relatively low because there is no standardized method, tool or set of guidelines for the application hereof. Also there has been little research into the added value of scenario analysis in this process. The aim of this this research is to find the added value of scenario analysis to the TCFD-guidelines by developing, testing and disclosing a new practical method for this purpose. The method is developed by conducting a literature review and expert interviews and subsequently tested and refined in a case study.

For the developed method to add value to the TCFD-guidelines seven key requirements on three different levels were identified. Firstly, on the applicational level, the method has to be engaging, generate a feeling of ownership and be applicable within time and resource constraints. Secondly, on the corporate level, the method has to generate decision useful information and be replicable and repeatable. And finally, on the supranational level, the method has to align with the goals of governing for financial stability and induce some form of transformative collective action.

The developed method satisfies the requirements on the applicational level. On the corporate level it generates decision useful information, is flexible enough to be replicable, yet consistent enough to be repeatable. And finally, on the supranational level, the developed method aligns with the goals of governing for financial stability by successfully identifying direct climate-related risks and opportunities but is not yet suitable for the identification of indirect climate-related risks and opportunities, nor to quantify them. By providing and disclosing a successful method for scenario analysis this research lowers the barrier for adoption and therewith increases the potential of the guidelines inducing some form of transformative collective action.

In conclusion this research has developed a successful approach to scenario analysis and shows the added value of scenario analysis in the identification of climate-related risks and opportunities. By also disclosing a replicable and repeatable method this research further increases the extent to which scenario analysis can add value to the TCFD-guidelines.

Cover: Stylized global mean temperatures 1850-2200. Historical data from HardCRUT 4.6.0.0. and NASA/GISS/GISTEMP v.3. Projections based on CMIP5 RCP scenarios (RCP2.6/RCP8.5) and extensions hereof from 2100-2200. Design adjusted from @alxrdk based on warming stripes from @ed_hawkins. Data and methodology on www.warmingstripes.com

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"Climate change is the *Tragedy of the Horizon*" - Mark Carney (2015, p. 4)

1 Introduction

Most of the risks related to climate change do not fall within the timespan of business cycles, political cycles, or even the horizon of technocratic authorities, such as central banks (Carney, 2015). Corporations do not identify climate-related risks as financially material and do not report them in their annual financial filings (WBCSD, 2019). Also, the Financial Stability Board (FSB) suspects that climate risks are not correctly priced into the market (Carney, 2015) and many of the world's central banks and insurance providers currently see climate change as one of the biggest threats to financial stability (TCFD, 2019; NGFS, 2019; Brainard, 2019).

Currently climate change is considered to pose one of the biggest threats to the stability of the financial system (Carney, 2015; TCFD, 2017), the global economy (WEF, 2019) and arguably the world (IPCC, 2014; Ripple, et al., 2017), but not considered financially material. Looking back at previous threats left unaddressed by the financial sector, the most recent example – before the Covid-19 crisis emerged – is the global financial crisis of '08-'09. One specific institution that fell short at that time was the Financial Stability Forum (FSF) (Carrasco, 2010; Goldin & Vogel, 2010).

The FSF was established by the G7 Finance Ministers and Central Bank Governors in 1999 in an attempt to better govern and regulate the globalized financial system (FSB, 2019). Following the financial crisis the G20 Leaders called for a broadening of the FSF's mandate which led to the finding of the Financial Stability Board (FSB) in April 2009 (FSB, 2019). The FSB's identification of climate change as a systemic risk to the stability of the financial system is a first step in reducing the likelihood of climate change inducing a crisis. However, based on lessons drawn from the global financial crisis of '08-'09, governance practices and the institutions that were in place at the time were (and are) not able to mitigate systemic risks effectively (Goldin & Vogel, 2010).

Also now, current sustainability- and risk management disclosure practices such as the Carbon Disclosure Project (CDP), Global Reporting Initiative (GRI), Sustainability Accounting Standards Board (SASB) and COSO Enterprise Risk Management (COSO ERM) do not provide the information needed to make climate change appear to be a material financial risk. Causing a discrepancy in the perceived materiality of climate change risks between corporations on the one hand and scientific- and financial institutions on the other (IPCC, 2014; NGFS, 2019).

An explanation for why sustainability disclosure practices are unable to address this discrepancy can be found in the *double materiality perspective*, where climate change is only financially material if the impacts of climate change on the company are considered and not the other way around (figure 1, p. 6) (European Commission, 2019a). Current sustainability disclosure practices focus on the impact of the company on climate change, making them unsuitable to address the financial risks. Current risk management disclosure practices, on the other hand, do not identify climate change as a material financial risk because they do not address the long-term time horizon needed to do so (Carney, 2015; TCFD, 2017). This highlights the need for new approaches to global financial governance when faced with global threats such as climate change (Goldin & Vogel, 2010).

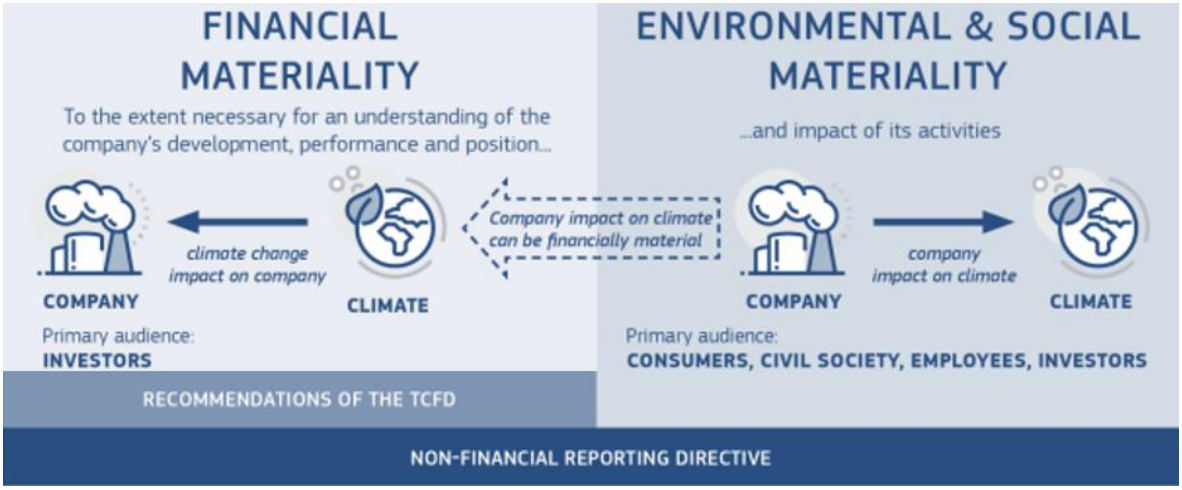


Figure 1: The double materiality perspective of the Non-Financial Reporting Directive in the context of reporting climate-related information (European Commission, 2019a)

One such 'new' approach is that of the Task Force for Climate-related Financial Disclosures (TCFD). To create awareness and widespread disclosure of climate risks and opportunities the FSB created the TCFD in 2015. Two years later the TCFD issued the TCFD-Guidelines to help corporations and financial institutions identify and quantify the (sector) specific climate risks and opportunities they are exposed to. The key risk types that climate change poses to corporations – and the financial system – are transition risks and physical risks (TCFD, 2017; European Commission, 2019a). Transition risks being those risks that "arise from the transition to a low-carbon and climate-resilient economy" (European Commission, 2019a, p. 9) and physical risks those that "arise from the physical effects of climate change" (European Commission, 2019a, p. 9)

The guidelines were specifically setup to provide "consistent climate-related financial disclosure for use by companies in providing information to investors, lenders, insurers, and other stakeholders" (TCFD, n.d.). They were designed to be in line with current disclosure formats such as CDP, GRI and SASB for maximum adoption. This approach has worked well with, only two years after publication, 80% of the Top 1100 global companies reporting towards the TCFD-guidelines (TCFD, 2019).

Although in line with current disclosure practices, the TCFD-guidelines differ on three fronts. Firstly, the TCFD-guidelines consider the impact of climate change on the company rather than the other way around. Secondly, on top of the current reporting initiatives' disclosure requirements the TCFD-guidelines have added the recommendation to also report on the strategic resilience of the company using scenario analysis (Corporate Reporting Dialogue, 2019; TCFD, 2017). Current available reports using the TCFD-guidelines, however, do not often result in the identification of climate risks as being financially material (WBCSD, 2019) even though they are likely to be financially material and should therefore be disclosed (Amel-Zadeh, 2019). A possible reason for this discrepancy can be found in the current levels of disclosure on the 'new' recommendation for strategic resilience, because without a long-term view (>10y, e.g. with the use of scenario analysis) climate change is not a material financial risk (Carney, 2015; TCFD, 2017). Research shows that currently only 8% of the Top 1100 global companies are reporting conform this specific recommendation (figure 2, p. 7) (TCFD, 2019).

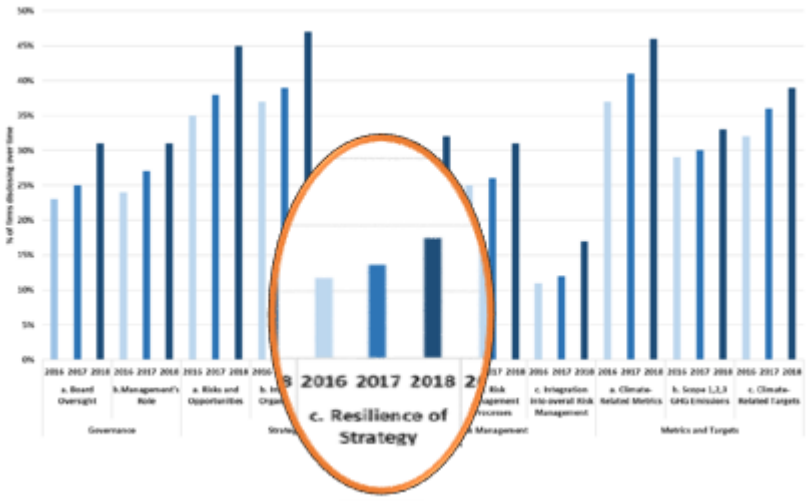


Figure 2: Current and past disclosure by category (adjusted from TCFD, 2019)

And thirdly, the TCFD also uses a different mode of governance from current approaches. On the supranational level, the TCFD is a form of public-private governance (FSB ↔ TCFD) as opposed to centralized- (e.g. the FSF) or self-governance (e.g. GRI or COSO ERM) (Driessen, Dieperink, van Laerhoven, Runhaar, & Vermeulen, 2012), both of which proved to be unequipped to prevent the global financial crisis (Goldin & Vogel, 2010). This public-private mode of governance does not by itself make it more suitable for the governance for financial stability in the anticipation of climate change (Lange, Driessen, Sauer, Bornemand, & Burger, 2013). However, it does allow for a more participative approach to governance, which the TCFD makes good use of with for example the World Business Counsel for Sustainable Development (WBCSD) preparer forums (WBCSD, 2019) and the MIT Working Group on Climate-Related Scenarios (Landry, et al., 2019). This, in turn, does make it more suitable for the governance for global financial stability (Lange, Driessen, Sauer, Bornemand, & Burger, 2013).

Potential on the supranational level, however, does not make this approach a panacea for climate change risk mitigation. The TCFD-guidelines are meant to be implemented on a corporate level, where they must successfully address the information demand and see a high level of adoption to be effective. This means that they must meet the requirements set for a successful corporate sustainability strategy (or at least the climate change aspect hereof).

Vermeulen and Witjes (2016) suggest that a successful corporate sustainability strategy depends on addressing all three dimensions of issue (Planet, People, Prosperity), time (now and then) and place (here and there). The TCFD-guidelines do not by themselves address the full extent of the issue dimension. However, as the TCFD-guidelines are a tool for the assessment of the financial impacts of climate-related risks and opportunities, and do not intend (nor pretend) to be an all-encompassing sustainability strategy, it is enough that they address the impact of the first P (planet) on the 2nd and 3rd Ps (people and prosperity). The time dimension is covered in full by reporting on current practices as well as long-term strategic resilience and both aspects of the place dimension are covered by taking into account the entire value chain. Addressing all three dimensions gives the TCFD-guidelines the potential to be a plan-do-check-act cycle that does not suffer from diminishing returns (Baumgartner, 2014) but rather one that increases its impact with every cycle, fostering transformative change (Vermeulen & Witjes, 2016).

With the use of scenario analysis the TCFD-guidelines also have the potential to engage (previously unengaged) people and institutions. The dry communication of (scientific) facts about climate change (e.g. emission disclosures or disaster scenarios) is generally considered counterproductive (Moser & Dilling, 2011) and unable to reach the ideologically opposed (Dryzek, 2016). Whilst engagement can increase the likelihood of effective and timely action in response to early warnings provided by science (Dryzek, 2016). This means that the information provided through successful applications of this framework sees a better chance of being integrated in decision making than the older disclosure practices.

1.1 Knowledge gap

On the supranational level Lange et al. (2013) identify the need for research that links the (un)sustainability of outcomes with the mode of governance used. Such research, however, is a complex and enormously ambitious undertaking, which poses challenges regarding, among other things, data availability and time (Lange, Driessen, Sauer, Bornemand, & Burger, 2013). To circumvent these challenges and make the necessary research more feasible Lange et al. (2013) suggest to instead look at the potential of governance modes, i.e. (1) whether the content of the policy or action is consistent with the identified goals and (2) whether some form of transformative collective action is induced.

On the corporate governance level Vermeulen and Witjes (2016) also highlight the need for empirical testing of both tools and methods for, as well as the assumptions about, effective strategies for transformative change. And although at first glance the TCFD-Guidelines appear to be a suitable approach to financial stability, this has not yet been scrutinized in scientific research.

On the applicational level companies still struggle with the application of scenario analysis to include a long-term (>10y) time horizon for decision making (Corporate Reporting Dialogue, 2019; WBCSD, 2019; TCFD, 2017). Without this part of the guidelines the issue of time (Vermeulen & Witjes, 2016) is not fully addressed leaving the risks and opportunities that come with climate change beyond the grasp of decision makers and the TCFD-Guidelines effectively similar to current (ineffective) disclosure practices.

The TCFD-Guidelines were created out of the need for a governance tool that could improve financial stability by identifying and quantifying climate-related risks and opportunities. To determine the effectivity of this governance initiative on the supranational level – its ability to govern for financial stability in the anticipation of climate change – the tool has first got to be tested for effectiveness on the corporate level. For the guidelines to be effective on the corporate level, they have to address all three dimensions of issue, time, and place. To be able to address all three of these dimensions a method for scenario analysis is needed that successfully addresses the long-term time horizon to generate decision useful information for corporate executives, investors and financial service providers. In other words, a method is needed that facilitates the identification of climate related risks and opportunities and allows for the estimation of the magnitude of impact of these events on the applicational level. Then, only when the method is successful on this level, can it start to foster transformative change on the corporate level and therewith potentially instigate transformative collective action, needed for success on the supranational level.

1.2 Research objective

To address these knowledge gaps, the first objective of this research is to address the knowledge gap on the applicational level. To find the best suitable approach to scenario analysis to include a long-term (>10y) time horizon along which climate-related risks and opportunities can be identified. Addressing the knowledge gap on this 'lowest' level of governance can make the model meet all three dimensions (issue, time, place) needed to foster transformative change on the corporate level. The second objective is to test whether or not this approach meets all three dimensions of issue, time and place, and generates the necessary decision useful information. The third and final objective of this research is then to determine the potential of the guidelines to induce transformative collective action and address its primary supranational goal: improving financial stability in the anticipation of climate change.

1.3 Research questions

To address the research objectives the following research question is posed:

> *To what extend can the application of scenario analysis increase the TCFD-Guidelines' contribution to the governance for global financial stability in the anticipation of climate change?*

To address the final research objective and answer the main research question, two intermediate research steps are necessary. These steps will be addressed by the following two sub-questions:

I. What type of scenario analysis is both feasible for companies and generates decision useful information for corporate executives and financial service providers?
II. How effective is scenario analysis, as part of the TCFD-Guidelines, in supplying the information necessary to identify and quantify relevant climate-related risks and opportunities?

1.4 Scientific and societal relevance

The scientific relevance of this research is twofold. Firstly this research will contribute to the fields of scenario analysis and corporate governance by developing and testing a novel approach for business-specific scenario analysis to identify climate-related risks and opportunities and formulate adequate responses to increase strategic resilience. And, secondly, this research will help determine the added value of using scenario analysis in the identification and response to climate-related risks and opportunities.

The societal relevance can be found in the contribution to the TCFD-guidelines, therewith in supporting the TCFD's goal of governing for global financial stability. If more companies start using scenario analysis to determine their exposure to climate-related impacts and disclose this to investors, the information can be used to more accurately price stocks, securities and other financial instruments, leading to a better functioning market and potentially increase global financial stability.

1.5 Internship objective and added value

Where the scientific research focus is on the development and implementation of a novel method for the application of scenario analysis within the TCFD-Guidelines, the internship focus is more practical. Starting at 1 November, 2019, the first objective is to create awareness of the existence and content of the TCFD-Guidelines. The second objective is to draw up a first deliverable that can be included in the 2019 annual report. The nature of the TCFD-Guidelines allow for, or even encourage, to start reporting partially as soon as possible. To disclose all of the available information within the company and then build on that to disclose more accurately and in more detail. This is also the third objective, to apply the developed scenario analysis approach to identify long-term risks and opportunities accurately and to prepare these for incorporation in the 2020 annual report.

Combining the research objective(s) and internship objective(s) in this research creates synergy. This research benefits from the direct connection with and feedback from managers and executives within the company. Also the approach can be tailored to fit the specific situation that exists within the company. This benefits both the research and the company, yielding results that are more likely to satisfy decision makers' information demand. The company benefits from this approach by receiving a tailored state-of-the-art scenario method.

2 Methodology

The research will consist of three steps, the first two of which are designed to provide an answer to their corresponding sub-question and the third and final step to answer the main research question. The first step will be to identify the best suitable type of scenario analysis for use in the TCFD-Guidelines. This part will start with a literature review complemented with external interviews. The second step will be an in depth case study applying, testing and refining the identified best suitable approach to scenario analysis in two of Corbion's three business units. This step will be performed in combination with an internship at Corbion (also the subject of the case study) enabling access to all required information. The final step will be to interpret the results to answer the main research question. A graphical representation of the three steps can be found in figure 3.

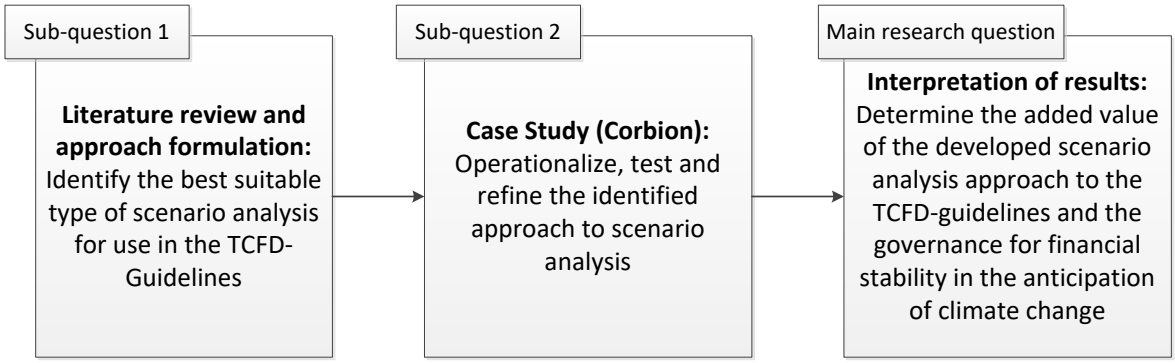


Figure 3: Core research framework

2.1 Literature review and approach formulation (sub-question 1)

Scenario analysis (or planning) is a particularly useful approach for dealing with uncertainty and complexity, especially when it comes to long-term planning and strategy formulation (Schoemaker, 1991; Martelli, 2001). However, for the successful application of scenario analysis it is crucial that the scenarios are tailored to the information demand and available resources of the client (Barber, 2009). Therefore, the first part of this research will be aimed at finding the best suitable type of scenario analysis for use within the TCFD-Guidelines in general and for Corbion in specific.

The identification hereof will be achieved through a three-step process. Firstly a comprehensive review of the scenario (analysis) literature will be conducted to identify potential approaches. Secondly the goals of the scenario analysis exercise will be formulated through a review of TCFD-specific (grey) literature. And finally the best scenario analysis approach to reach the TCFD objectives will be formulated with the help of expert interviews and current best practices of scenario analysis both in the corporate as well as the scientific community. A graphical representation of these first research steps can be found in figure 4.

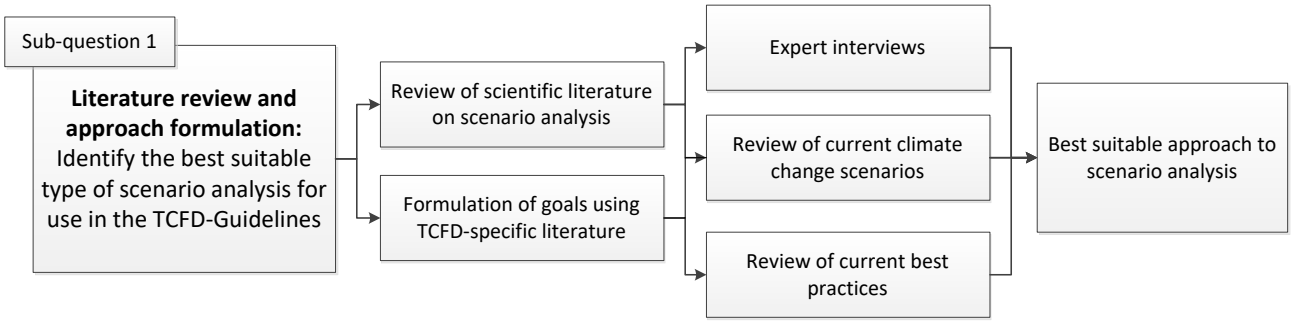


Figure 4: Literature study framework

2.2 Case Study (sub-question 2)

In the case study the identified method for scenario analysis will be empirically tested, i.e. a positive approach will be followed. The focus will be on a single case (Corbion), which is in line with Gerring's (2004) definition of the case study as "an in-depth study of a single unit" (p. 341). The choice for a single case is justified by Corbion being a representative case. Proximity to the research subject and continuous feedback on the applicability of the research will be achieved by means of an internship at the subject company (Corbion). This research setup allows for the application of the case study process feedback loops as identified by Yin (2009) (figure 5).

