

Climate Scenario Analysis Reference Approach:

For companies in the energy system

Produced by the Energy Forum
in collaboration with the World Business Council
for Sustainable Development (WBCSD)
and with support from the Task Force on
Climate-related Financial Disclosures (TCFD)

February 2023

About this report

In October 2021, the Task Force on Climate-related Financial Disclosures (TCFD) issued its latest [Status Report](#).¹ While showing significant momentum around adoption and support for its recommendations, the Status Report showed improved but relatively low levels of disclosure in response to the recommendation that companies should assess their strategic resilience taking into consideration different climate-related scenarios.

In November 2020, the [COP26 Private Finance Hub](#),² led by Mark Carney in his capacity as UN Special Envoy and Finance Advisor for COP26, set out the priorities for building a system that mobilizes private finance to support the re-engineering of our economies for net-zero. One of the goals of the risk management pillar of the strategy is to assess the resilience of companies

to climate risk. The goal is supported by promotion of scenario analysis in the real economy through development of sector-specific scenarios and guidance. The action is to be taken by companies.

The TCFD requested WBCSD to work with leading companies in the energy system to develop a business-relevant climate scenario analysis reference approach designed to support corporate scenario analysis practice and inform disclosures about strategic resilience.

WBCSD convened 12 leading companies that are supporters of the TCFD to develop business-relevant approaches to climate scenario analysis. Companies participating in the project come from industries across energy supply and primary demand and have formed the Climate Scenarios Energy Forum (the Energy Forum).



Although the project was requested by the TCFD and the TCFD Secretariat has provided valuable input to it, this report is not a TCFD product. Neither the TCFD, nor the TCFD Secretariat has had detailed oversight of the project. This report has been prepared by WBCSD based on advice and input provided by the Energy Forum.

This report describes the Energy Forum's proposals for a business-relevant Climate Scenarios Reference Approach to be used for the purpose of assessing strategic resilience to climate risk and to inform disclosures in response to the TCFD's recommendations.

The proposals are not a definitive guide to the optimal approach to climate scenario analysis by companies. Given the limited time, analytical capacity and engagement opportunities available to the WBCSD team and the Energy Forum, the proposals in this report should be viewed as a first step toward developing business relevant climate scenario analysis reference approaches for companies and pursuing the research priorities outlined in the conclusion. The Energy Forum anticipates that climate scenario analysis practices will continue to evolve over time.

Disclaimer

This report is the product of and reflects the collective work of the WBCSD team and the Energy Forum. The views in this report represent a broad consensus of the Energy Forum without necessarily, in all details, representing the individual views of each Forum member or their company. Unless otherwise stated, the positions expressed in this report do not represent the views of any of the external organizations that are acknowledged for their help and input.

Acknowledgments

About the WBCSD project team

WBCSD is the premier global, CEO-led community of over 200 of the world's leading sustainable businesses working collectively to accelerate the system transformations needed for a net zero, nature positive, and more equitable future. www.wbcسد.org

WBCSD sincerely thanks:

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Vivid Economics for developing the Catalogue and providing technical expertise
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CICERO – Center for International Climate Research

IEA – International Energy Agency

IRENA – International Renewable Energy Agency

NGFS – Network for Greening the Financial System

PIK – Potsdam Institute for Climate Impact Research

PRI – Principles for Responsible Investment

RSK

UNEP FI – United Nations Environment Programme Finance Initiative

WRI – World Resources Institute

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An aerial photograph showing rows of solar panels in a field, with green grass and small trees growing between the rows. The panels are arranged in a grid pattern, and the perspective is from a high angle, looking down at the rows.

1. Executive summary

This report presents an approach to scenario analysis for companies in the energy system to use, as part of a wider suite of activity, when using climate scenarios to assess strategic resilience. The approach has been developed by members of the Energy Forum with the primary objective of helping companies with scenario analysis using a common and transparent set of climate scenarios.

We refer to the ‘energy system’ to recognize the individual and collective contributions of and dynamic interactions between companies in that system as the energy transition unfolds in different scenarios. As such, the membership of the Energy Forum is made up of companies from across the energy system spectrum, from production to conversion and end-use.

The Energy Forum developed and agreed principles to guide their work. The principles are designed to promote simplicity by focusing on

how to use existing scenarios; to enhance business relevance; to offer a comprehensive approach that encourages assessment of climate-related risk and opportunities across a range of possible temperature outcomes and diverse pathways; to support a policy and technology neutral, common starting point and transparent approach to scenario analysis and, as a result, to ease the interpretation of scenario analysis information, particularly for investors.

The approach is based on existing climate scenarios. The Energy Forum’s Climate Scenarios Reference Approach is not a new scenario. It provides a way in which a selection of existing public scenarios, representing a broad range of possible outcomes, can be interpreted and used by companies in the energy-system for assessing strategic resilience to climate risk. The approach is intended to complement the use of company-specific and other scenarios.

The approach comprises three ‘Climate Scenario Reference Families’ to be used for conducting strategic resilience assessment. The selection of these scenario ‘families’ is not intended to imply any judgement by the Energy Forum about the probability or expectation that a particular outcome or scenario will be achieved. The three families are: Paris Ambitious 1.5°C, Paris Aligned well-below 2°C and Current Policies/Business-as-Usual (2.5-3.5°C warming). The families and associated scenarios allow for the assessment of strategic resilience under different climate-related scenarios, including a 2°C or lower scenario, aligned with the TCFD guidance. Selected public scenarios are allocated to the families and organized in an online platform known as *the [Climate Scenario Catalogue](#)* (the Catalogue).

The approach uses criteria and filters to identify the scenarios that will be allocated to the Catalogue from the hundreds that are available. The criteria are used to identify scenarios that best suit strategic resilience analysis by business against the Energy Forum's scenario families.

The approach is intended to add value to the climate scenario analysis landscape by clarifying which types of scenarios are useful for assessing strategic resilience and by offering an online platform, the Catalogue, to make scenarios easier to interpret and use. The Catalogue includes additional business relevant variables and parameters derived and expanded from public scenarios. It also offers the ability to compare different scenarios and variables to inform scenario choice, interpretation and selection. The Catalogue version 2.0 released February 2023 is designed to be updated to incorporate new functionality and scenarios over time.