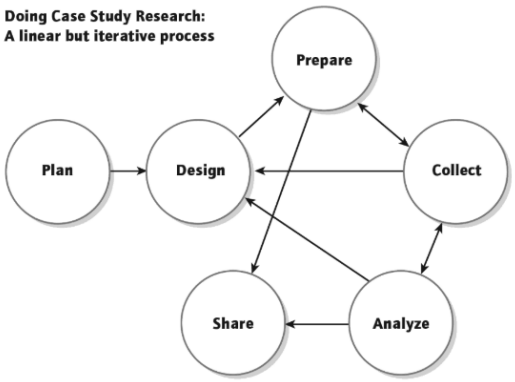


Figure 5: Doing Case Study Research (Yin, 2009)

The first step in the case study will be to fit the currently available climate disclosure information into the mold of the TCFD-Guidelines. This will also be the very first step overall, not because of research design considerations, but because it will allow Corbion to disclose conform the TCFD-Guidelines in their 2019 annual report. Also, through this process a degree of awareness of the existence, content and goals of the TCFD-guidelines is created.

The second part of the case study will be to apply and refine the identified method for scenario analysis. This will be done by firstly organizing a trial workshop to test the approach followed by the official workshops at Corbion. The second step will be to determine the success of the workshop process in achieving the identified goals of the TCFD and generation of decision useful information. This will be done by means of a survey. The third step is, in line with the first step, aimed at fulfilling the internship goals and will consist of incorporating the results in the TCFD disclosure format. The final step is to provide recommendations for further improvement, integration and continuous implementation of the process. A graphical representation of the case study framework can be found in figure 6.

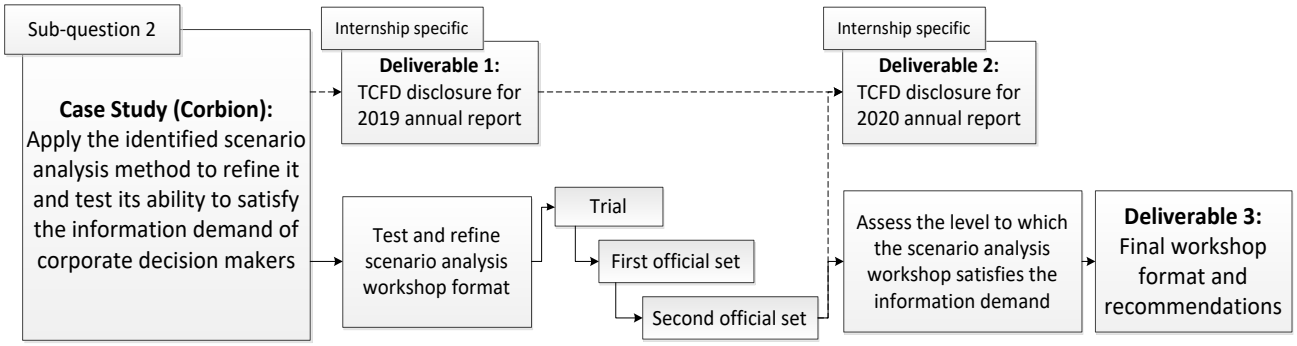


Figure 6: Case study framework

2.3 Added value of scenario analysis to the TCFD (main research question)

The interpretation of the results from the literature- and case study will serve to answer the main research question. To be able to determine the extent to which the TCFD-Guidelines contribute to the governance for financial stability in the anticipation of climate change, however, concrete indicators have to be formulated. Lange et al. (2013) define two requirements that need to be fulfilled in order for a governance tool to contribute to sustainable development. Firstly, "its content has to be consistent with the goals coming from the pursuit of SD" (p. 18) and secondly, "some form of transformative collective action must be induced" (p. 18).

These requirements, however, cannot be directly applied to the results of this research, but by reformulating them they can be tailored to this research and become suitable indicators. The first requirement can be reformulated as: Is the content consistent with the goals of governing for financial stability, i.e. does the application of scenario analysis within the TCFD-Guidelines lead to a more accurate pricing of climate risks and opportunities? And the second requirement can be reformulated as: Is there a form of transformative collective action induced, i.e. is there transformative change in the approach of companies to climate-related risk management? Using the case study results to answer these two questions the added value of scenario analysis to the TCFD-guidelines can be interpreted and therewith the main research question can be answered.

2.4 Thesis outline

In line with the sub- and main research questions this research is divided into three parts. To address the first sub-question, part 1 consists of chapter 3 (theoretical foundation) and chapter 4 (developing the scenario method). In this first part a scenario method will be developed based on the available scenario literature and expert interviews. Part 2, the application, refining, and testing of the scenario method is covered in the case study in chapter 5 and addresses sub-question 2. The third part of this research houses the conclusion in chapter 6 where the main research question is answered and the discussion in chapter 7. Finally chapter 8 will outline a step-by-step guide to the implementation, integration and continuation of the developed method.

3 Theoretical foundation

This chapter will first outline the current state of the art in scenario analysis literature, covering the terminology, definition and process, followed by an overview of the most highly cited and most recent reviews in the field and an approach to the application of scenarios in corporate strategy setting. Subsequently the goals of the scenario analysis will be formulated using TCFD specific literature as well as the conditions needed to accomplish these goals.

3.1 Scenarios

Identifying and anticipating when the environment is likely to shift, and what it might look like is where scenario analysis comes in. Take Shell for an example, in the early 1970s the oil market just came out of a relatively stable two decades of consistent growth. The first reaction of oil companies was to forecast continuous growth and formulate their strategy accordingly. Managers unconsciously anticipated 'more of the same'. Using the then novel approach of scenario analysis, Shell was able to anticipate the shift from a buyers' to a sellers' market and act accordingly (Wack, 1985a; Wack, 1985b). Although its competitors did not perish in the way Kodak did, Shell did come out of the following oil crisis on top of its competitors. Climate change can potentially be another such major environmental shift and scenario analysis could also here facilitate the identification of related risks and opportunities as well as of signpost events that can signal the onset hereof early on.

The approach to scenario analysis that Shell developed is, however, one of many. Therefore this section will first address the terminology and definitions related to scenarios, followed by an overview of current approaches. For example, the TCFD (2017) define scenario analysis as "a well-established method for developing strategic plans that are more flexible or robust to a range of plausible future states" (p. 25) and "an important and useful tool for understanding the strategic implications of climate-related risks and opportunities" (p. 25). This definition, although eloquently written, does not provide any information on what scenarios are and what scenario analysis entails.

In the field of scenarios there is an extensive amount of – contradicting and complementing – terminology, definitions and methodologies. Ramírez and Wilkinson (2016) confirm this by observing that "the sheer volume of publications on scenario planning makes it difficult […] to navigate the relevant literature" and that "not every paper on scenario planning claiming 'good' or even 'best' practice is of high quality, replicable, testable, usable, or even interesting" (p. 5). Consequently, the field has been described as a "very fuzzy multi-field" (Marien, 2002), suffering from "methodological confusion" (Balarezo & Nielsen, 2017), or even in a state of "methodological chaos" (Martelli, 2001; Wiebe, et al., 2018).

On top of this sits the often confusing use of terminology within the field, with Ramírez and Wilkinson (2016) finding that "scenario planning can be used to mean very different things in different organizations" (p. 5) whilst Bradfield et al. (2005) argue that scenario *planning, -analyzing, -thinking, -forecasting* and *-learning* all mean essentially the same and can be used interchangeably. To avoid as much confusion as possible, firstly the terminology used will be clarified and a definition will be given which will be used throughout the remainder of this thesis. Secondly a brief overview of approaches and methods will be provided followed by an outline of the specific goals for the scenario analysis exercise when performed in relation to the TCFD-guidelines.

3.1.1 Terminology and definition

For the use of terminology, Cairns and Wright (2011) provide a good go-to. In their response to the critique that scenario *planning* is not a suitable term they distinguish between three different references to the concept of scenarios. They see "scenario methods as the set of frameworks, models and approaches to undertaking structured scenario development. (...) [S]cenario analysis as the process of application of scenario methods by individuals and groups in order to explore a particular issue. (…) [And] scenario thinking (…) as a state of mind, a way of being that embraces complexity, ambiguity, and difference of values and beliefs" (p. 20).

Moving past the terminology and focusing on the definition of 'scenarios', Spaniol and Rowland (2019) find over 400 full and partial definitions. Rather than trying to come up with yet another definition they attempt to synthesize the existing definitions into a "process for classifying a phenomena as a scenario" (p. 10). Although mainly focused on the Intuitive Logic School of scenario analysis this process (figure 7) clearly defines what will and what will not be considered a 'scenario' in this thesis. For a more eloquent definition of a scenario I will quote both Porter (1985) and Schoemaker (1991) respectively, because these two definitions together paint a clear and concise picture of what Spaniol and Rowland's (2019) process defines as a scenario. According to Porter (1985) a single scenario is "an internally consistent view of what the future might turn out to be — not a forecast, but one possible future outcome" and in one of the first academic defenses of scenario analysis Schoemaker (1991) defined a set of scenarios as "focused descriptions of fundamentally different futures presented in a coherent script-like or narrative fashion".

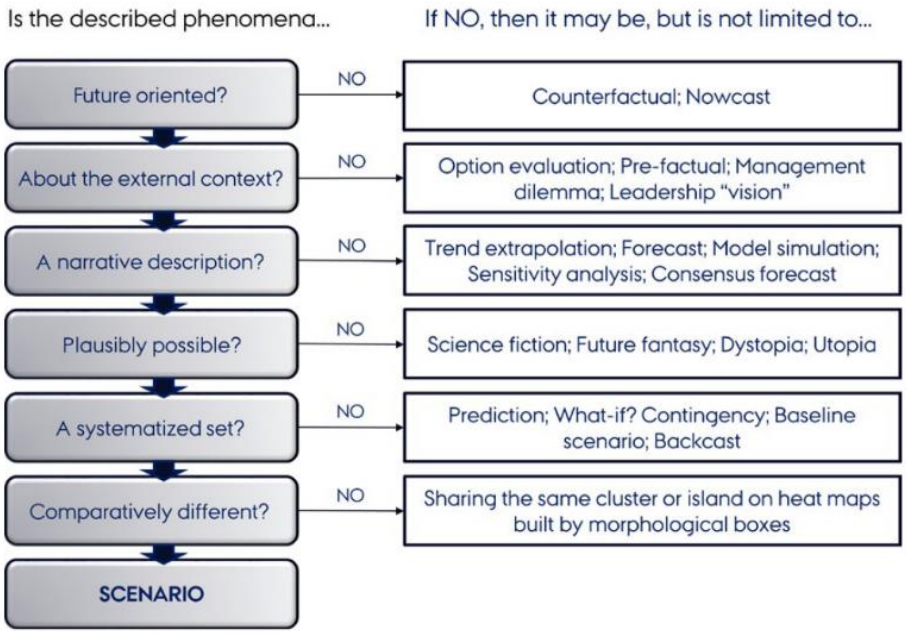


Figure 7: Process for classifying a phenomena as a scenario (Spaniol and Rowland, 2019)

3.1.2 Reviews

Over the years many reviews have been written aimed at creating some order in the scattered field of scenarios. The five most cited reviews are those by Börjeson et al. (2006), Bradfield et al. (2005), Van Notten et al. (2003), Bishop et al. (2007), and Amer et al. (2013). They have all been cited over 500 times

with Börjeson et al. (2006) seeing more than 1250 citations (as of 1/6/2020). Without attempting to write yet another review of scenario practices, the typologies used in these five papers will be highlighted and used to create a comprehensive overview of the field for reference in the remainder of this research and the selection of the most suitable approach for use within the TCFD-Guidelines.

With the last highly cited review dating back to 2013, it is important to also consider the potential advancements in the field since then. In this process one paper stands out from the rest: Wiebe et al. (2018) provide the – to the author's knowledge – most recent overview of methodological approaches to scenario analysis. Therefore this review will also be covered in this overview of reviews.

Börjeson et al. (2006) create a typology with three categories and six types. They build on variants of the categories probable, possible and preferable (Amara, 1981), adjusting them to focus on how the scenarios are used. To do this they distinguish between three categories based on three principal questions: *What will happen?, What can happen?* and *How can a specific target be reached?*. As a result of this they define the three categories of Predictive, Explorative and Normative scenarios. The six types are then created through distinguishing between internal and external factors. This results in the following typology (figure 8):

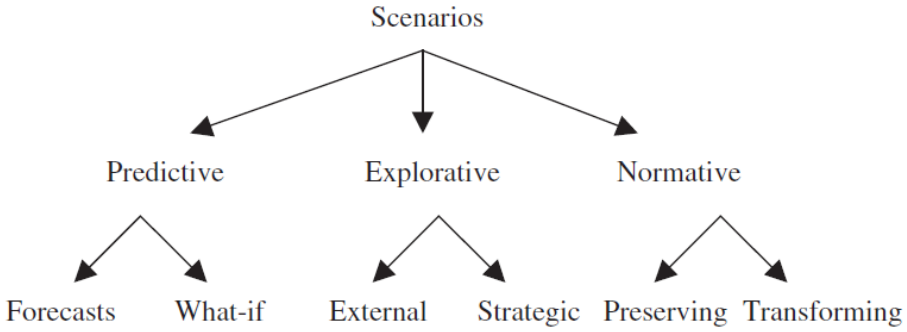


Figure 8: Scenario typologies (Börjeson et al., 2006)

In this typology, predictive scenarios are divided into forecasts and what-if scenarios. Forecast scenarios are designed to show the most likely outcome in case of a specific, expected external event. This type of scenario is most useful in short-term applications when there is not too much uncertainty in the development of the external factors. What-if scenarios cover the futures after specific 'splits' in the projected path, i.e. after a specific event has or has not happened. This can concern, for example, an (internal) strategy choice, the election of a president or some other referendum.

Explorative scenarios are split into external and strategic (internal) explorations of possible futures. External scenarios concern events over which the subject has no control, for example climate change, the onset of (cyber/nuclear) war, or a pandemic. Where strategic scenarios incorporate the decisions made by the scenario user to cope with the external environment.

Normative scenarios deal with the question of how a specific (desired) target can be reached. In preserving scenarios this is explored without altering the present status-quo, where transforming scenarios, on the other hand, explore how the desired future can be reached when it is at odds with the currently prevailing structure.

Bradfield et al. (2005) take a different approach and attempt to create some order by analyzing the historical origins of different scenario methods and finally group all currently existing approaches towards scenarios in three 'schools': The *Intuitive Logics (IL) School*, the *Probabilistic Modified Trends (PMT) School*, and the *French School*, or *La prospective*. This is a continuation of the work started by Huss and Honton (1987), who identified the IL School and the "Trend-Impact Analysis" (TIA) and "Cross-Impact

Analysis" (CIA) approaches, all three of which find their basis in the United States. Bradfield et al. (2005) group both the TIA and CIA methods into the PMT School and add the La Prospective method, which finds its origins in France.

The origins of the 'modern' IL School are often accredited to Pierre Wack with his work at Shell in the 1960s and '70s, with the 'historic' origins accredited to Kahn (Kahn & Wiener, 1967). Wack's outline of this approach in the Harvard Business Review (Wack, 1985a; Wack, 1985b) are among some of the most highly cited papers in the field. In this approach scenarios are created to engage decision makers and widen their scope of thinking beyond "business-as-usual". To have them consider the 'unknown unknowns' (Ingham & Luft, 1955). One specific characteristic of this school of scenario analysis is that none of the scenarios are assigned probabilities.

The PMT School, on the other hand, has its foundations rooted in assigning probabilities and uncertainties to the different scenarios constructed. Two of the main founders of this approach are Gordon and Helmer who developed the CIA approach in 1966 at the RAND Corporation (working together with Kahn) and later continued their work at the Stanford Research Institute. Because of its extensive use of probability the construction of scenarios within the PMT School almost always include extensive computer modelling and the involvement of a (large) group of specialists, either from academics or in consultancy.

The French School developed completely separate from the two schools with American origins. This approach was developed by French philosopher Gaston Berger in the 1950s in response to his dissatisfaction with 'classical' forecasting approaches. It was developed to create positive images of the future with which to influence policy makers in the political arena. To construct these 'positive images' often a combination of qualitative and quantitative approaches is used. One of the main differences between the French School and the American approaches is that the American approaches often take a global view, where the French School often creates more narrowly focused scenarios.

Van Notten et al. (2003) take yet another approach towards scenario typologies. They divide the different approaches into three overarching themes. Namely, the project goal, process design, and scenario content. Or, in other words, the why? (exploration or decision support), how? (formal or intuitive) and what? (simple or complex) of the scenario analysis exercise. With these themes they create a 'cartwheel' consisting of 8 scenario typologies. The approach is most suited for analyzing scenario sets in retrospect, rather than for scenario construction (Wilkinson & Eidinow, 2008).

Bishop et al. (2007) argue that the reviews of Börjeson et al. (2006) , Bradfield et al. (2005) and Van Notten et al. (2003) only cover the *approach* to the scenario *project* and fail to provide an overview of the different *techniques* or *methods* available that are practiced within one such approach. Therefore Bishop et al. (2007) provide an overview of 8 categories of techniques with among them 23 variations used. They outline (1) four techniques to create *judgement* scenarios (Genius, Visualization, Role playing, Coates and Jarratt), (2) a single technique to create *baseline* scenarios (Manoa), (3) two techniques for the *elaboration of fixed scenarios* (Incasting and SRI), (4) four techniques for the construction of *event sequences* (Probability trees, Sociovision, Divergence mapping, Future mapping), (5) two techniques to use for *backcasting* scenarios (Backcasting/Horizon mission methodology and Impact of future technologies), (6) four techniques to model *dimensions of uncertainty* (Morphological analysis/Field anomaly relaxation, GBN, Option development and evaluation, MORPHOL), (7) three techniques for *cross impact analysis* (Cross-impact analysis, IFS, SMIC PROB-EXPERT), and (8) three different *modelling* techniques (Trend impact analysis, Sensitivity analysis, Dynamic scenarios).

Amer et al. (2013) build on the scenario schools identified by Bradfield et al. (2005). They elaborate on the development of raw scenarios using four quantitative approaches (Fuzzy Cognitive Map, Trend Impact Analysis, INTERAX, and Interactive Future Simulations) and combine this with qualitative support data. More generally they provide an overview on how to select the number of scenarios to use for the scenario analysis exercise as well as how to validate the developed scenarios. They conclude that 3-5 future scenarios is the appropriate amount and that internal consistency and plausibility are the two most important aspects of a scenario.

Wiebe et al. (2018) follow, to a large extend, the conceptual approaches outlined in the above covered reviews, which they call scenario development approaches. They add to these by elaborating on what they call the 'foresight analysis' process, which can be loosely interpreted as the practical application of scenarios to make more informed choices. Within this process they identify the following five steps: (1) Confronting questions, (2) structuring dialog, (3) designing scenarios, (4) analyzing impacts, and (5) making choices. They visualize this process as can be seen in figure 9.

Confronting questions are defined as the starting point of every (formal) foresight process. They are followed by (and often intertwined with) structuring dialogue, the step in which the relevant stakeholders are identified and included, based on the goal of the foresight exercise.

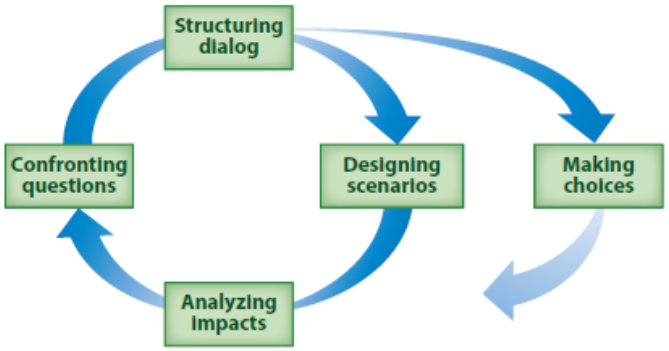


Figure 9: Foresight analysis process (Wiebe et al., 2018)

For the actual scenario design process firstly the pros and cons of creating versus customizing scenarios are outlined, followed by the desired scale of the scenarios, whether they are for exploratory or identifying risk purposes, choosing among possible scenarios, and the value of standardization of scenarios.

In the fourth step of analyzing impact they discuss the possible quantification of scenario results, the corresponding technical issues, linking of biophysical and economic scenarios and the interpretation of the outcomes. Which, when performed well, can help decision makers make more informed choices. They stress that, for scenarios to help "highlight and explain the implications and long-term consequences of current trends and choices (…) it is particularly important that the scenarios are perceived to be credible, stimulating, thought provoking, and – most important – relevant to the audience" (p. 558).

3.1.3 **Application**

Before applying scenarios in practice it is crucial to understand what they can and cannot be used for. Cairns and Wright (2011) eloquently summarize this by stating that the "scenario method does not provide 'the answer' to the problem. Scenario stories themselves are *not* predictions of the future. Rather, they offer a range of future possibilities against which to test current plans, develop and appraise new options and, hopefully, make better informed and more robust decisions on action. Scenarios provide a means of better understanding the complexity and ambiguity of the present" (p. 29). To

understand this shields the user from the overconfidence which would inevitably result from scenarios being used forecasts.

When applying scenarios for strategy setting it is almost impossible to forego the work of Pierre Wack at the time he worked for Shell France. However, most of his work (Wack, 1985a; Wack, 1985b) is concerned with the identification of scenario topics and hypothesis formulation to develop raw scenarios. With the TCFD's focus on climate change the topic has already been determined and plenty of scenarios have been developed. This shifts the main focus towards the integration of scenarios and scenario analysis in corporate strategies. Lehr et al. (2017) provide a practice based approach for the integration of scenario analysis and strategy.

Lehr et al. (2017) actively use scenarios in the formulation of strategy aiming to overcome the 'rationality bound', 'plasticity bound', and 'shaping-ability bound' to improve the transparency, ease of judgement, versatility, flexibility, and theoretical correctness of the strategizing process. In this process scenarios are used to communicate and incorporate the exogenous drivers into the strategy setting process, leading to the following schematic approach (figure 10):

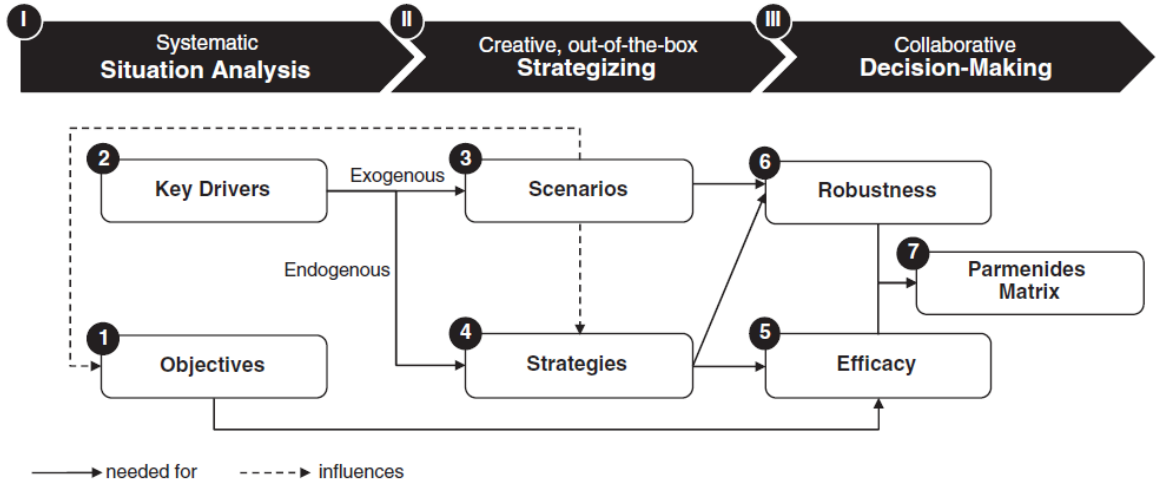


Figure 10: The Parmenides Matrix approach – overview (Lehr et al., 2017)

The outcome of this process is what they call a 'Parmenides Matrix'. This matrix, with robustness on one axis and efficacy on the other, allows for the selection of a strategy that performs well across a range of scenarios rather than in just a single scenario. Reducing the potential to be caught off-guard or being left unable to respond to a range of potential future events.

3.2 TCFD-specific goals and conditions

The main – supranational – goal of the TCFD is to increase the financial stability in anticipation of climate change. To give investors the chance to know which companies face the most risk, which are the best prepared, and which are already taking action (TCFD, 2017). To achieve this they provide a framework that guides companies and financial institutions in consistently identifying and reporting climate-related risks and opportunities. To successfully identify the long-term risks and opportunities they recommend the application of scenario analysis.

As Ramírez and Wilkinson (2016), however, duly note and what the covered reviews show is that there is "no single best or right method or set of techniques or tools comprising 'the' method in scenario planning" (p. 19). Rather, they say, "it is advisable to understand and navigate methodological

choices in designing an intervention that effectively supports the purposes and capabilities of the specific scenario learner" (p. 19). Following this notion the remainder of this chapter is aimed at outlining the goals specific to the application of scenario analysis within the TCFD-guidelines and the conditions needed for this scenario exercise to achieve these goals.

The specific goal of the scenario analysis within this framework is to identify the long-term risks and opportunities and allow decision makers to estimate the (financial) impacts hereof and formulate strategic responses to these threats and opportunities. Complementary to these goals, and needed for the disclosure of a company's strategic resilience are the estimation of the likelihood of events and identification of signpost events.

Although it might sound straightforward, using scenario analysis to identify long-term risks and opportunities, the nature of the TCFD-guidelines and the topic it addresses make the road to success a challenging one. The power of the TCFD-guidelines to induce transformative change relies on a broad level of engagement. Historically climate change has been the responsibility of the sustainability department (if there already was one), but now has the opportunity to attract attention from a different group of people within the company, the day-to-day decision makers.

Human influence as the main driver of climate change, however, can be considered an essentially contested concept, with corporate mitigation of and adaptation to climate change following in its footsteps. The company wide strategic focus means that employees from a range of departments need to be included in the discussion, increasing the chance of encountering the ideologically opposed or otherwise skeptical employees. On top of this the participants will often be from high(er) levels of management, because of the high-level strategic focus of the guidelines. These employees are often time-deprived and need to be convinced of the benefit and necessity of the scenario analysis.

To facilitate this the scenario method has to, firstly, be engaging to convince participants of the value of the exercise. Secondly it has to be participative and give participants a feeling of ownership. This way the method can facilitate the ideologically opposed to participate without having to renounce their believes. And, thirdly, it has to be feasible within the time and resource constraints of the company and participants. These are key requirement to get those people on board that do not necessarily show any interest in the subject (Moser & Dilling, 2011; Dryzek, 2016).

Only if these conditions on the applicational level are met can the goals of the scenario analysis be addressed on the corporate level. The exercise should yield decision useful information for participants, whether it be risks or opportunities, to motivate participants to participate in a follow-up session or even organize such an event themselves. Also it has to be replicable in other departments, companies, and/or industries as well as that it has to be repeatable, continuously building on the previous application of the method. This is necessary to allow for widespread adoption and to create the consistency both across organizations and over time to make the results useful for investors and financial service providers.

4 Developing the scenario method

To construct a method for scenario analysis that achieves all of the identified goals and meets all formulated conditions, one choice precedes all others because it influences all others: Should the scenarios be developed in house or should externally developed scenarios be used and tailored towards the specific situation? Depending on the choice of scenario type, a technique should be selected and/or a set of external scenarios has to be selected.

In search of the format that facilitates all of the formulated conditions for a successful scenario analysis on the applicational level, three questions need to be answered: (1) What is the best approach to engage a potentially skeptical audience? (2) how do you provide participants with a feeling of ownership and (3) what is possible within the boundaries of the time and resource constraints? To not lose sight of the conditions for corporate level success three additional questions have to be kept in mind: (1) Does the method yield decision useful information for participants? (2) can the method be easily adjusted to also be successful in other departments, companies, and industries? And (3) can the process be repeated in a constructive manner, building and improving on the previous cycle?

The method development will draw from the available scientific literature as outlined in the previous chapter complemented with expert interviews, current best practices and available climate (change) scenarios. Workshop development will rely on these same sources with the addition of some extra topic specific literature (e.g. on engagement, ownership, and participation).

4.1 Internally or externally developed scenarios

Choosing between an externally developed set of climate (change) scenarios or building one in-house seems almost deceptively easy when the arguments in favor are summed up. For example, the TCFD recommends the use of either the IPCC (2014) RCPs or the IEA (2019) World Energy Outlook scenarios. Also the climate consultancy 427mt (Four Twenty Seven, 2018) recommends that “corporations should not be concerned with developing new climate scenarios themselves” (p. 7). Bringing the time and resource constraints forward, using external scenarios is also simply less resource intensive.

Supporting the above argument that internal scenario generation is more resource intensive than using external scenarios is the opportunity to use quantitative over qualitative scenarios with much less resources. Due to the nature of climate change, modelling is at the foundation of most (scientific) climate scenario exercises. And although some basic models can be built by individuals it is almost impossible to come near the level of detail of the current state-of-the-art scientific climate models. On top of this even purely qualitative climate scenario exercises require a relatively large amount of (human) resources because of the demand for diversity to create representative scenarios (Cornish, 1977).

Using and tailoring external scenarios also has the potential to improve the methodological validity of the scenarios, when compared to scenarios constructed internally within the organization with limited resources, time and diversity. For example, when resources are limited and scenarios are still developed internally, they are likely not to satisfy one of the basic notions of the Delphi method, which is that “the judgement of a number of informed people is likely to be better than the judgement of a single individual” (Cornish, 1977, pp. 118-119). Also, Bishop et al. (2007) highlight the advantage that, using externally developed scenarios, “participants do not have to struggle with the uncertainties of the future” (p. 12). This is a major advantage when initial engagement is low and/or there is little previous experience with scenario thinking within the organization.

Most current best practices follow this advice and make use of external scenarios (e.g. Unilever, Nestlé, Mondi, AkzoNobel, DSM and others) with the exception of only a few major corporations, such as Shell. Internal scenario development, however, also has to deal with bias – that a company will not easily envision a future in which it is unable to survive. They tend to develop climate change scenarios in which they (the company) continue to play an important role, or at least do not perish. This is in contradiction with the initial goal of (IL) scenarios, which is to try to imagine the 'unknown unknowns', therefore also a potential future in which the current product of any single company could become obsolete, either through a technological development, or change in demand and supply characteristics.

Altogether, the decision to opt for external scenarios seems rather straightforward and could, considering the resource constraints of this specific scenario analysis exercise, even be considered the only option. However, the use of external scenarios is not without its drawbacks and risks. External scenarios often lack fit to the subject they are applied to. Also, without the creation of scenarios, the scenario thinking process is disrupted. This increases the difficulty to meet all specified conditions (e.g. engagement, participation, and feeling of ownership) for the scenario analysis process to become successful.

4.1.1 External scenario selection

Because of these conditions, several key factors have to be taken into account when selecting the externally generated scenarios for the scenario analysis. In this process the typologies of Börjeson et al. (2006) and van Notten et al. (2003) provide some direction on where to start. Firstly, using the typology of Börjeson et al (2006) the most fitting type of scenarios for the identification of risks and opportunities along the climate spectrum are explorative scenarios of the external kind. The scenarios should be exploratory, because for sound business decisions it is crucial to also attempt to consider the unknown unknowns, rather than just exploring the known unknowns as is the case in most predictive and normative scenarios. They should be external rather than internal because climate change is outside of the circle of influence of (most) companies.

Looking at the typologies of van Notten et al. (2003) the most likely way to engage an audience deprived of intrinsic motivation is to pick a simple, intuitive set aimed at decision support. This type of scenario, however, only provides a limited amount of information, making them less suitable for the generation of decision useful information. For example the two scenarios suggested by the TCFD (2017; IPCC, 2014; IEA, 2019) are complex and formal, with only the IEA scenarios aimed at decision support. Therefore, for the scenario sets to yield both the required information density as well as for them to be engaging, a formal and complex set of scenarios will have to be customized.

In concrete requirements for the scenario set this means that the *fit* of the scenario set has to be on point with the key focal issues of the scenario analysis (Cairns & Wright, 2011). Subsequently, the scenarios should be (easily) customizable to the subject company. This is important for both the relevance to the participants as well as for the potential to quantify the scenario impact to generate decision useful information for financial reporting. And finally, the (customized) scenarios have to be able to capture the attention of participants, create engagement and generate a feeling of ownership.

Where IPCC (2014) and IEA (2019) scenario sets do not fulfill all of these requirements. The Shared Socioeconomic Pathways (SSPs) (O'Neill, et al., 2017) provide a good next step in engagement. They are based on narrative storylines, adding a qualitative element to the scenarios that allow for the consideration of non-quantitative elements reflecting socioeconomic change. A factor that formal

models are unable to include (Riahi, et al., 2017). This approach yielded 5 scenarios linking the IPCC RCPs to the newly developed SSPs. These scenarios, however, do still not cover all criteria with their back-casting approach and matter-of-fact narratives aimed at the scientific community.

Goldthau et al. (2019) provide another engaging set of narrative, exploratory climate change scenarios, that does tick all of the initial boxes of Börjeson et al. (2006) and van Notten et al. (2003). These scenarios offer a challenging view of how the future could potentially manifest itself. Although creative enough to potentially spark the interest of decision makers, they do not link their narratives to quantitative data showing the results in temperature change, atmospheric CO_2 concentrations, energy mix or the like. Without this data the scenarios are less suited to customize, less useful in identifying risks and opportunities and even less able to then quantify this information.

Finally, the scenarios developed by Ansari and Holz (2019) fulfill the above requirements the best of all currently (to the author's knowledge) available global climate change scenarios. Other than the SSPSs, Ansari and Holz (2019) link qualitative and quantitative approaches in three steps: formulating the storylines, analyzing their quantitative implications, and only then writing the narratives. This creates a set of narratives that is both engaging and scientifically relevant. Also their scenarios are based on an exploratory approach to the future rather than being a back-casting exercise. Their set of 4 scenarios (reference case, worst case, best case, and surprise scenario) stays within the limit of information processing capabilities (Amer, Daim, & Jetter, 2013) as well as covering a wide variety of potential future events. And finally, their inclusion of quantitative data processing allows for (financial) quantification of the effects in the customized scenarios.

Although the scenario set constructed by Ansari and Holz (2019) is the most suitable as a baseline set for customization, this does not render all the other scenario sets useless for this research. The IPCC (2014) scenarios are still the most thorough scenarios in terms of quantified consequences of the impacts of radioactive forcing. The SSP scenarios outline (Riahi, et al., 2017), in a very thorough and detailed way, possible pathways to get there, making them very useful in linking the IPCC climate change consequences to socioeconomic actions to the scenarios narratives created by Ansari and Holz (2019). The IEA (2019) scenarios provide the most detailed outlook on possible future energy mixes and Goldthau et al. (2019) provide the most interesting graphic representation of possible scenarios. Therefore, it will improve the accuracy as well as the storytelling potential of the customized scenarios when including aspects of these scenario sets.

Finally Four Twenty Seven & Acclimatize (2018) recommend that as a basis for their scenario analysis companies should consider at least two main types of existing climate scenarios: the current GHG pathway towards more than 3^{o}C of warming and an aspirational GHG pathway towards less than 2^{o}C. This is in line with the recommendations of the TCFD (2017) and this method is also applied by, for example, Unilever, Nestlé, and Mondi (WBCSD, 2020).

4.2 Technique selection

Using externally- over internally generated scenarios changes the scenario creation process to a scenario customization process. Bishop et al. (2007) outline two techniques specifically aimed at the use of external scenarios: (1) Incasting, and (2) the Stanford Research Institute (SRI) Matrix. Incasting uses a relatively unstructured approach, presenting specific scenarios to small groups of participants and asking them to "describe the impacts on a series of domains, such as law, politics, family life, entertainment, education, work, etc." (p. 12). The SRI Matrix approach is similar but uses a more structured basis.

Presenting a set of (often) 4 scenarios representing different futures such as "the expected future, the worst case, the best case, and a highly different alternative" (p. 12).

For the purposes of this scenario analysis the 'incasting' approach appears to be the best fit. With incasting small groups are presented with descriptions of extreme versions of potential futures for which they then have to describe the estimated impacts (Bishop, Hines, & Collins, 2007). The impacts can be estimated most accurately when these small groups are able to communicate directly, which is best facilitated through a workshop. Essential to keep in mind when customizing scenarios are the requirements for successful scenarios identified by Amer et al. (2013) and Wiebe et al. (2018). That the scenarios remain internally consistent and plausible as well as credible, stimulating, thought provoking, and relevant to the audience.

4.3 Expert interviews

To support the application of theory to practice and linking climate scenarios to strategy, three expert interviews were conducted. The interviewees were Andries Hof (PBL Netherlands Environmental Assessment Agency and Utrecht University), Oscar Kraan (Deloitte), and Gert Jan Kramer (Utrecht University). The interviews were conducted on February 3, 4, and 12 respectively.

Andries Hof specializes in mitigation and adaptation strategies for climate change policy and the use of integrated assessment models in informing climate policy decisions. The interview was mainly structured around the effects of uncertainty in climate models and its impact on the validity of the collected information. According to Hof uncertainty puts two limitations on the application of IAMs for decision making purposes. Firstly, that it is not (yet) possible to make models estimate impacts accurately enough to justify the use of more than two climate pathways, e.g. more than a 2-degree and a 4-degree scenario. And secondly that the estimation of localized impacts is currently only possible using the most detailed models. However, because of the large uncertainty in for example precipitation patterns, even these models are unable to accurately predict the impacts and results can depend more on the climate model that is used for reference than the climate scenario within that model. Hof also emphasized what can be concluded from these IAMs with relative certainty. Which is that for the world to stay below 2-degrees of warming over pre-industrial levels, strong transitional efforts have to be made within the next five to ten years.

Oscar Kraan currently works as Senior Strategy Consultant at Deloitte. Before starting at Deloitte he obtained his PhD from Leiden University focusing on the emergence of the energy transition, working in close collaboration with the Scenario Team and New Energies Strategy Team at Shell. The focus of this interview was on the strategic application and feasibility of the proposed scenario method. He introduced what he called the 'U-model' (figure 11) showing that, to be able to imagine a company say 10 years from now, it is necessary to zoom out to current macro-economic conditions and move forward in time at this level before zooming back in to

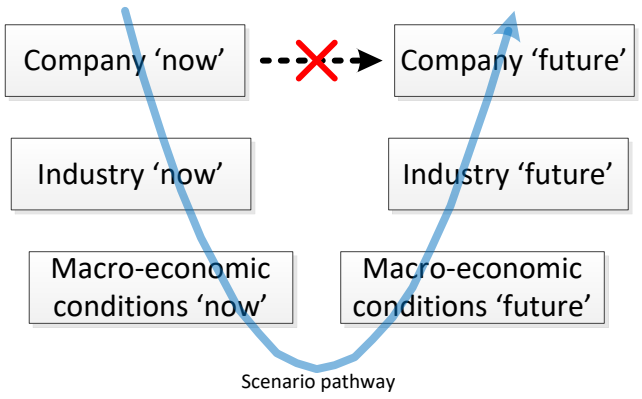


Figure 11: Scenario U-model

the company. According to Kraan it could also prove to be most efficient to focus on the two extremes of the scenario set. Looking at the transition risks on the one hand and physical risks on the other to avoid overlap, confusion and an overly high demand on the time of participants.

Gert Jan Kramer is Professor of Sustainable Energy Supply Systems and head of the Energy & Resources group within the Copernicus Institute of Sustainable Development at Utrecht University. The interview with professor Kramer was the final interview in the development of the scenario method. This interview was set up to review the developed method. Professor Kramer agreed in broad strokes with the developed method highlighting a few pitfalls and providing advice on how to avoid them. Firstly, for the use of Ansari and Holz's (2019) scenario set, he warned against a bias that behavioral change would have a larger impact than a technological breakthrough. He also pointed out to be careful with the use of 'business-as-usual' as a scenario title, because different people can interpret the term differently. And secondly he suggested to not alter a scenario anymore once the workshop was underway. He agreed that it could be valuable to solicit input from participants regarding the scenario narrative and events beforehand, but not during the workshop. Professor Kramer was also the one to introduce the term 'signpost events' into this report, referring to events that indicate specific future pathways to become more likely.

4.4 Scenario and strategy integration

In their framework integrating scenario analysis and strategy setting, Lehr et al. (2017) jump from key drivers to scenarios to robustness in single steps (see figure 10, p. 18). However, without disclosing the approach to their scenario analysis exercise, i.e. without an outlined scenario method, the research is difficult to replicate. Because consistency and replication are important aspects for the (supranational) success of the TCFD-guidelines (WBCSD, 2020; TCFD, 2017), an extended framework for risk identification and strategic resilience using scenario analysis has been developed (figure 12, p. 25). This framework builds on the body of scientific literature, the goals of this specific scenario analysis and the expert interviews and is tailored for use within the TCFD-guidelines.

On the left (in grey) is the strategy setting process which, apart from the minor addition of 'business units' is identical to the framework of Lehr et al. (2017). This process is outside of the scope of this research, but can be included through the 'optional input' line in a scenario setting process as opposed to this research's strategy testing process. On the right (in blue) is the scenario method. Complementary to the three steps identified by Lehr et al. (2017) are step 3 – workshops, step 4 – risk-heat map, step 5 – controls, and step 7 – external disclosure. Also, *robustness* is replaced by *resilience* for consistency with the terminology used by the TCFD and because it better reflects the definition of the IRGC (IRGC, 2018). Additionally there is the inclusion of an optional feedback loop from the workshops back to scenarios. Each step of the scenario process will be briefly elaborated upon below.

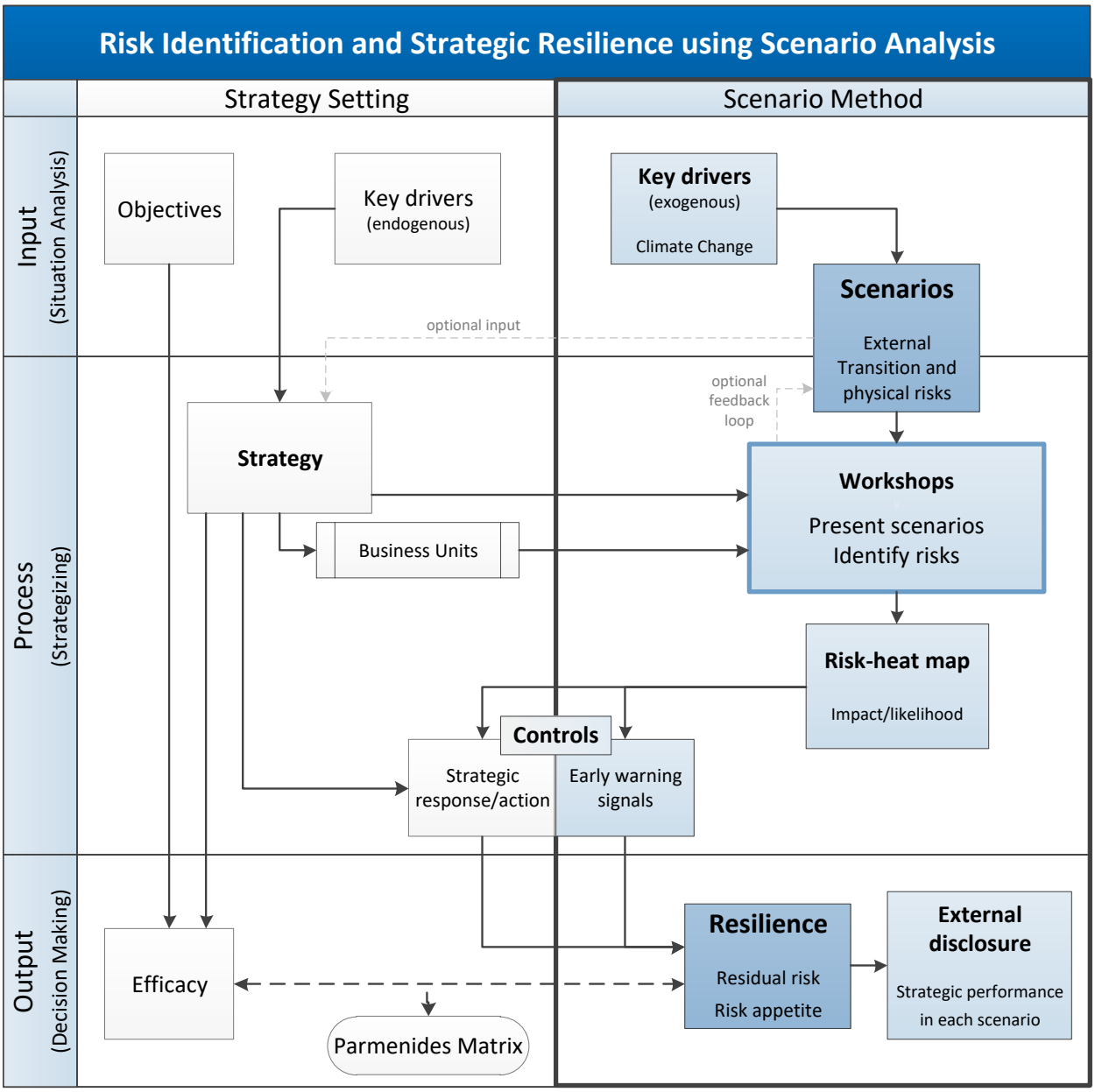


Figure 12: The scenario analysis process (adapted for application within the TCFD-guidelines from Lehr et al. (2017))

Key drivers (exogenous)

Although many exogenous factors influence a business and can be the input variable(s) in a scenario analysis exercise and a source of risks and opportunities, the focus of this research lies on the potential impacts of climate change. This focus stems from the research's aim to provide a method for scenario analysis to be applied within the TCFD disclosure framework, which specifically addresses climate change.

There are currently two approaches to define climate change, that of the IPCC, which adopts a value neutral stance on the potential influence of human activity, and the anthropogenic notion of climate change, which assumes a large influence of human activity on current climate variability. Because the scenarios used in this research assume human influence on climate change progression, the UNFCCC (anthropogenic) definition is used in which climate change is "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere

and which is in addition to natural climate variability observed over comparable time periods" (UNFCCC, 1992, p. 3).

Scenarios

To achieve the goals of the TCFD scenario analysis the most suitable set of climate change scenarios currently available is the one developed by Ansari and Holz (2019). They combine an internally logical structure and quantitative estimates of emission and energy transition pathways with compelling narratives. This combination allows the scenarios to be plotted along an *estimated degrees of warming* scale with, on the lower-warming side, 1.5-2^{o}C of warming and on the higher-warming side more than 4^{o}C of warming at the end of the century, aligning with the IPCC (2014) RCP 2.5 through RCP 8.5 emission scenarios. Where the extremes of this scale are suitable for identifying the expected transition and physical risks, each scenario is likely to see a combination of these risks to pop-up along the way. To be able to anticipate these risks and opportunities the narratives play an important role, because they allow for the integration of geo-political development and preliminary identification of signpost events. A visual representation hereof can be found in figure 13.

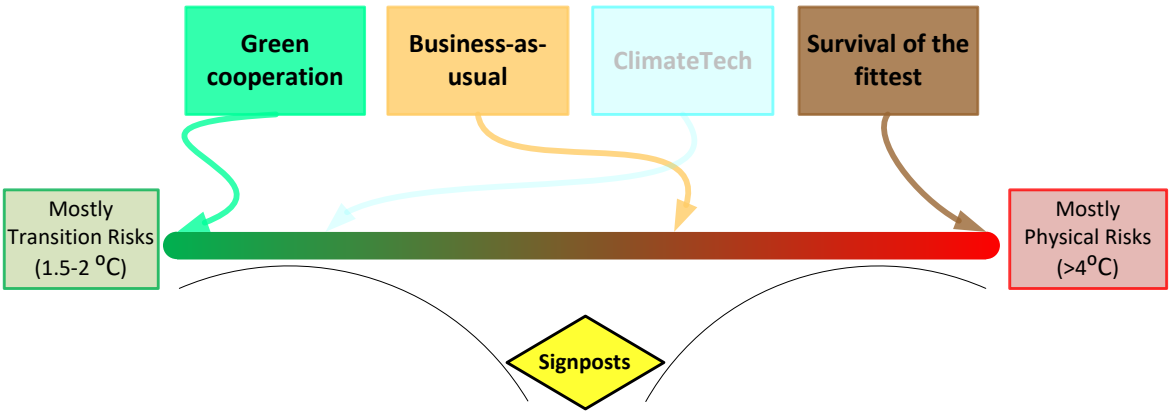


Figure 13: Scenario operationalization

Workshops

For the workshops there are two interdependent aspects. Firstly, there is the scenario presentation, because the scenarios are not developed in-house, there is no real scenario thinking process with which the involved stakeholders become invested in the potential pathways. This automatically puts more weight on the communication of the narratives. The makes the most important aspect to construct the narratives in such a way that they feel relevant to the involved stakeholders, that they feel as if every step of the way they have the option to make an influential decision. Potential options to achieve this are to construct business unit specific storylines and events (optionally with the involvement of someone with a thorough understanding of the value chain) and/or to make the presentation interactive.

Secondly there is the risk identification process. Each scenario will present the company an individual combination of transition and/or physical risks. Every set will consist of risks unique to the scenario and risks that will occur in multiple scenarios but have distinctive timing and magnitude of impact characteristics for every scenario. To retain order in this jungle of overlapping events, all events will be carefully selected before the start of the workshop and each event will be covered in the scenario

in which it has either the largest impact or is most likely to happen. This way the workshops are most likely to generate decision useful information.

Risk-heat map

Risk-heat maps can be constructed in many ways. However, the most effective way to do so within this method will be to align it with the currently applied risk management practice within the company. For Corbion this is the Impact-Likelihood matrix as described in the COSO ERM Framework (COSO, 2017). Additional advantage to using this framework is that it is currently the most widely used approach for enterprise risk management (COSO, 2017), enhancing the potential for widespread adoption of this specific scenario method.

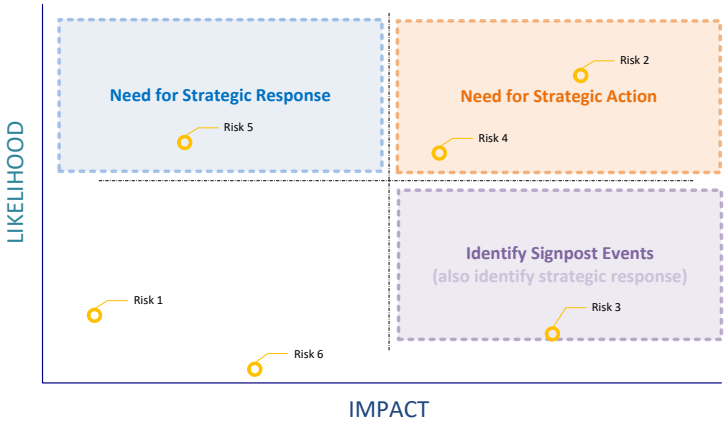


Figure 14: Risk-heat map

In the workshops the impact of specific (risk) events will be estimated. The follow-up survey will have a specific section dedicated to the likelihood of occurrence of these events. Based on the combined results of the workshop and survey, a risk-heat map can be constructed (figure 14).

Controls

Figure 14 already gives a preview of the types of controls and when to apply them. Based on the nature of the identified risk specific actions are recommended to lower the level of residual risk as much as possible (figure 15). For high likelihood/high impact events a strategic action should be devised, reducing the exposure to a level in line with the company's risk appetite on that front. High likelihood/low impact events should have a potential response laid out, to minimize or avoid any damages that might be incurred. Low likelihood/high impact events should be monitored closely. Signpost events that increase the likelihood of such a risk event occurring should be identified and a strategic response should be formulated in case action is needed. Finally low likelihood/low impact events do not require any immediate action. They should, however, not be forgotten, but be monitored to not be caught off guard if they increase in likelihood or potential impact. Formulating exact strategic actions and/or responses is beyond the scope of this research because it is part of the strategy setting process.

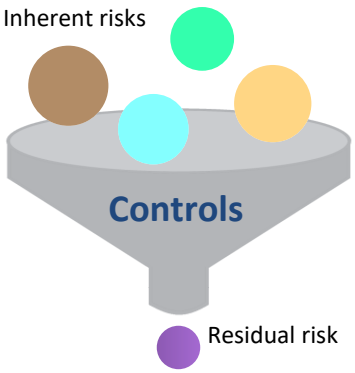


Figure 15: Risk management process

Resilience

Much like scenarios, resilience can also be applied to multiple fields such as military, socio-ecological systems, and organizations. In line with the rest of this thesis also here the focus will be on organizational, or strategic, resilience. The IRGC (2018) devote a special chapter in their report on systemic risks on resilience, synthesizing the work of, amongst others, Bresch et al. (2014) and Kupers (2014) into

formulating the main goal of enterprise resilience as "to improve the *adaptability* of a company" (IRGC, p. 50) and clearly distinguish it from "the goal of building robustness (or 'hardness')" (p. 50).

To achieve enterprise resilience the IRGC (2018) recommends the building of three distinct types of resilience: (1) structural resilience, e.g. the creation of buffering capacity, (2) integrative resilience, understanding and anticipating interactions between different scales and identifying tipping points, and (3) transformative resilience, to "enhance the capability of a company to transform itself if the fundamental conditions of its survival have changed" (p. 50).

Members of the WBCSD Food, Agriculture, and Forests Preparer Forum (2020) interpret climate resilience as "a dynamic state of preparedness for a range of different futures in pursuit of a particular state in which society lives and flourishes within the planet's climatic boundaries" (p. 44) and strategic resilience as "the way in which a company's strategy supports and prepares for the achievement of a resilient state under different climate scenarios" (p. 44).

As support in the quest for resilience the forum members have created a 'circular model of resilience' (figure 16). Although specifically aimed at food, agriculture and forest products it is general enough to also be applied in other industries. The model represents the tree types of resilience identified by the IRGC (2018) while also providing more guidance towards applying the concept.

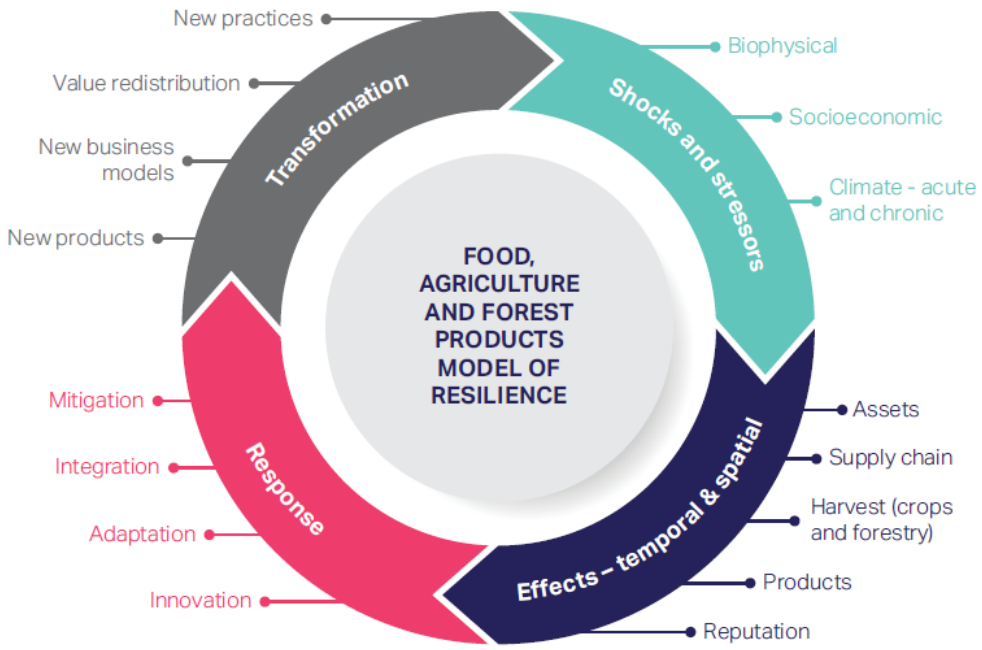


Figure 16: Circular model of resilience for food, agriculture and forest products (WBCSD, 2020)

Because the formulation of strategic responses and actions is beyond the scope of this research the circular model cannot be fully run through. Therefore the identified strategic resilience will not be a completely accurate representation of the potential resilience of the company. This should be taken into account when disclosing scenario performance and strategic resilience in external (and internal) sources.

Scenario performance (external disclosure)

The main driver for the external disclosure output is the need for decision useful information (TCFD, 2017). In turn the most important driver for the generation of decision useful information is consistency between organizations (WBCSD, 2020; TCFD, 2017). Ideally, in this case, all non-financial sector

companies report their performance (resilience) plotted against a set of widely adopted standard scenario events (figure 17). This methodology is constructed in such a way that, although it advices on a set of scenarios to use, it is not committed to this specific set of scenarios. Herewith the disclosures can progress with either newly developed (more up-to-date) scenarios, or simply other scenarios, without having to alter the entire setup. This approach allows for this method to address the strengths of standardization whilst avoiding the downsides hereof (Wiebe, et al., 2018).

External disclosure could then take the form of disclosing the used methodology followed by a short summary of each scenario (event) and the organization's expected performance in every one of them, i.e. does the organization reach its internal objectives (growth/revenue/sustainability goals) and how does it achieve these objectives. Through such consistent disclosure it should be relatively simple for investors and financial service providers to anticipate the effects of each scenario (event) on their portfolio.

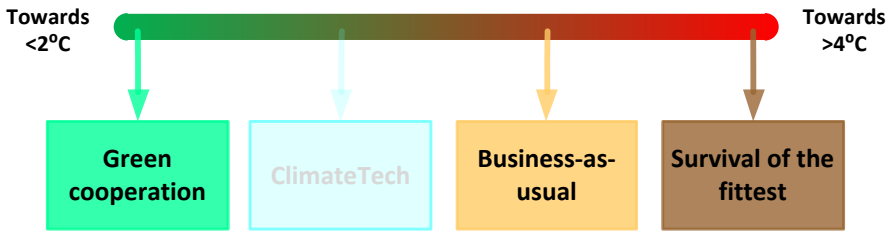


Figure 17: Scenario performance

4.5 Developing a workshop

Arguably the most crucial step in shaping this scenario method is to develop a workshop format that facilitates the fulfillment of all of the discussed goals and conditions. To list them once more, the workshop should primarily facilitate the identification of climate-related risks and opportunities and ideally also allow for the estimation of the magnitude of impact of these events. Conditions for success are that the workshops are engaging, participative and feasible as well as that they generate replicable, decision useful information. Therefore the scenarios should be relevant to the audience and company, plausible, internally consistent, credible, stimulating, and thought provoking (Amer, Daim, & Jetter, 2013; Wiebe, et al., 2018). Because the scenario events are decided upon before the start of the workshop the flow of the workshop itself should be to ask confronting questions, spark discussion, allow for choices to be made and impacts to be analyzed in line with the foresight analysis process as defined by Wiebe et al. (2018). Finally, the workshop should permit the participation of the ideologically opposed without them having to renounce their believes.

4.5.1 CLIMAGINARIES seminar and expert interview

To complement the available literature in this part of the development process a fourth expert interview was solicited. This time with Joost Vervoort, assistant professor at Utrecht University and senior researcher at the Environmental Change Institute at the University of Oxford. Also the 'Storyworlds of Decarbonization in Models and Fiction' seminar, organized by a CLIMAGINARIES and Utrecht University, was attended by the author.

The seminar (March 4, 2020) focused on the similarities and differences between model based futures and fiction based futures. It served as an initial exploration of the potential that these two fields

together could create compelling 'storyworlds of decarbonization'. The main speakers were Prof. dr. Detlef van Vuuren (Utrecht University, modelling), dr. Wytske Versteeg (author, (non-)fiction), and Jasmijn Visser (artist in residence, Meertens Institute). Primary panel-discussion subjects were 'what makes stories persuasive or credible?' and 'how could both modes of storytelling be combined?'.

A key takeaway from the presentations of Detlef van Vuuren and Wytske Versteeg was that models are plausible because they are rooted in science, where fiction is plausible because of how it is told. A conclusion emphasizing the power of well told, science based scenario storylines, because they have roots in both approaches. In more detail, science based scenarios can fill the gaps unbridgeable through fiction alone and vice versa. Fiction, or art in general, has the ability to identify questions, but not answer them. And the plausibility of a story depends on the audience – it emerges in the space between writer and reader. Models, on the other hand, can be strengthened by stories, and the unwritten rules for successful engagement hereof, e.g. for a story to work writers and narrators have to keep their promises, but also surprise. On top of that, fiction is much more personal than the numbers generated by models. It can also clarify these numbers to those who find them hard to follow.

Versteeg, towards the end of her presentation, noted that both model based scenarios as well as fictional scenarios do not (necessarily) generate active engagement. Jasmijn Visser opened her presentation with a similar message: she quoted Otto Neurath with "words are not enough to understand the full enterprise". She also argued that the run-of-the-mill approach to climate change, what she called the "12-years-left trope" doesn't engage. In response to this she created the fleeting-earth.live never-ending countdown clock to show that time pressure itself doesn't equal action. Implicitly providing the second takeaway of the seminar, that active participation isn't easily come by, but crucial to spark action. The seminar was eloquently wrapped up in the panel discussion with the lingering question: How do you tell a story that is both immediate and relevant to persuade from inaction to action, when faced with a situation potentially too complex to comprehend?.

The interview with Joost Vervoort (March 6, 2020) picked up almost where the seminar left off: the generation of plausible scenarios. Plausible scenarios depend, to a large extend, on the perception of plausibility and feeling of ownership by the audience. Plausibility should be generated in collaboration with the audience rather than presented, i.e. the participants should have the opportunity to contribute to the generation of the scenarios. This reflects the notion in fiction-writing that plausibility emerges in the space between writer and reader. As a starting point for methods that have the potential to generate plausibility and ownership Vervoort suggested his research paper *Stepping into futures: Exploring the potential of interactive media for participatory scenarios on social-ecological systems* (Vervoort, Kok, van Lammeren, & Veldkamp, 2010).

The second part of the interview covered the approach to risk identification and risk management. Vervoort stressed that for accurate identification and successful management of risks a transformative approach to risk management should be taken. Meaning that, as time progresses and poses evolving (climate-related) risks to the company, the company should also evolve with time. In a way this is also represented by the final step in the scenario U-model: projecting the company in line with the future macro-economic and industry conditions (figure 11, p. 23).

4.5.2 Workshop format

One of the main limitations of customizing existing scenarios as opposed to the creation of new scenarios is the reduced feeling of ownership and plausibility. For scenarios to be considered relevant and plausible, it is of great value for participants that they see their own worldviews reflected in the final scenario set. To encourage participation and generate a feeling of ownership Vervoort et al. (2010) look into three methods: Landscape visualization, serious gaming, and visual analytics. Of these three methods serious gaming scores highest in both capturing the characteristics of Complex Adaptive Systems (CAS) as well as communicative clarity and engagement (on par with landscape visualization). A game setup also allows the ideologically opposed to participate without having to renounce their believes. Serious gaming, however, sees some limitations in the feasibility, flexibility and participation due to the high level of resources needed to reach the standard of commercial games.

These limitations, however, could be overcome if the focus of gaming is not on digital (computer) games, but rather on tabletop (role-playing) games. Specifically the setup of the fantasy role-playing game (RPG) *Dungeons and Dragons* (DnD). In this game a world is build and storyline created by the so called *dungeon master* who describes a situation after which the players can choose their actions. A role of the dice decides the success rate of those actions based on character characteristics. This creating a game process of *Describe – Decide – Roll*. A *good* dungeon master is able to guide the players in the direction he/she intends without impairing on their sense of ownership e.g. if the dungeon master intends for the players to end up in a specific castle, he can withhold the information on the exact location of this castle, therewith being able to place it in the forest if players go there, but also on a mountaintop if players choose to venture in that direction.

The game has been around for roughly 40 years now and has been continuously improved to best engage players and create the sense of freedom and ownership players look for. An enormous amount of popular literature (articles, videos, etc.) is available into what works and what doesn't. This game setup can be transferred to scenario workshops that aim for the highest level of participation and feeling of ownership whilst using existing scenarios.

The setup of DnD is not directly transferable to scenario workshops, because fantasy worlds are not plausibly possible, they are not scenarios (Spaniol & Rowland, 2019). In the case of (climate) scenarios the world cannot be constructed freely by the facilitator alone but has to adhere to the conditions of worldmaking (Vervoort, Bendor, Kelliher, & Helfgott, 2015; Goodman, 1978). Therefore, although the setup of the game draws many ideas from the game of DnD, the final game is quite far removed from the original. In such a way that the link can no longer be considered obvious if it isn't known.

Because of the constraint that a scenario has to be plausibly possible and a fantasy world does not, there are some key differences in the final setup. The most notable are the freedom of events and the perception of the potential reality. In a fantasy game the entire setting can be made up. In a business specific climate scenario the setting is the global footprint of the subject company. Also, the events are not arbitrary anymore. Rather they now consist of the changes needed and/or likely to go with a transition scenario, or the projected changes accompanying a physical risk scenario. To still achieve the desirable level of participation and sense of ownership for the participants to consider the scenarios as plausible, they have to be able to tailor them to their own worldviews.

The need for collective worldmaking is addressed by introducing the En-ROADS climate action simulation game. Developed by Climate Interactive and the MIT Sloan Sustainability Initiative, this simulation game increases personal engagement with the energy transition as well as a feeling of empowerment and a better sense of the cumulative amount of transition measures needed to keep the world from warming more than 2°C (Rooney-Varga, et al., 2020). A screenshot of the interactive dashboard of the simulator can be found in figure 18. To facilitate the En-ROADS climate action simulation game the author completed the online 7 lecture training course offered by Climate Interactive and participated in (online) events hosted by accredited facilitators.

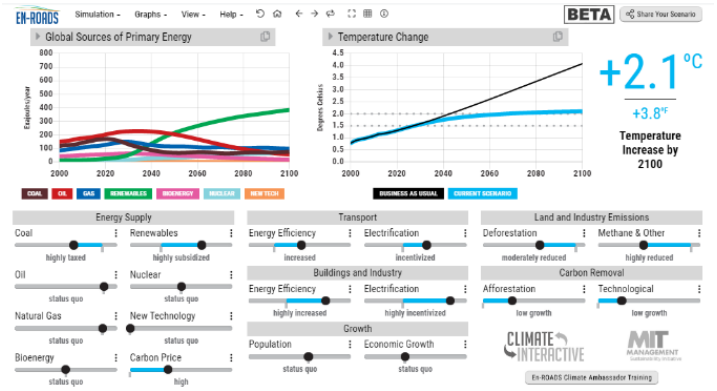


Figure 18: En-ROADS interactive dashboard

Worldmaking is less of an issue when the scenario game covers a physical risk scenario. This is because there is no need for change or collective action to reach this future. It is simply *more of the same*, a future that people are naturally good at imagining. In other words, the introduction of the physical risk scenario can be, and will be an ordinary presentation of the projected events according to the current scientific consensus (e.g. (IPCC, 2014; IPCC, 2018; McKinsey Global Institute, 2020).

5 Case study

The developed workshop format was subject to continuous improvement during this project and is open to further development now that this thesis project is finished. The development process started with the first trial workshop on March 26, 2020. This was followed by an 'En-ROADS only' trial workshop with Corbion's sustainability department on April 7, 2020. After these two trial runs the official workshops were held on April 22 (LAS transition), April 24 (LAS physical risk), May 1st (SFS transition) and May 7, 2020 (SFS physical risk). Because of the Covid-19 situation all workshop took place in a virtual meeting room using Microsoft Teams. The development process that took place is described in this chapter.

5.1 The trial workshop

The first trial workshop had four participants (my three supervisors and Corbion's Sr. Director Risk Management) and lasted 1.5 hours. The workshop consisted of two parts: after the introduction, the first part consisted of playing the En-ROADS climate simulation and the second part was the 'game' in which Corbion had to weather an array of transition scenario events. Initially the focus lay on the scenarios developed by Ansari and Holz (2019), who created a set of four scenarios, and these four scenarios were introduced. However, already from the beginning the idea was to play the game through three scenarios over two workshops. With the first workshop consisting of the En-ROADS simulation and one scenario game and the second workshop of two back-to-back scenario games, omitting the ClimaTech scenario, because it was considered less relevant to Corbion. This changed to one simulation game per workshop in the final sets, but later more on that.

The game in this trial workshop had three-and-a-half rules and a hypothetical financial situation. The three main rules were as follows: (1) You are a team, working together to guide Corbion through the turbulent next three decades, (2) The events presented are external events on which you have no influence, you'll have to deal with them as they are, and (3) The magnitude of impacts is up for discussion, however, the facilitator (me) has the final say (or we might role a die). The last half rule was that 'if any more rules appear to be necessary as the game is played, they can (and will) be made up on the spot by the facilitator (me again)'.

The hypothetical financial situation was loosely based on Corbion's annual results and consisted of $1bln in annual revenues, operating costs of $550mln, overhead of $200mln and other expenditures of $200mln. Leaving $50mln in free cash flows and a current cash balance of $20mln. To discourage debt, but avert any direct financial stress, the debt ceiling was set at $100mln with a steep 15% interest. This setup, however, was discarded halfway through the trial game already, because it was next to impossible to keep realistic track of finances when the discussed events covered only such a small part of the total company finances and ventured so far into the future.

The game itself consisted of eight event slides (e.g. figure 19) derived from a scenario developed in the En-ROADS simulator. The slides had a higher density in the first decade, easing off towards 2050, with the last event in 2045. All slides had transition measures of which the impact was to be determined during the game. Some slides also covered a single physical impact. This was to try out the reaction to these types of events, because there was only a single trial workshop before the start of the first set of official workshops. Also every event slide had the impacts of the scenario on temperature, price of electricity and price of (natural) gas with their relative change to the 2020 baseline price.

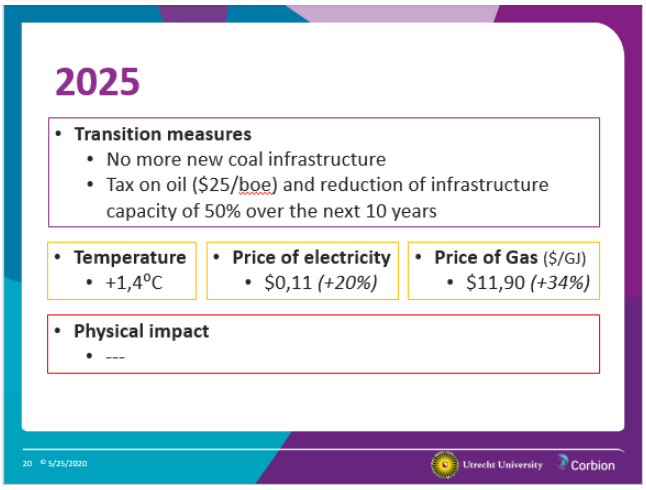


Figure 19: Excerpt from the trial workshop slide deck (3rd event)

Although not explicitly included in the trial workshop slides, the participants were also asked after each event whether or not they wanted to invest in specific regions or products to strengthen their resilience to potential future events. This gave them the opportunity to dynamically change their company in line with the scenario timeline. Because, as the climate changes, so does the company. It does not make much sense to estimate the impact of an event that is most likely to happen 20 to 30 years from now on the current footprint of the company. For the trial workshop there were six handout sheets, two En-ROADS related handouts (see appendices 1 & 2), one risk related handout and three addition pages providing some background information on the company for all non-Corbion participants.

5.1.1 Feedback

Following the trial workshop there was a short discussion on strengths and weaknesses of the workshop and game setup as well as individual interviews with three of the four participants. Although reactions to the general setup of the workshop were very positive, and engaged discussion resulted from the event slides, there were many points for improvement.

Starting with the financial scorekeeping, it took up a lot of time and was considered to be too abstract. Potential solutions were agreed upon to be in the directions of a more comprehensive overview of the financial situation and/or scorekeeping in the direction of major and minor risks and opportunities (e.g. --, -, ±, +, ++).

More towards the general setup of the workshops, the first area for improvement was to make the aim of the workshop more clear. Because the workshop starts with a global simulation model, it is important to communicate to all participants that this is not to solve the world's climate crisis, but to get an idea of the extent of measures needed for a full low-carbon transition. This can be achieved in part through making sure that scenarios and their purpose – they are potential futures, not forecasts or predictions – are made clear in advance.

The second area for improvement was the tailoring of events to Corbion's value chain, including the inclusion of events outside of the energy transition and En-ROADS simulation model. Doing so would reduce the number of variables present in the workshop, such as the energy prices, making it more

comprehensible for participants whilst at the same time putting more focus on the events and their impact. This meant including events that have a direct or indirect impact on specific products, modes of transport or raw materials in Corbion's value chain. A final recommendation was to include some dedicated time for feedback at the end of the workshop.

5.1.2 En-ROADS only (2nd trial)

After the first trial workshop I was requested to facilitate an En-ROADS only workshop for Corbion's sustainability department. This provided the opportunity to also test the En-ROADS workshop format which, opposed to the simulation game, does not assign *lobby-groups* to the participants. Although the workshop was met with many positive responses, Diana Visser, who participated in both trial workshops, noted that she found that the inclusion of role-playing increased the participation and open-mindedness of participants, making this the go to approach for the first set of official workshops.

5.2 Official workshops

Two out of three business units were covered with the climate-related risk and opportunity workshops: Lactic Acid & Specialties (LAS) and Sustainable Food Solutions (SFS), accounting for 27% and 54% of revenue respectively. LAS was chosen for the first set because this business unit is also a key supplier for the SFS department. This way the results from the LAS workshops could be used as inputs in the SFS workshops.

For both business units a set of two workshops lasting 2.5 hours each were scheduled. The LAS workshops were scheduled on April 15 and April 22, but rescheduled to April 22 and April 24 due to personal circumstances. The SFS workshops were scheduled May 1 and May 7, 2020.

Also, in the process of preparing for the official workshops the decision was made to focus on two rather than three (or even four) scenarios for the game. This had two complementary reasons. Firstly, the way in which the game developed during the trial workshop and the time spent discussing the events it felt unnatural and too time consuming to play two separate scenarios back-to-back in a single workshop. Secondly, all scenarios ranging from well below 2-degrees to over 4-degrees of warming by 2100 are within the range of roughly 0.5-degrees difference in 2050 and even less before. With the focus of these workshops on the three decades between 2020 and 2050 with an emphasis on the first two decades this was judged to not leave out any essential information, the planning thus became one transition risk scenario game (<2^{o}C by 2100) and one physical risk scenario game (±4^{o}C by 2100). This approach is also in line with the recommendations of the TCFD (2017) and Four Twenty Seven (2018).

5.2.1 Introduction to the official workshops

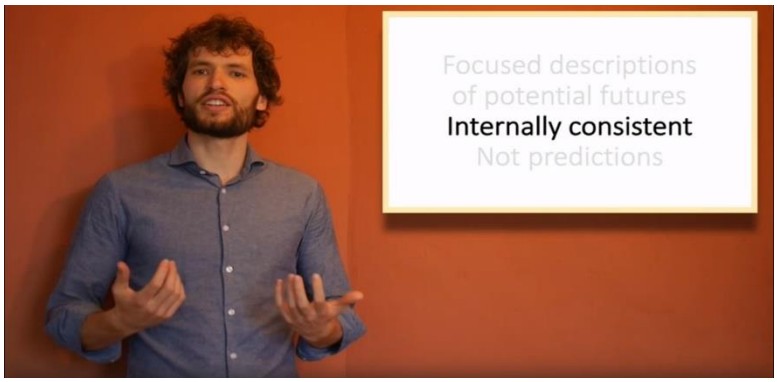


Figure 20: Still from episode 3 - Introducing concepts

Acting on the trial workshop feedback and the Covid-19 work-from-home orders, I created three short introductory videoclips to introduce myself, the workshops, and key concepts (figure 20). The three clips of roughly 4:30 minutes allowed me to present myself to the audience in a more engaging way than through a simple Skype call/Teams meeting. It also allowed me to shave some time off of the in-workshop introduction leaving more time for the En-ROADS simulation and scenario game. The responses to these videos were nothing but positive, ranging from "Great introduction. Good to see a video instead of a skype call" to "Very helpful […] I think it saves lots of question during the workshop itself".

5.2.2 Participants

To generate a representative image of the future company and to estimate the impact of the climate related events as accurately as possible, employees from five departments were initially invited to participate in the workshops. These departments were Strategy, Operations, Procurement, R&D and Finance. On top of this my supervisors (Sustainability department & external/university) were invited as well as the Chief Science & Sustainability Officer (CSSO).

For the LAS workshops the initial finance representative was unable to attend and was replaced only in the second workshop. The CSSO was only able to attend the first workshop. For the SFS workshops a representative from the Sales department was also invited, again the CSSO was only able to attend the first workshop and the R&D representative was only able to attend part of the second workshop. The strategy department was represented by the President of Sustainable Food Solutions who is also a member of the executive committee.

Aside from the diversity of departments represented, the global footprint of the company was also done justice, with participants from offices and factories in the Netherlands, Spain, Thailand and the United States. The only geographic region in which Corbion houses production facilities that was not represented was Brazil.

5.3 Lactic Acid & Specialties

The outlines of this first official workshop was very similar to the trial workshop with two parts: the En-ROADS climate simulation followed by the transition risk scenario game. Most of the topics that would normally have been covered in the in-workshop introduction were already covered by the introductory videos. Before the start of the workshop all participants received three handouts, two related to the En-ROADS climate simulation (see appendices 1 &2) and one related to the scenario game (see appendix 3 for the final revised scorecard as used in the SFS workshop). The scenario game kept the same set of three-and-a-half rules as the trial workshop, since they appeared to cover the extent of the game and

provide clear guidance. Only one minor adjustment was made which was to leave out the option to role a dice to decide on the outcome of an event.

This left the first major change to be in the (financial) scorekeeping, where there was ample room for improvement over the trial. This was addressed by formulating a set of three goals based upon Corbion's strategy (Corbion, 2020) and introducing a scorecard indicating the absolute and relative performance towards these goals.

The second major change related to the timeline of decisions. Where in the trial workshop investment decision had to be made after each event slide, this caused some confusion and therewith disrupted the clarity of decisions. This was addressed by creating a timeline in which every six years (2026, 2032 and 2038) there was specific room for discussion towards which investments should and could be made to be better prepared for the scenario's future.

Thirdly the first official game had a dedicated scenario setting. Based on the CLIMAGINARIES seminar (2020) as well as the Dungeons and Dragons game setup, this was included to increase the level of engagement and feeling of ownership towards the specific scenario. Not only of the transition measures and events – covered already by the En-ROADS simulation – but also the broader setting including the company's current strategy, as well as external inputs such as the (at the time of the workshops very relevant) Covid-19 situation.

5.3.1 LAS transition events

Events featuring in the first official workshop were based on three principles for achieving net-zero emissions: Scaling up technology, policy changes, and generating demand (World Economic Forum, 2020). The specific events were derived from various sources including, but not limited to, the En-ROADS simulator (to keep the connection with the developed scenario and the game), the EU Green Deal plans (European Commission, 2019b), the Green New Deal (Ocasio-Cortez, et al., 2019) and various grey literature sources. The technical events, such as a carbon price, built more on the models (e.g. En-ROADS, IPCC RCPs) where the societal actions built more on concepts such as good citizenship (e.g. less consumption of meat) and the circular economy. All events were calibrated to fit the company and relevance to the scenario with my internship supervisor, because of her intricate knowledge of the company, and my university supervisor to avoid tunnel vision.

Figure 21: Excerpt from the LAS transition workshop

Six transition events were selected to be covered during the workshop: (1) A global carbon price in 2021 ($150/ton CO2-eq, outcome of the En-ROADS simulation), (2) more ambitious Science Based Target in 2023 (from 2 to 1.5 degrees, figure 21), (3) circular economy related customer demands in 2028 (e.g. recyclability of PLA), (4) a global afforestation initiative devised at the COP 31 in 2030, (5) movements against GMOs and Food for Feedstock in 2033, and (6) a scientific breakthrough in 2036.

As mentioned before the transition events were interrupted in 2026 and 2032 by two investment rounds in which the participants could put money towards making the company more resilient. An example of an investment made was the investment of money in R&D towards a breakthrough product. Without hints from the facilitator this was the exact investment needed to make the sixth transition event an opportunity rather than a risk. The third investment round was a backup and wasn't needed. There was also a physical risk event as backup in 2045, but this also wasn't needed because the selected events generated the expected discussion to fill the workshop.

The event (and investment) slides were designed to capture the attention of the participants. Each slide showed the year the scenario had come to as well as information and graphics related to that specific event. Accompanying each slide was a short narrative storyline providing background information, connecting the events to each other and explaining their relation to the scenario. Every time the situation had been sketched the participants were asked: What do you do? To signal the start of the discussion.

5.3.2 LAS physical risk introduction

At the start of the second workshop physical climate risks were introduced in three steps: (1) graphically, (2) a selection of global impacts, and (3) a selection of socio-economic impacts. For the graphical representation data and figures from the IPCC (2014) were used. More specifically the 'Reasons for Concern' (RFCs) (figure 22) and figure SPM.7 (IPCC, 2014, p. 12). Global impacts for several different levels of warming were adapted from the work of Climate Interactive (Climate Interactive, 2020). And finally, socio-economic impacts were derived from the McKinsey Global Institute (2020) report.

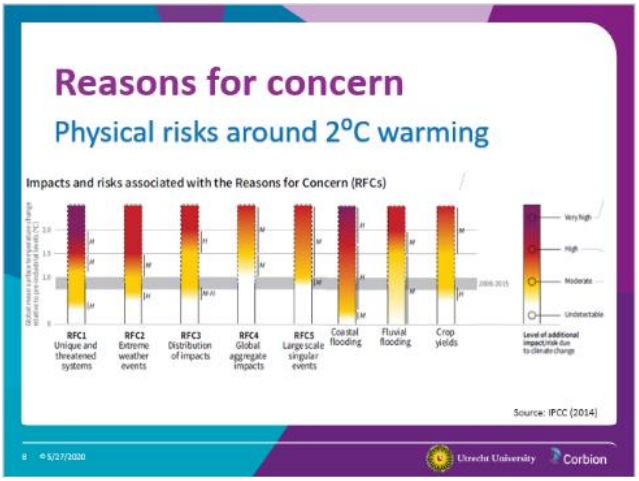


Figure 22: Reasons for concern, adapted from IPCC (2014)

Subsequently the concept of uncertainty related to scenarios and specifically physical risk scenarios was covered. This included discussing uncertainty within a study regarding scenarios, probability, and modelling uncertainty, as well as interstudy uncertainty. The introduction lasted approximately 15 minutes and was clear, i.e. there were no questions left at the end of the introduction. Because of the shorter introduction as opposed to the En-ROADS simulation in the transition workshop and other commitments from some of the participants this workshop was rescheduled to last 2 rather than 2.5 hours.

5.3.3 LAS physical risk events

The introduction to the game was very similar to the transition scenario game. Rules, goals, scorecard and timeline did not change. One alteration was made in the setting, the Covid-19 crisis slide was omitted, because this was judged not to have a direct effect on the physical risks of climate change and was replaced by an overview of the global footprint of Corbion LAS and the most important raw materials susceptible to physical climate risks (figure 23, p. 39). Although this overview was likely not a necessity

given the inherent knowledge of the business unit by the participants it still added value through the creation of a clear playing field with predetermined objects, i.e. the key commodities and production locations. Also, if there are external participants or specialized employees with less inherent knowledge of the company/business unit a graphical representation such as the one in figure 23 can contribute to a more inclusive and participative experience.

Figure 23: Global footprint and selection of key raw materials of Corbion LAS (Tableau interactive dashboard),

Where the transition events were most dense in the first decade ('20 – '30), physical risk events are expected to mainly take place in the 2030s and beyond. This projected timeline, however, does not mean that the first decade is without any events. Therefore, to incorporate the most significant (physical risk) events, without alienating the participants by extended time gaps in which they cannot develop the company in line with the scenario, some narrative events were included. These event-slides developed the storyline without requiring action on behalf of the participants.

Preceded by two narrative events – 'The COP21 gets cancelled in 2020' and 'Ever more countries are leaving the Paris agreement by 2023' – six physical risk events were selected as the main scenario events. The first event was not a physical risk in itself, but an important part of the scenario storyline combined with the 'Advance 2025' strategy outlay: Do you keep investing in sustainability when sentiment is down? in 2025. After the first investment round in 2026 the other events were: (2) storm hits Thailand facilities in 2027, (3) drought in the US Midwest followed by (4) extreme precipitation and flooding of, amongst others, the Missouri river in 2030, (5) sustainability is not a selling point for PLA anymore, how does it now compete against petroleum based plastics by 2033, and (6) severe water shortage in the Paraiba do Sul River Basin in 2035 (figure 24). There was again an investment round in 2032.

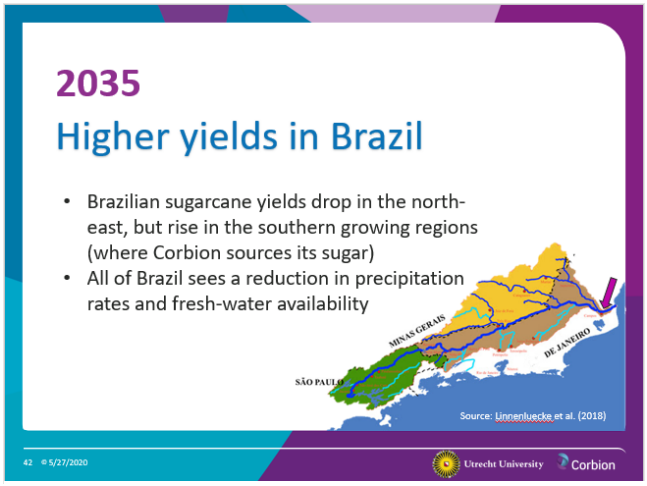


Figure 24: Higher sugar cane yields, but also water shortages expected for South-Eastern Brazil

After 2035 there were four more game slides: three narrative/backup slides in 2038, 2042, and 2045 and a backup investment slide in 2038. The narrative slides covered an overall sugarcane yield decline in Thailand by 2038 (event 7), increase of extreme weather events in Europe impacting wheat harvests by 2042 (event 8), and increased price volatility of corn by 2045 because of unreliable yields (event 9). Events 3, 6, 7, 8, & 9 were directly based on Tigchelaar, Battisti, Naylor and Ray (2018), Linnenluecke, Nucifora and Thompson (2018), Pipitpukdee, Attavanich and Bejranonda (2020), Trnka et al. (2014), and Tigchelaar et al. (2018) respectively. All other events were based on a combination of the IPCC (2014; 2018) reports, McKinsey Global Institute (2020), Corbion internal documents, scenario

storylines (e.g. (Ansari & Holz, 2019)) and other sources. Again all events were selected in collaboration with my internship supervisor and checked for consistency by my thesis supervisor.

5.3.4 Reflection

At the end of the physical risk workshop there were a dedicated 20 minutes of reflection on the outcome, implications and functionality of the two workshops. Looking back at the results of both workshops the first impression was that from the results it appeared that the transition scenario was likely to be more favorable to Corbion (LAS) than the physical risk scenario. However, it was also quickly noted that, looking back at the results, there might have been a slightly optimistic bias looking towards this future.

The favorability of one scenario over the other also sparked the discussion whether or not Corbion could and/or should try to do anything to increase the likelihood of that specific scenario. For example through engaging suppliers and customers as well as providing solutions for other companies to become more sustainable.

More technically the two workshops, and the game specifically, were credited with "increasing awareness whether you believe in [climate change] or not". The format was considered very interactive, making the two (and-a-half) hours go by very quickly. The participants found the provided information and discussion valuable and worth their time.

For the physical risk workshop the specificity of the events was credited as contributing to a relevant discussion, but at the same time it was pointed out that this specificity meant that the focus lay on direct impacts and passed over indirect impacts. For now this seems to be a tradeoff, especially in the limited timeframe of 2-2.5 hours. Another critique was that one participant missed a true negotiation phase in the En-ROADS simulation, suggesting to either make it more general (e.g. the workshop format) or dedicate more time towards this part of the workshop. The scorecard was not naturally covered in the reflection, but when brought up specifically by the facilitator it was considered to be adequate, definitely better than having to put monetary values on the events, and no concrete suggestions for improvement were suggested.

5.4 Sustainable Food Solutions

Based on the reflection of the LAS workshops there was definitely room for minor improvements, but the format in general met with very positive responses. The most specific critique, regarding the En-Roads simulation, was addressed not by removing the assigned roles, but rather through a clearer introduction that the participants would be providing input from a specific standpoint and not negotiating based on standpoints from that industry group. This decision was made because reviewing the (recorded) workshop sessions revealed engagement through the identification with the assigned industry or representative group.

Reviewing the workshop sessions also brought the limitations of the scorecard in its current form to attention. Firstly it was often skimmed over at the end of an event. Once the discussion started to come towards an end – or was steered towards an end if it didn't do so naturally – there was often little patience to circle back to the scorecard and put down specific details about the impact. Secondly, if a specific impact was identified it often consisted of the addition of a *minor risk* and a *minor opportunity* summing it up to become *insignificant*. This second limitation was addressed by separating

the category 'insignificant/minor risk' to 'minor risk' and 'no effect' together with allowing an event to be both a risk and an opportunity (for the revised scorecard see appendix 3). The first limitation was addressed by inserting a simplified version of the scorecard at the end of each event (figure 25).

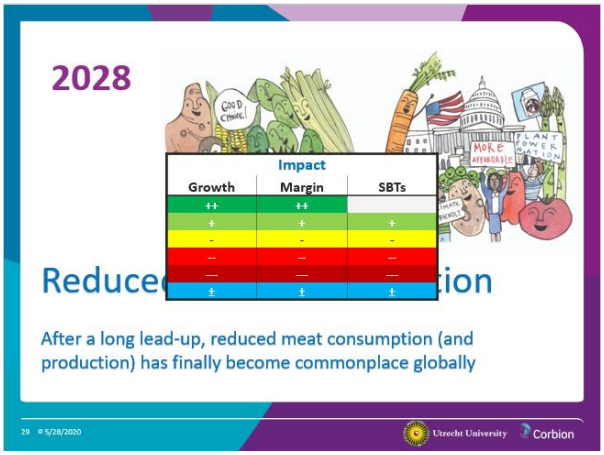


Figure 25: Insert of the simplified scorecard

Aside from these changes the setup of the second set of workshops was almost identical to the first. One more takeaway from the first set of workshops was still integrated in the second. In both LAS workshops participants started to struggle imagining (the footprint of) the company post 2030, making any event happening after this point in time seem more hypothetical and less realistic, while still projected on the company's footprint of roughly around 2030. Therefore the most significant events in the SFS workshops were brought forward as far as realistically possible.

5.4.1 SFS transition events

Equal to the LAS transition workshop the SFS transition risk scenario game consisted of six events with two investment rounds (2026 and 2032), one backup investment round (2038) and one backup physical risk (2045). On top of this the 2030 event 'a global afforestation initiative devised at the COP 31' was transformed into a narrative event without discussion and an extra backup transition event was planned for 2036 (although this did not get used). The six selected events were (1) a global carbon price in 2021 ($100/ton CO2-eq, outcome of the En-ROADS simulation), (2) more ambitious Science Based Target in 2023 (from 2 to 1.5 degrees), (3) significantly reduced global meat consumption by 2028, (4) demand for action against GMOs and uncertefied products in 2029, (5) agriculture-afforestation conflicts involving soy, palm and sugar cane production in 2031, and (6) a movement towards more locally produced products with less preservatives in 2033. The 2036 backup event was related to the circular economy principle.

5.4.2 SFS physical risk introduction

Except for a minor clarification in the timeline of the global impact slides the physical risk introduction was identical to that of the LAS physical risk workshop. Based on the feedback of the first physical risk workshop there was no need to make changes to this part.

5.4.3 SFS physical risk events

The physical risk scenario game saw a few alterations advancing from the LAS to the SFS workshops. Firstly there was now a specific introduction slide separating the narrative/storyline events from the impact/discussion events. Secondly, the setting was tailored towards the SFS business unit. Because the SFS procurement data wasn't compatible to make an accurate global sourcing (Tableau) dashboard, this was replaced with a general global supply chain setting. Thirdly, because it was requested at the end of the SFS transition workshop, a non-extreme (i.e. a middle-of-the-road) scenario event was added to the

Figure 26: alternative impact assessment method

physical risk workshop, namely: what if part of the world would make serious work of the energy transition whilst the rest of the world didn't? Although this would effectively have some effect on the amount of global warming, this was considered to be negligible both in terms of absolute impact as well as for the scenario exercise. And finally, one of the events saw a different scoring method, where the participants were asked to identify the key supply chain risks for a factory and the extend (of time) to which Corbion was capable of dealing with these disruptions before they would start inflicting significant damages (figure 26).

Again there were six events were selected to be discussed in the scenario game. They were complemented by four narrative events in 2020, 2021, 2027 & 2028, and the now customary two investment rounds in 2026 and 2032. And topped of by a structured look into the future (past 2038) with two physical risk events and the 2038 investment round. The selected events for this scenario game were (1) Europe implements its ambitious green deal *with* border taxes in 2022, (2) do you keep investing in sustainability when sentiment is down? in 2024, (3) drought in the US Midwest (narrative event) followed by extreme precipitation and flooding of, amongst others, the Missouri river in 2028, (4) supply chain disruptions at the Totowa plant in 2030 (figure 26), (5) consecutive extreme weather events disrupting production in Dolton and Grandview in 2033, and (6) in 2037 a global period of extreme drought.

The 2020 and 2021 narrative events were the same is in the LAS workshop, however now the second event 'more countries leaving the Paris agreement' was pulled forward to allow for the new impact event. Climate change showed no direct physical risks to the Totowa facility and was therefore covered in a narrative event (2027). The 2028 narrative event was a drought in the US Midwest, because this was a valuable introduction to the subsequent flooding, but was considered to yield no real threat to Corbion (both LAS and SFS) by the participants in the LAS workshop. For future (post scenario game) events the expected yield reduction of sugar cane (Pipitpukdee, Attavanich, & Bejranonda, 2020) and wheat were covered (Trnka, et al., 2019). Similar to the LAS physical risk workshop some events (1, 5, and 6) were derived directly from source papers (European Commission, 2019b; Strader, Ashley, Pingel, & Krmenec, 2017; Mitchell, et al., 2012; Trnka, et al., 2019) while others were based loosely on multiple sources.

5.4.4 **Reflection**

In the final reflection firstly some general strategic insights based on the workshops were discussed. For example that 'if you're more adaptable than the competition you can create opportunities' and that 'the workshop is really useful in shifting focus from day-to-day meetings and conference calls to zoom out and look at the long-term'. It also linked the corona crisis to the climate crisis through the need for

leadership in a crisis situation. That a company needs 'talented leadership' that is 'prepared to take risks (be pro-active) to avoid other risks (reactive, stagnant)'.

Towards the end of the reflection the focus shifted to the continuity of sustainability and climate change mitigation. What is needed to keep it on the agenda and let it not just be two workshops in which managers participate. How to involve more people within the company and how to create engagement. To make sustainability from a workshop topic to coffee table conversations it needs to become present throughout the company. This has, for example, been achieved at Corbion with EHS (health & safety). Another suggestion to engage a larger part of the company as well as to ensure continuity of addressing climate change and sustainability is to organize the workshop for the next generation of (potential) leaders as well. This extends the reach and engages with the *leaders of the future* about the climate crisis. Lastly tapping into the (rising) demand for sustainable products and -solutions was suggested. Corbion is already seen as a sustainable company and has, both internally and externally, a relatively clear sustainability culture, but this can be more actively promoted.

5.5 Risks and opportunities

During the workshops, Diana Visser took up the role as second facilitator, introducing the workshop but also taking minutes of the discussed results. The virtual environment of the workshops (Microsoft Teams) however, made it harder to keep these minutes accurate, because there was little opportunity to quickly confirm an answer or ask for clarification without disrupting the entire workshop flow. The positive side of this virtual environment, on the other hand, was that all workshops were recorded in full. Making it possible to retroactively fill out the scoresheet. This came with a second advantage after the scorecard was updated between the LAS and SFS workshops. The LAS results could now be noted down in the same (final) format of the scorecard as the SFS results, making them more concise and comparable.

The setup of the results-scorecard was simple, showing the year of the event, followed by a short description and whether it was a risk, opportunity and/or without effect. It subsequently allowed for the notation of the impact on growth, margin and SBTi commitments and finally a description of why the event was considered a risk, opportunity or to have no impact. An impression of what the result-scorecard looks like can be found in figure 27. All tabulated results were sent back to the participants for conformation (especially important for the LAS results because they were tabulated using a different scorecard than in the original workshop).

Figure 27: Impression of the scorecard used to keep tab of the workshop results

5.6 Survey

After the workshops and in-workshop reflections there were a few aspects that remained unaddressed and/or needed final confirmation. Firstly there were the tabulated workshop results – especially those of the LAS now using the adjusted scorecard – that needed confirmation. Secondly the likelihood of the covered events had been discussed for some but left unaddressed for others and needed to be formalized. Thirdly, to be able to say something about the effectivity of the workshops, some more information on the generation of decision useful information as well as the perceived (future) impact of the workshop results was desired.

To collect this information all participants of the workshop received a survey two weeks after their respective final workshops. The survey consisted of three parts reflecting the three areas with a remaining information demand. The first part asked respondents to confirm or adjust the tabulated workshop results. The second part to estimate the likelihood of events. And the third and final part consisted of 22 Likert-scale statements divided over four categories, one open question and a final question rating the overall workshop experience from poor (1 star) to excellent (5 stars).

The first two parts, combined with the tabulated workshop results, allow for the construction of a risk-heat map containing the covered climate-related risks and opportunities. The third part covered the two main parts of the workshop – the En-ROADS simulation and the scenario game – followed by a reflection on the value of the results and the impacts of the workshop (results). All statements and corresponding responses can be found in appendix 4.

Although the survey's sample size was small in absolute numbers it was sent out to all participants making it representative of the population. 80% of all participants responded, evenly distributed over both workshop sets. One response (to part three) was omitted from the results because it showed positivity bias, confirming both the positive and negative statements, showing as much interest in organizing a follow-up as in participating in one. This specific respondent also only responded after several reminders and took much less time than average to complete the survey.

Confirmation of results (part 1) and likelihood of events (part 2)

None of the participants disagreed with the content of the tabulated results, confirming also the interpretation of the LAS workshops towards the adjusted scorecard. In the estimation of the likelihood of specific events there was less agreement between participants, both within the business units as well as between the business units. To adequately represent the differences between the two business units, even though they share some events, two separate risk-heat maps have been constructed. They can be found in figure 28.

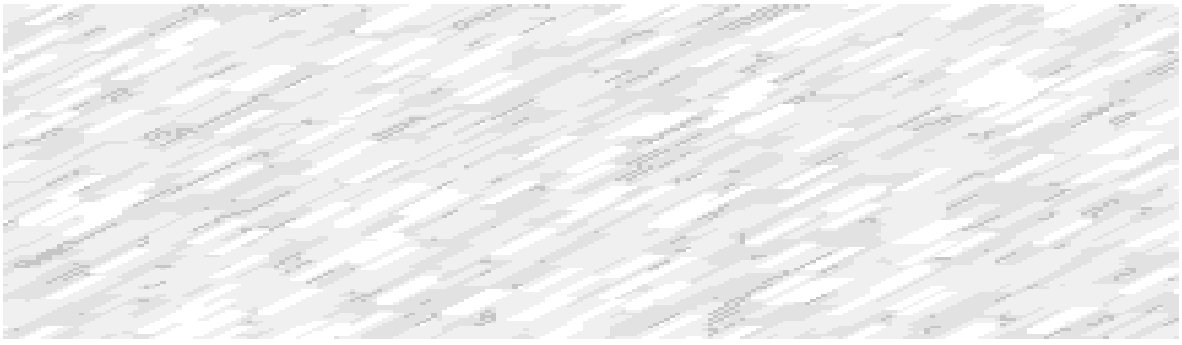


Figure 28: Risk-heat maps of SFS and LAS

Reflection (part 3)

Responses for En-ROADS' contribution to the scenario game were almost unanimously positive with no negative responses. The added value of the simulation game was neutral to slightly positive with a single negative response in both workshops. The game setup was a success with less than 10% of responses being neutral and all other responses positive. The results were considered to be relevant to Corbion (all positive responses), but not fully unexpected (neutral response). For LAS all participants found that the workshops succeeded in identifying both risks and opportunities (all positive responses), whilst for SFS the reactions were predominantly positive but not unanimous (several neutral and one negative response). In terms of impact the workshops were considered to increase awareness of climate-related risks and opportunities both in general and in financial terms. Some respondents found that it would help them with day-to-day decision making while all respondents considered the results useful for application in specific situations. And finally a large majority had discussed the results afterwards with one or more co-workers, some had already planned follow-up meeting while others considered them, and all participants would participate again in a follow-up related to the workshops. An overview of the responses to this third part of the survey can be found in appendix 4.

Commentary on the workshop was unanimously positive and ranged from "will have more impact than we anticipated" to "worked surprisingly good from behind the screen versus a face-to-face meeting" and "an excellent platform to discuss long term risks related to the climate". However, with only half of the respondents leaving a comment it cannot be ruled out that this might be influenced by selection bias. Where the LAS group mentioned a preference to the second (physical risk) workshop in the in-workshop reflection, two participants in the SFS workshops mentioned a preference to the first (transition) workshop in the survey responses. The average rating for the entire workshop experience was 4.73 out of 5 (stars).

5.7 Signpost events

Although not explicitly covered during the scenario workshops, the scenario narratives themselves already included a handful of signpost events. Examples hereof are the outcome (or cancellation) of the COP21, countries leaving the Paris Agreement, or specific citizen protests. Other short-term events that can potentially signal a move towards a specific scenario are for example the United States 2020 presidential elections and the success of the EU Green Deal.

Although such foresight exercises always contain a degree of speculation, there are also several approaches to reduce the degree of speculation by using designated methods to identify these potential events. Examples hereof are the OECD Horizon Scan of Megatrends and Technology Trends (OECD, 2016) or use of the Dynamic Adaptive Policy Pathways (Haasnoot, van 't Klooster, & van Alphen, 2018). Such an approach to the identification of signpost events, however, is beyond the scope of this research, but could be included in a follow-up.

5.8 Reflection on the method development process

During the development of the scenario method several opposing demands had to be managed. On the applicational level the need for engagement and a feeling of ownership had to be balanced with the

available time and resources. At the same time, on the corporate level, the method needed to be specific enough to generate decision useful information and be repeatable within a company, but also be general enough to be replicable in other companies to create a potential for widespread adoption.

The first major decision in the development process was to take a workshop-based approach over an interview based approach. Secondly, the use of externally developed scenarios and supporting use of the En-ROADS simulator as an introduction to the transition scenario. Thirdly there was the introduction of a serious game based on the tabletop role-playing game *Dungeons and Dragons*. And finally the selection of two rather than three or more scenarios.

Choosing a workshop approach over an interview approach has had a major impact on the final method. Based on theory however, this was the clear choice to be able to address the issues in the most efficient way. Potentially interviews could have complimented the method (e.g. in event selection), but due to time and resource constraints this would most likely not have paid off because another aspect would have received less attention.

Using existing scenario sets over internally generated scenarios significantly reduces the feeling of ownership participants have over the scenarios and therewith the engagement and degree of participation. To counteract this the transition scenario was introduced using the En-ROADS climate simulator. Using the climate action simulation game the participants were able to co-create a transition scenario and experience the impacts of specific actions in real time. This achieved the objective of ownership generation and at the same time informed participants of the multitude of actions needed to keep the climate from warming more than 1.5^{o}C or 2^{o}C by 2100.

Once the decision to use external scenarios was made, the ambition to gamify (part of) the workshop emerged with the identification of the conditions for engagement and reaching the ideologically opposed as well as to create a dynamic approach to risk management. Approaching this gamification as a tabletop game rather than a computer game or simulation allowed for it to be successful despite the time and resource constraints. This proved to be a valuable decision because it significantly contributed to the achievement of both objectives. Having one participant repeatedly arguing against the flow of the scenario, but saying he'll "play along because it is a game" confirmed the first objective, while active investment developing the company during the investment rounds confirmed the second. This is clearly not evidence saying that this is the *best* or *only* approach, but it does suggest that it can be considered a *successful* approach.

And finally, to be able to accurately address the time-frame of climate scenarios within the time constraints of the workshops, two scenarios were chosen to be played through rather than three or four. This decision allowed for a more in-depth discussion of the selected scenarios within the available time while still covering the potential extremes of both transition- and physical risks. It, however, also excluded the possibility to cover the impact of some specific (combinations of) scenario events. This showed primarily in the inability to discuss middle-of-the-road events which, despite their name, can have rather extreme impacts. [redacted]

6 Conclusion

The use of scenario analysis is recommended by the TCFD to include a long-term time horizon in the identification- and anticipation of climate-related risks and opportunities. This long-term strategy oriented approach is what sets the TCFD-recommendations apart from current disclosure practices. However, because this tool is so different from current practices, the adoption rate of this specific recommendation is still relatively low at 8% (TCFD, 2019). Consequently the TCFD is not able to successfully address the long-term time horizon associated with climate related risks and opportunities. Therefore it is currently still unsuited to significantly increase global financial stability in the anticipation of climate change. To discover whether the TCFD-guidelines would be able to contribute more to this if the adoption rate of scenario analysis was higher, the aim of this research was to find the extent to which scenario analysis could increase the ability of the TCFD-guidelines to govern for global financial stability in the anticipation of climate change. This aim was addressed in the main research question:

> *To what extend can the application of scenario analysis increase the TCFD-Guidelines' contribution to the governance for global financial stability in the anticipation of climate change?*

For scenario analysis to contribute to the governance for global financial stability in the anticipation of climate change it has to meet specific requirements on two fronts. Firstly, the results of the scenario analysis should be in line with the goals of governing for financial stability. And secondly, the method should induce some form of transformative collective action (Lange, Driessen, Sauer, Bornemand, & Burger, 2013).

For scenario analysis to be in line with the governance for financial stability in the anticipation of climate change it should lead to more accurate pricing of climate related risks and opportunities. For the method to be able to induce some form of transformative collective action it should bring about transformative change in the approach of companies to climate-related risk management. To be able to find the full extent to which scenario analysis can meet these requirements, first, the best suited method for scenario analysis had to be found. This was addressed by the first sub-question: *What type of scenario analysis is both feasible for companies and satisfies the information demand of corporate executives and financial service providers?*

However, one reason that the adoption rate of scenario analysis within the TCFD is so low is that there is no standardized, easy-to-implement approach to performing scenario analysis in line with the TCFD-guidelines. This severely reduces the capacity of the TCFD-guidelines to accurately price climate-related risks into the market. A novel approach therefore had to be developed as well as tested for its ability to generate decision useful information whilst still being feasible to implement. This was addressed by the second sub-question: *How effective is scenario analysis, as part of the TCFD-Guidelines, in supplying the information necessary to identify and quantify relevant climate-related risks and opportunities?*

Addressing the first sub-question this research shows that the best suited scenario method is one that is engaging, generates a feeling of ownership of the scenarios and can be applied within the company's time and resource limitations. Subsequently the scenario method, when applied, should yield decision useful information, i.e. identify climate-related risks and opportunities. Also, it should be

replicable and repeatable to give it potential for widespread adoption and continuous use, extending the value from single businesses to investors and other financial service providers. Only if the scenario method satisfies all of these conditions can it be successful on the supranational level and contribute to the ability of the TCFD-guidelines to govern for global financial stability.

Addressing the second sub-question, for the method to be effective, it has to include the three dimensions of issue (planet, people, prosperity), time (now and then), and place (here and there). The developed method successfully addresses the direct impacts of climate change on all of these dimensions. It also succeeds in estimating the potential impact on revenue, margin, and reputation. An additional requirement for the method to generate decision useful information is that it had to be able to facilitate the participation of the ideologically opposed. The developed method successfully accommodated this group of participants by presenting the scenarios as a serious game. This means that the method proved to be successful on a corporate level in identifying direct risks and opportunities and generating decision useful information. The survey results confirmed this potential.

The method, however, did not include a tool to quantify the results. Also it has only been applied as a strategy tester and not in the strategy setting process, leaving it unable to complete the full resilience cycle (WBCSD, 2020). A positive feedback cycle in order to foster transformative change could be achieved if the method is applied in the strategy setting process.

Based on these results the extent to which scenario analysis can contribute to the ability of the TCFD-guidelines to govern for global financial stability in the anticipation of climate change can be interpreted. The first indicator for the method's contribution to the goals of the TCFD was formulated in the methodology as: Is the content consistent with the goals of governing for financial stability, i.e. does the application of scenario analysis within the TCFD-Guidelines lead to a more accurate pricing of climate risks and opportunities? The second indicator was formulated as: Is there a form of transformative collective action induced, i.e. is there transformative change in the approach of companies to climate-related risk management?

Looking at the first indicator the method succeeded in identifying direct climate-related risks and opportunities. It does, however, not include a tool to quantify and/or monetize these impacts. Also, the method does not address indirect climate-related risks and opportunities such as mass migration, loss of biodiversity etc. Therefore it can be concluded that the method partially addresses this first indicator but has to be further developed to be fully in line with the goals of the TCFD.

As for the second indicator, generating transformative change means that the process has to be repeated and improved continuously. This is best achieved by continuously addressing the resilience circle (WBCSD, 2020). Currently the method has only been tested while being applied as a strategy tester rather than within the strategy setting process. The method is designed to be applicable in the strategy setting process theoretically making it suitable to generate transformative change but this has not yet been proven in practice. Also, the approach has to be adopted by other companies in order to add value to investors and financial service providers by providing consistent climate-related disclosures. Providing a step-by-step guide to implement the method, however, is a good first step in achieving widespread adoption.

All together this research shows that scenario analysis has the potential to increase the TCFD-guidelines' contribution to the governance for global financial in the anticipation of climate change. The extent to which scenario analysis is able to do this depends on the ability of the scenario method to (1) identify and quantify direct and indirect climate-related risks and opportunities, (2) complete and repeat

the resilience circle, and (3) provide consistency in the application and disclosure between companies and over time.

The scenario method developed in this research provides a basis to further develop an approach that includes not only direct but also indirect events. It can also be combined with tools that quantify the identified impacts. It has not been tested when included in the strategy setting process, but it is designed to be included herein. And by providing a step-by-step guide to implementation, integration and continuation of the method it also significantly lowers the barrier of adoption of the scenario method by other businesses, increasing the potential for consistent reporting.

7 Discussion

In this research a new scenario method for application within the TCFD-guidelines has been developed and tested. The development process itself has been reflected upon in the main body of the report, but its relation to current approaches deserves some further scrutiny. Also the limitations of this new method, which touched the surface in the conclusion, will be discussed in more depth. Lastly some suggestions for future research will be given.

When the TCFD launched its recommendations in 2017 it also published a technical supplement specifically aimed at scenario analysis (TCFD, 2017). The report provided guidance on what to include (at least a 2^{o}C-or-lower scenario) and published an extensive list of external scenarios to use. It also recommended on what to report (potential resilience), including an extensive list of parameters, assumptions, analytical choices and impacts. The TCFD also urged for companies to disclose the choices they make to increase comparability and replicability. However, it failed to connect these recommendations with guidance on how to translate climate scenarios into relevant business impacts. And businesses often fail to disclose all of the choices they make (WBCSD, 2020).

The TCFD reflected on this themselves in their 2019 Status Report (TCFD, 2019), concluding that to promote greater adoption additional work was needed towards "process guidance around how to introduce and conduct climate-related scenario analysis" as well as more "business-relevant and accessible scenarios" (p. 74). The scenario and strategy literature generally covers the development of scenarios from scratch to create engagement and a feeling of ownership. This, however is too time and resource intensive and therefore not recommended for application within the TCFD-guidelines (Four Twenty Seven, 2018; TCFD, 2017). The developed method therefore uses external scenarios as a starting point. It contributes to the current literature by providing a standardized method to adapt external climate scenarios for use within businesses. This approach is integrated in the strategy process following the framework of Lehr et al. (2017).

Using externally developed climate scenarios, however, it is harder to make them relevant to the audience and company, for them to be considered plausible, internally consistent, credible, stimulating, and thought provoking (Amer, Daim, & Jetter, 2013; Wiebe, et al., 2018). These are, however, conditions that need to be satisfied in order to generate decision useful information. Therefore, for this method, relevance was created through customizing the scenarios using incasting (Bishop, Hines, & Collins, 2007). This way the strengths of both the IL and PMT schools (Bradfield, Wright, Burt, Cairns, & van der Heijden, 2005) could be combined, making quantitative climate models relevant to the company. Using quantitative scenarios allowed for better estimation of impact and likelihood of events. The feeling of ownership was created using the En-ROADS simulator (Climate Interactive, 2020). Engagement and participation were achieved through applying a serious game (Vervoort et al. 2010).

For this method to be successful in achieving the above mentioned conditions, the workshops and facilitation hereof, is a critical factor. The extent to which the workshop (facilitation) is a critical factor depends on the initial rate of adoption. If this is low, the workshops need to convince and engage skeptical leadership and the facilitation of the workshop becomes a critical factor for success. If initial adoption and engagement with the topic is high the workshops are still crucial for successful identification of relevant risks and opportunities, but there is slightly more room for error in the facilitation.

Depending on the initial rate of adoption and available knowledge, the workshops can be facilitated in-house or be outsourced. When internal adoption is relatively high internal facilitation might be preferable. Internal facilitation, however, is reliant on the knowledge being available in-house and is also more prone to confirmation bias (Nickerson, 1998).

Outsourcing, on the other hand, can provide valuable knowledge on the topic of interest (climate change) and bring in experience with scenario analysis. It is therefore a good starting point if initial adoption is low or the required knowledge is not available in-house. The impact of climate change and subsequent need for adaptation and/or mitigation, however, can often be a sensitive issue. Without broad internal support it can meet resistance from certain employees, severely reducing the potential of the analysis. In this case facilitation of and participation in the workshop are critical success factors for both the short- and long term.

7.1 Limitations

The limitations of this research can be divided into two categories. Firstly there are the limitations in addressing the full extent to which scenario analysis aligns with the goals of governing for financial stability and its ability to induce some form of transformative collective action. And secondly there are the limitations that appear within the execution of the developed method and workshop.

At the start of this research two indicators for success on the supranational level have been formulated. The method developed in this research only addresses parts of these indicators. Firstly, the developed method only addresses direct climate-related impacts and not indirect impacts. Nor does the method provide or identify specific tools for quantification of the identified impacts. This limits the method in its current form in the extent to which it fulfills the goals of governing for global financial stability. Secondly, because in this research an in-depth study of a single case was performed it is beyond the scope of this research to promote and/or identify adoption of the method by other companies. This limits the research in its potential to identify whether the method induces some form of transformative collective action.

Regarding the execution of the method, four specific limitations have been identified. Firstly, setting out to develop a novel approach meant accepting that in this first round of developing and facilitating the workshops the results of the analysis would be subject to the imperfections of a not yet fully developed method. In the workshops this is most prevalent in the two separate scorecards for the LAS and SFS workshop sets and the inclusion of the middle-of-the-road event (EU Green Deal) in only the SFS workshop. The former issue could be corrected by reviewing the LAS workshops with the new scorecard in hand, while the latter could not be readdressed.

Secondly, by limiting the method to use only two scenarios, only one type of transition scenario has been considered for use within the scenario game. Ansari and Holz (2019) define both a Green Cooperation scenario as well as a ClimateTech scenario as potential transition scenarios. And using the En-ROADS simulator it also quickly becomes clear that there are very many combinations of measures, actions and developments that could lead to a successful transition. There is, for example, a significant difference between a transition with, on the one hand, extensive reliance on and use of bio-based materials (green transition), while on the other hand the bet could also be focused on hydrogen, synthetic fuels or other non-bio-based options (blue transition).

The third limitation was created with the exclusion of the estimation of the likelihood of events during the workshops. This was done to enhance the flow of the game and increase the number of

discussed events within the workshop timeframe. However, where the in-workshop discussion yielded relatively specific risk and opportunity identifications, the estimated limitations based on the survey showed a relatively large variation, sometimes from an event thought likely to happen within the next two years to not within the next decade to not at all. Therefore, inclusion of the likelihood estimations within the workshop games could contribute to the specificity of these estimations. Additional accuracy, however, can only be generated through more extensive coverage of signpost events.

The final in-workshop limitation that I think is valuable to discuss is the event selection method. Using existing scenarios and tailoring them to the subject's global footprint made the workshops to-the-point and efficient. Part of this efficiency came from the prepared events in the scenario game. This did however mean that all the events considered as potential risks or opportunities were selected and created by a small group of people (the author, Diana Visser, and Udeke Huiskamp). Although a diverse group it was small and therefore limited in its perceptions (Cornish, 1977). As discussed before this could have been addressed through the use of interviews to select these events, but this was not done because of time and resource constraints.

7.2 Suggestions for future research

The research focused on testing the current strategy for exposure to climate-related risks and opportunities. This resulted in the successful identification of climate-related risks and opportunities for the subject company. However, the exclusion of the strategy setting process meant that the developed method does not yet fully address the resilience circle. Therefore, as a first suggestion, future research could test and further improve the method for application in the scenario setting process to be able to complete and repeat the resilience circle.

Secondly, the method only partially addressed the goals of governing for global financial stability by not addressing indirect impacts nor providing a tool for the quantification of the identified risks and opportunities. Therefore future research could try to include the indirect effects of climate change in the scenario events as well as focus on the identification and/or development of standardized tools for the quantification of climate-related risks and opportunities.

Finally, because of the timeframe of this research, the results have not been tested for the added value they provide to investors and other financial service providers. I suggest that this could be tested and included in the continuous feedback loop between companies and financial services that is currently already present in the financial reporting cycle.

8 Recommendations: a step-by-step guide to implementation

Because the success and impact of scenario analysis relies on widespread adoption and continuous application I will provide my view on how I think the developed method is best implemented into a company: a step-by-step guide of the scenario method and how it can used as a strategy tester (which is how it was applied in this research). Subsequently I will provide recommendations on how I think the method could be best integrated and how this can support continuous application. Finally I will provide suggestions for future research based on the limitations of this study and the developed method.

8.1 Final scenario method

The flow of steps that together form the basis of this newly developed scenario method have shown to yield the desired results. Therefore, where the *scenarios* and *workshops* steps have seen some adjustments in their internal mechanisms as the case study progressed the flow of steps remained unaltered. A compact overview of the scenario method and its integration with the strategy setting process can be found in figure 29. The full-size overview can be found in figure 12, p. 25.

Where in chapter 4 each step was highlighted by providing a short capture of concept, here a short recommendation of the, in my view, best approach to operationalization of each concept will be given.

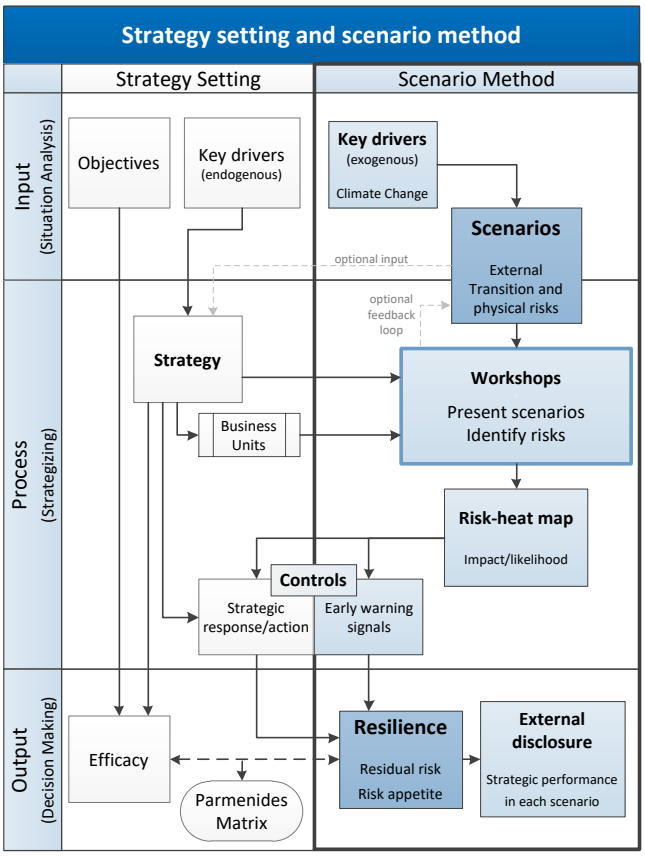


Figure 29: Compact framework for scenario and strategy integration (conceptually similar to figure 12, p. 25)

Key driver (exogenous)

The key driver, as input variable, is a given for the application of scenario analysis in line with the TCFD-recommendations: climate change. The approach within this method is to consider all effects related to climate change, both transition and physical impacts, as external events in which the subject (company) has no influence.

Scenarios

The method is compatible with any set or combination of climate (change) scenarios, whether it be the IPCC RCPs or Greenpeace's transition scenario. Here, however, I will highlight what I think are the currently most valuable scenarios as a basis for scenario analysis within the TCFD. Although the final workshops only consisted of a transition- and a physical risk scenario, the four scenarios provided by Ansari and Holz (2019) still formed a very valuable starting point. This is because of their integration of both qualitative, societal developments as well as modelled quantitative climate system developments. This provides the basis for a much more engaging set of scenarios to use in the workshops. Also, any

separation between more than two scenarios within a timeframe up to 2050 should be based on geo-political developments rather than climate-related modelling, because the climate scenarios are all still within their respective ranges of uncertainty. Using the scenario set developed by Ansari and Holz (2019) allows for such an extension.

The second most useful set I found was that of the IPCC (2014). The biggest advantage of this set is the completeness and thoroughness of the report, and its relative detail all the way to 2100. The two disadvantages, however, are that it was published in 2014 and the climate science has advanced since then, as well as it being a purely scientific report, not taking into account geo-political developments. A newly updated report (the 6th IPCC synthesis report) is scheduled to be published in 2022 and could prove to hold valuable information for use within this method.

To create the most relevant experience, the scenarios should be extensively tailored to the subject company before including them in the workshop. For a more exploratory exercise they can be separated into a transition- and a physical risk scenario, as was done in this study (figure 30). In case of a broader exploratory study a business-as-usual/middle-of-the-road scenario can be included (dotted line, figure 30) and/or the transition scenario can be split (green or blue transition). A single scenario can also be used if, after having performed an exploratory study, it is deemed beneficial.

The scenarios can be tailored combining internal company information (documents, reports, interviews, etc.) with additional literature. Depending on the specific goals of the exercise and the scenarios used this can be anything from more sector specific climate modelling to (grey) literature on current and expected geo-political developments to expected laws and regulations.

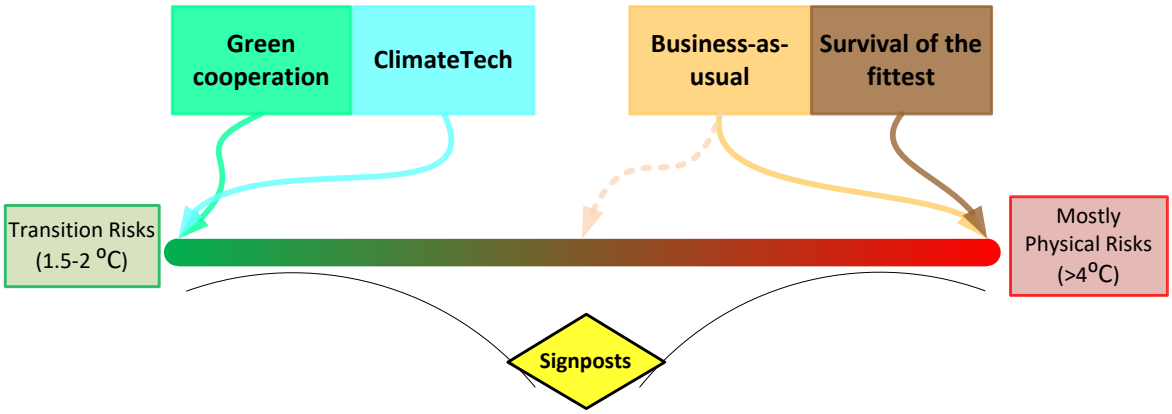


Figure 30: Use of scenarios model

Workshops

Where tailoring the scenarios is the main factor in providing relevance to the audience, the workshops are the key to creating engagement, provoking participation, and sparking discussion. All three needed for the generation of decision useful information. However, because externally developed scenario are used for the construction of events the feeling of ownership is naturally low. To be able to stir up this valuable feeling in the participants, the En-ROADS simulation game can be used to collectively generate a transition scenario. The En-ROADS simulator can provide the audience with a feeling of ownership of the scenario(s) as well as in creating awareness of the extent of actions needed to stay below 2-degrees.

For this research the choice was made to make the workshops business unit specific. Although the workshop format can be applied to a range of different levels in the organization, from product value chain or specific factory location to an enterprise-wide focus, business units were the logical choice for

Corbion. Because of the decision to use a transition- and physical risk scenario exploratory approach, the business unit specific workshops were clustered in sets of two. Firstly a transition workshop in which a transition scenario is built collectively using the En-ROADS simulator followed by a participative serious game playing through the potential events of the developed scenario. And secondly a workshop focusing on physical risks which kicked off with a short presentation of the current state-of-art of the science surrounding physical climate impacts followed by another serious game, now with (mostly) physical risk events. The first workshop takes approximately two-and-a-half hours based on a short scenario role-playing game around the En-ROADS simulator and six or seven transition events interrupted by two investment rounds. In the second workshop again 6 or 7 events were played in the game and this workshop can include an overall reflection while still finishing within two hours. The game can, however, also be extended with more physical events, or even some 'middle-of-the-road' events and therewith naturally extended to also last two-and-a-half hours. Both games are supported by the scorecard (appendix 3) to facilitate the clear estimation of impact. The En-ROADS simulation game is supported by the En-ROADS one page guide to the control panel and adjusted briefings (Climate Interactive, 2020) (appendices 1 & 2). Two weeks after the final workshop of the set a survey was sent out asking participants to confirm the tabulated results as well as to estimate the likelihood of the covered events.

In the end, the key steps in designing the workshops for this particular scenario method are: (1) to make sure the audience knows what to expect and is familiar with the concepts of scenarios and climate change, (2) the external scenarios are tailored to the audience and the events are relevant and clear, (3) a decision is made as to the goal of the exercise (simple exploratory, extensive exploratory, etc.), (4) the facilitator is familiar with facilitating an En-ROADS simulation game and also includes such a game to introduce the transition scenario, and finally (5) the participants should be able to adequately represent the business unit or other level of the organization that is covered.

Risk-heat map

The workshops were used to identify climate-related risks and opportunities, the survey linked these to estimated likelihoods, together these indicators can be plotted on a risk-heat map. In my view the most efficient way to construct and communicate such a metric is to construct it in line with current company risk management practices. For Corbion, and many other companies, this is in line with the COSO ERM framework, creating risk-heat maps with impact on the x-axis and likelihood on the y-axis.

Controls

To reduce the identified risks and to be able to better estimate their likelihood, there are two different types of controls that can be applied. On the strategy setting side there are the strategic responses and strategic actions, based on the combination of the current risk level and risk appetite to reduce exposure. On the scenario analysis side stands the identification of signpost events.

Neither have been explicitly addressed by the workshop or survey, but neither have been completely ignored either. With the investment options within the scenario game participants have had the opportunity to address the emerging risks and opportunities and formulate strategic actions. Several signpost events were covered in the narrative events during the workshops and a handful have been suggested in paragraph 5.7. To paint a complete picture, however, more dedicated action towards the identification of signpost events is needed.

Resilience

The omittance of specifically addressing controls in this workshop means that the identified risks are inherent risks rather than residual risks. It also means that, looking at the circular model for resilience (figure 31, full size figure on p. 28), only the first two steps (shocks and stressors, and effects) are addressed in full, the third step (response) is touched upon and the fourth step (transformation) is not yet included in the process. This follows logically from the aim of this research as strategy testing, rather than strategy setting. If the optional feedback cycle from workshop to scenario to strategy is activated the workshop method can address all elements of resilience and help the company integrate climate related risks and opportunities in full.

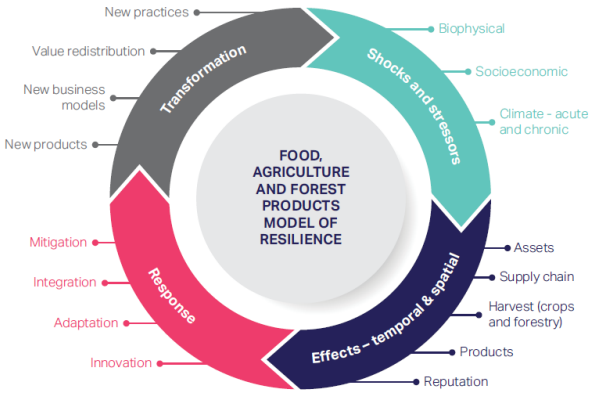


Figure 31: circular model for resilience (WBCSD, 2020)

External disclosure

Currently the TCFD encourages companies to disclose as much information as they have as soon as possible. They prefer this over companies postponing disclosure whilst aiming to cover all aspects of the guidelines in the first disclosure round. The strategy testing application of the workshop, as outlined in this report, is a great first step in reporting on the climate-risks and opportunities as identified with the use of scenario analysis. When the steps in this guide are followed it should be possible to publicly (or internally) disclose the risks and opportunities related to climate change for the covered parts of the company (figure 32). If the optional feedback loop is included and the derived results are integrated back into the strategy setting process, it also becomes possible to fully address the strategic resilience of the company, fulfilling the full disclosure recommendations of the TCFD.

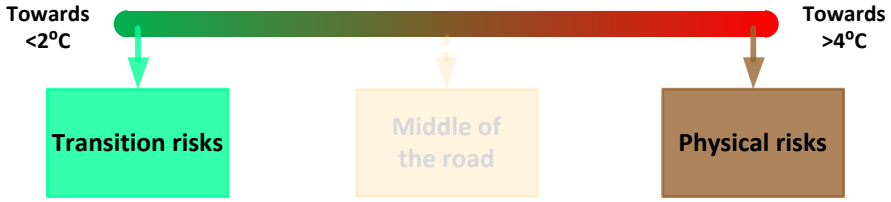


Figure 32: Scenario disclosure

8.2 Integration and continuation

There are two main conditions for successful integration of this method into standard company practices. Firstly, there has to be support from the Executive Committee (C-Suite Officers), and secondly participants have to be convinced of the value of the scenario analysis. For the first time implementation of the workshop as a strategy testing approach, support from the C-Suite officer responsible for the identification of climate-related (sustainability) risks is sufficient. In the case of Corbion this is the Chief Science and Sustainability Officer (CSSO).

After the initial stadium of identifying risks and opportunities, broader support is desirable and beneficial for successful continuous integration and reporting. Specifically the support of the CFO to secure space in the annual report and to manage the financial implications (WBCSD, 2020), the Chief Operating Officer – or similar – for managing and monitoring specific physical risks and the CSSO – or similar – should remain responsible for managing and monitoring transition risks and, when applicable, achieving the Science Based Targets.

Support from C-Suite officers, however, is still a long shot from successful integration and continuation. For this, support from a diverse group of managers is needed. To effectively identify the climate-related risks and opportunities along the entire value chain, a representative group of participants is needed in the workshops. These can be brought together by a single initiator, but this does not guarantee active participation and lingering interest in the topic. For this the developed scenario method can be used because it is successful at engaging the participants, even the ideologically opposed, and generating decision useful information.

The workshop can be prepared and facilitated by external consultants if the required knowledge is not available in-house. Also, the use of external consultants can reduce or even remove in-company bias. However, for continuity and integration beyond strategy testing, in-house coordination of the process is recommended. In-house adoption of the process will help facilitate the completion and continuity of the resilience circle (shocks and stressors, effects, response, transformation). Partnering with an external party, e.g. a university, can benefit the process.

9 Bibliography

Amara, R. (1981). The futures field: searching for definitions and boundaries. *The futurist, 15*(1), 25-29.

Amel-Zadeh, A. (2019, March). The Materiality of Climate Risk. Retrieved from https://ssrn.com/abstract=3295184

Amer, M., Daim, T. U., & Jetter, A. (2013). A review of scenario planning. *Futures, 46*, 23-40.

Ansari, D., & Holz, F. (2019). Anticipating global energy, climate and policy in 2055: Constructing qualitative and quantitative narratives. *Energy Research & Social Science, 58*, 1-23.

Balarezo, J., & Nielsen, B. B. (2017). Scenario Planning as Organizational Intervention: An Integrative Framework and Future Research Directions. *Review of International Business and Strategy, 27*(1), 2-52.

Barber, M. (2009). Questioning scenarios. *Journal of Future Studies, 13*(February), 139-146.

Baumgartner, R. J. (2014). Managing corporate sustainability and CSR: A conceptual framework combining values, strategies and instruments contributing to sustainable development. *Corporate Social Responsibility and Environmental Management, 21*(5), 258-271.

Bishop, P., Hines, A., & Collins, T. (2007). The current state of scenario development: an overview of techniques. *Foresight, 9*(1), 5-25.

Börjeson, L., Höjer, M., Dreborg, K. H., Ekvall, t., & Finnveden, G. (2006). Scenario types and techniques: Towards a user's guide. *Futures, 38*, 723-739.

Bradfield, R., Wright, G., Burt, G., Cairns, G., & van der Heijden, K. (2005). The origins and evolution of scenario techniques in long range business planning. *Futures, 37*, 795-812.

Brainard, L. (2019). Why Climate Change Matters for Monetary Policy and Financial Stability. *The Economics of Climate Change.* San Fransisco: Federal Reserve Bank. Retrieved from https://www.federalreserve.gov/newsevents/speech/brainard20191108a.htm

Bresch, D. N., Berghuijs, J., Egloff, R., & Kupers, R. (2014). A resilience lens for onterpirse risk management. In R. Kupers, *Turbulence: A corporate perspective on collaborating for resilience* (pp. 49-65). Amsterdam: Amsterdam University Press.

Cairns, G., & Wright, G. (2011). *Scenario Thinking.* Cham: Palgrave Macmillan.

Carney, M. (2015). Breaking the Tragedy of the Horizon - climate change and financial stability (speech). *Lloyd's of London.* London: Bank of England.

Carrasco, E. R. (2010). he Global Financial Crisis and the Financial Stability Forum: The Awakening and Transformation of an International Body. *Transnational Law & Contemporary Problems*, 203-220.

CLIMAGINARIES. (2020, March 4). Storyworlds of Decarbonization in Models and Fiction - seminar. Utrecht, The Netherlands: Utrecht University.

Climate Interactive. (2020). *climateinteractive.org.* Retrieved from climateinteractive.org: https://www.climateinteractive.org/tools/en-roads/the-en-roads-climate-workshop/

Corbion. (2020, March 9). *corbion.com.* Retrieved from corbion.com: http://www.corbion.com/about-corbion/press-releases?newsId=2260438

Cornish, E. (1977). *The Study of the Future; An Introduction to the Art and Science of Understanding and Shaping of Tomorrow's world.* Washington: World Futures Society.

Corporate Reporting Dialogue. (2019). *Driving Alignment in Climate-related Reporting: Year One of the Better Alignment Project.* London: Integrated Reporting Foundation.

COSO. (2017). *Enterprise Risk Management: Integrating with Strategy and Performance.* Committee of Sponsoring Organizations of the Treadway Commission.

Driessen, P., Dieperink, C., van Laerhoven, F., Runhaar, H. A., & Vermeulen, W. J. (2012). Towards a Conceptual Framework for The Study of Shifts in Modes of Environmental Governance – Experiences From The Netherlands. *Environmental Policy and Governance, 22*, 143-160.

Dryzek, J. S. (2016). Institutions for the Anthropocene: Governance in a Changing Earth System. *British Journal of Political Science, 46*(4), 937-956.

European Commission. (2019a). *Guidelines on reporting climate-related information.* Brussels: European Union.

European Commission. (2019b). *Communication from the commission: The European Green Deal.* European Union. Brussels: EUR-Lex. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1588580774040&uri=CELEX%3A52019DC0640

Four Twenty Seven. (2018). *Advancing TCFD Guidance on Physical Climate Risks and Opportunities.* Berkeley: Four Twenty Seven.

FSB. (2019). *About the FSB.* Retrieved from fsb.org: https://www.fsb.org/about/

FSB. (2019). *History of the FSB.* Retrieved from fsb.org: https://www.fsb.org/history-of-the-fsb/

Gerring, J. (2004). What is a case study and what is it good for? *American political science review, 98*(2), 341-354.

Goldin, I., & Vogel, T. (2010). Global Governance an dSustemic Risk in the 21st Century: Lessons from the Financial Crisis. *Global Policy, 1*(1), 4-15.

Goldthau, A., Westphal, K., Bazilian, M., & Bradshaw, M. (2019). How the energy transition will reshape geopolitics. *Nature, 569*, 29-31.

Goodman, N. (1978). *Ways of Worldmaking.* Indianapolis: Hackett Publishing.

Haasnoot, M., van 't Klooster, S., & van Alphen, J. (2018). Designing a monitoring system to detect signals to adapt to uncertain climate change. *Global Environmental Change, 52*, 273-285.

Huss, W. R., & Honton, E. J. (1987). Scenario planning - what style should you use? *Long range planning, 20*(4), 21-29.

IEA. (2019). *World Energy Outlook.* Paris: International Energy Association.

Ingham, H., & Luft, J. (1955). The Johari Window: a graphic model of interpersonal awareness. *Proceedings of the western training laboratory in group development, 246*, 2014-03.

IPCC. (2014). *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Geneva, Switzerland: IPCC.

IPCC. (2018). *Global Warming of 1.5^{o}C. An IPCC Special Report on the impacts of global warming of 1.5^{o}C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change.* Geneva: IPCC.

IRGC. (2018). *Guidelines for the Governance of Systemic Risks.* Lausanne: International Risk Governance Center (IRGC).

Kahn, H., & Wiener, A. J. (1967). year 2000; a framework for speculation on the next thirty-three years. *Daedalus*, 705-732.

Kupers, R. (2014). *Turbulence: A Corporate Perspective on collaborating for Resilience.* Amsterdam: Amsterdam University Press.

Landry, E., Carranze, L., Gomes, J. R., Jacoby, H., Lessard, D., Paltsev, S., & Patten, B. (2019). *Climate-Related Financial Disclosures: The Use of Scenarios.* Cambridge, MA: MIT.

Lange, P., Driessen, P. P., Sauer, A., Bornemand, B., & Burger, P. (2013). Governing Towards Sustainability - Conceptualizing Modes of Governance. *Journal of Environmental Policy & Planning*, 1-23.

Lehr, T., Lorenz, U., Willert, M., & Rohrbeck, R. (2017). Scenario-based strategizing: Advancing the applicability in strategists' teams. *Technological Forecasting & Social Change, 124*, 214-224.

Linnenluecke, M. K., Nucifora, N., & Thompson, N. (2018). Implications of climate change for the sugarcane industry. *WIREs Climate Change, 9*, 1-34.

Marien, M. (2002). Futures studies in the 21st century: a reality-based view. *Futures, 34*(3-4), 261-281.

Martelli, A. (2001). Scenario building and scenario planning: state of the art and prospects of evolution. *Futures Research Quarterly, 17*, 57-70.

McKinsey Global Institute. (2020). *Climate risk and response: Physical hazards and socioeconomic impacts.* Shanghai: McKinsey Global Institute.

Mitchell, D. M., Osprey, S. M., Gray, L. J., Butchart, N., Hardiman, S. C., Charlton-Perez, A. J., & Watson, P. (2012). The Effect of Climate Change on the Variability of the Northern Hemisphere Stratospheric Polar Vortex. *Journal of Atmospheric Sciences, 69*, 2608-2618.

Moser, S. C., & Dilling, L. (2011). Communicating Climate Change. In J. S. Dryzek, R. B. Norgaard, & D. Schlosberg, *The Oxford Handbook of Climate Change and Society* (pp. 161-174). Oxford: Oxford University Press.

NGFS. (2019). *A call for action: Climate change as a source of financial risk.* Paris: Network for Greening the Financial System.

Nickerson, R. S. (1998). Confirmation Bias: A Ubiquitous Phenomenon in Many Guises. *Review of General Psychology, 2*(2), 175-220.

Ocasio-Cortez, A., Hastings, Tlaib, Serrano, Maloney, C. B., Vargas, . . . Waters. (2019). *Recognizing the duty of the Federal Government to create a Green New Deal.* U.S. House of Representatives. Washington D.C.: U.S. Government. Retrieved from https://www.congress.gov/116/bills/hres109/BILLS-116hres109ih.pdf

OECD. (2016). *An OECD Horizon Scan of Megatrends and Technology Trends in the Context of Future Research Policy.* København: Danish Agency for Science, Technology and Innovation.

O'Neill, B. C., Kriegler, E., Ebi, K. L., Kemp-Benedict, C., Riahi, K., Rothman, D. S., . . . Solecki, W. (2017). The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st centrury. *Global Environmental Change, 42*, 169-180.

Pipitpukdee, S., Attavanich, W., & Bejranonda, S. (2020). Climate Change Impacts on Sugarcane Production in Thailand. *Atmosphere, 11*(408), 1-16.

Porter, M. (1985). Technology and competitive advantage. *The Journal of Business Strategy, 5*(3), 60.

Ramírez, R., & Wilkinson, A. (2016). *Strategic Reframing: The Oxford Scenario Planning Approach.* Oxford: Oxford University Press.

Riahi, K., van Vuuren, D. P., Kriegler, E., Edmonds, J., O'Neill, B. C., & al., e. (2017). The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview. *Global Environmental Change, 42*, 153-168.

Ripple, W. J., Wolf, C., Newsome, T. M., Galetti, M., Alamgir, M., Crist, E., . . . 15, 3. s. (2017). World Scientists' Warning to Humanity: A Second Notice. *BioScience, 67*(12), 1026-1028.

Rooney-Varga, J. N., Kapmeier, F., Sterman, J. D., Jones, A. P., Putko, M., & Rath, K. (2020). The Climate Action Simulation. *Simulation & Gaming, 51*(2), 114-140.

Schoemaker, P. J. (1991). When and how to use scenario planning: a heuristic approach with illustration. *Journal of Forecasting, 10*, 549-564.

Spaniol, M. J., & Rowland, N. J. (2019). Defining scenario. *Futures Foresight Science*, 1-13.

Strader, S. M., Ashley, W. S., Pingel, T. J., & Krmenec, A. J. (2017). Projected 21st century changes in tornado exposure, risk, and disaster potential. *Climatic Change, 141*, 301-313.

TCFD. (2017). *Final Report: Recommendations of the Task Force on Climate-related Financial Disclosures.* Basel: Task Force on Climate-related Financial Disclosures.

TCFD. (2019). *Task Force on Climate-related Financial Disclosures: Status Report.* Basel: Task Force on Climate-related Financial Disclosures.

TCFD. (n.d.). *Our Mission*. Retrieved November 26, 2019, from fsb-tcfd.org: https://www.fsb-tcfd.org/

Tigchelaar, M., Battisti, D. S., Naylor, R. L., & Ray, D. K. (2018). Future warming increases probability of globally synchronized maize production shocks. *PNAS, 115*(26), 6644-6649.

Trnka, M., Feng, S., Semenov, M. A., Olesen, J. E., Kersebaum, K. C., Rötter, R. P., . . . Büntgen, U. (2019). Mitigation efforts will not fully alleviate the increase in water scarcity occurrence probability in wheat-producing areas. *Science Advances, 5*, 1-11.

Trnka, M., Rötter, R. P., Ruiz-Ramos, M., Kersebaum, K. C., Olesen, J. E., Žalud, Z., & Semenov, M. A. (2014, May 25). Adverse weather conditions for European wheat production will become more frequent with climate change. *Nature Climate Change*. doi:DOI: 10.1038/NCLIMATE2242

UNFCCC. (1992). *United Nations Framework Convention on Climate Change.* Geneva: United Nations.

van Notten, P. W., Rotmans, J., van Asselt, M. B., & Rothman, D. S. (2003). An updated scenario typology. *Futures, 35*, 423-443.

Vermeulen, W., & Witjes, S. (2016). On addressing the dual and embedded nature of business and the route towards corporate sustainability. *Journal of Cleaner Production, 112*, 2822-2832.

Vervoort, J. M., Bendor, R., Kelliher, A. S., & Helfgott, A. E. (2015). Scenarios and the art of worldmaking. *Futures, 74*, 62-70.

Vervoort, J. M., Kok, K., van Lammeren, R., & Veldkamp, T. (2010). Stepping into futures: Exploring the potential of interactive media for participatory scenarios on social-ecological systems. *Futures, 42*, 604-616.

Wack, P. (1985a). Scenarios: uncharted waters ahead. *Harvard Business Review, 63*(5), 72-89.

Wack, P. (1985b). Scenarios: shooting the rapids. *Harvard Business Review, 63*(6), 2-14.

WBCSD. (2019). *TCFD Chemical Sector Preparer Forum.* Geneva: World Business Counsil for Sustainable Development.

WBCSD. (2020). *Food, Agriculture and Forest Products TCFD Preparer Forum.* Geneva: WBCSD.

WEF. (2019). *The Global Risks Report 2019.* Geneva: World Economic Forum.

Wiebe, K., Zurek, M., Lord, S., Brzezina, N., Gabrielyan, G., Libertini, J., . . . Westhoek, H. (2018). Scenario Development and Foresight Analysis: Exploring Options to Inform Choices. *Annual Reviews, 43*, 545-570.

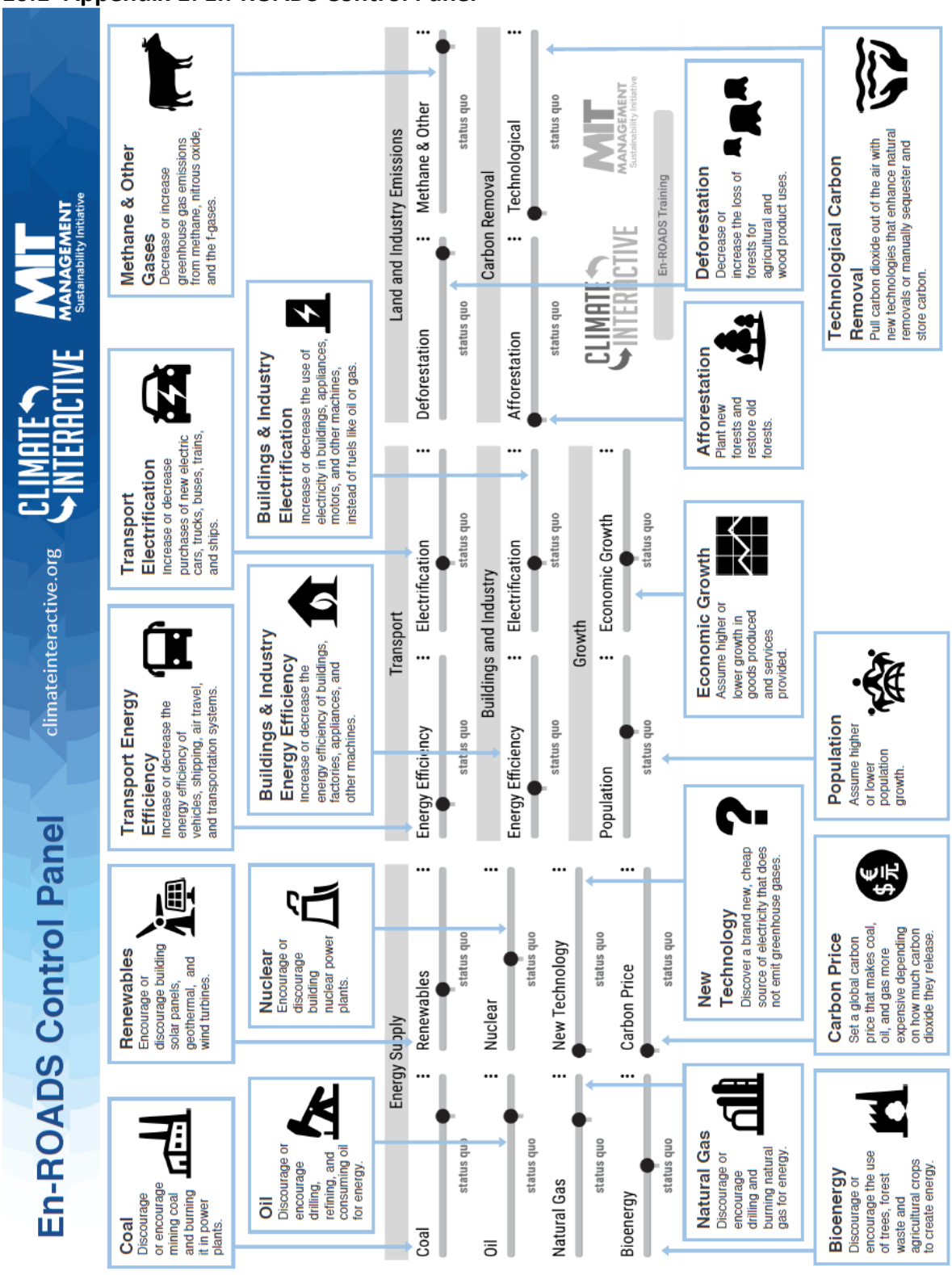
Wilkinson, A., & Eidinow, E. (2008). Evolving practices in environmental scenarios: a new scenario typology. *Environmental Research Letters, 3*, 1-11.

World Economic Forum. (2020, Jan 17). *weforum.org*. Retrieved from weforum.org: https://www.weforum.org/agenda/2020/01/whether-we-achieve-zero-emissions-rests-on-these-3-pillars/

Yin, R. K. (2009). *Case Study Research: Design and Methods* (Vol. 4). Thousand Oaks, California, United States: Sage publications.

10 Appendices

10.1 Appendix 1: En-ROADS Control Panel



10.2 Appendix 2: Briefing sheet for En-ROADS workshop (1 of 5 different groups)

Climate Action Simulation: Conventional Energy Supply

To: Chief Negotiator for the Conventional Energy Industry
Subject: Preparation for the Climate Action Summit

Welcome to the Climate Action Summit. You and leaders from all relevant stakeholders are here to create a plan to limit global warming to less than 2°C [3.6°F] above preindustrial levels and to strive for 1.5°C [2.7°F], the international targets formally recognized in the Paris Climate Agreement.

You represent the coal, oil, natural gas, nuclear, and electric utility industries that supply most of the world's energy today. Your group includes publicly traded and national oil and gas (O&G) companies, coal companies, electric utilities reliant on fossil fuels, and firms that supply services and equipment to these industries.

Your policy priorities are listed below. You can, however, propose, or block, any available policy.

1. **Oppose a high carbon price.** Your economists acknowledge that raising fossil fuel prices to reflect the environmental and social costs of greenhouse gas (GHG) emissions with a carbon price could be the best way to reduce global emissions. However, a carbon price above $25- 30/ton of CO_2 would unacceptably harm the fossil fuel industry by raising costs and slashing demand, leading to stranded assets and loss of shareholder value.

2. **Oppose taxes on fossil fuels.** Your industry wants neither to be regulated nor to pay the costs of mitigating climate change. Since you already anticipate significant business losses as the world transitions away from fossil fuels in the coming century, you cannot bear extra costs that unfairly punish your industry. In fact, you may ask for subsidies for natural gas, which you promote as a bridge fuel because it is less carbon intensive than coal and oil. If regulations are inevitable, it is better to restrict coal than oil and gas. Coal emits the most carbon when burned and is less profitable than oil and gas.

3. **Encourage actions that don't directly affect your industry.** While you understand that climate change is dangerous, you also need to protect shareholder value. You therefore advocate policies that could reduce GHG emissions without reducing fossil fuel use. Although CO_2 from fossil fuel use contributes the most to climate change, methane (CH_4), nitrous oxide (N_2O) and other gases are potent GHGs, and their impact is growing. Global agriculture and forestry practices contribute greatly to emissions of these gases. You support policies to reduce these other GHGs, primarily emissions from land use, agriculture, and forestry. You support efforts to cut deforestation, and to afforest previously degraded and deforested lands.

Goals:

Annual growth of 3% (EBITDA) Margin of 17% Meeting Science Based Targets

Score:

	Description	IMPACT: Impact on growth	IMPACT: Impact on margin	SBT rating
++	Major Opportunity			
+	Minor opportunity			Frontrunner
-	Minor risk			Compliance
--	Major risk			Laggard
---	Catastrophic event			Unable to comply
±	No effect	x	x	x

	Description	RESULT: Annual growth rate	RESULT: (EBITDA) Margin	SBT rating
++	Major Opportunity			
+	Minor opportunity			Frontrunner
-	Minor risk			Compliance
--	Major risk			Laggard
---	Catastrophic event			Unable to comply
±	No effect	x	x	x

Example:

SBT rating:

Frontrunner: Always on the lookout for more ways to reduce emissions etc.
Compliance: Good participant in the SBTs, always meeting goals (also 1.5)
Laggard: Missing occasional goals, never doing more than necessary
Unable to comply: Facing compliance, regulatory and reputation issues

10.4 Appendix 4: Workshop reflection survey results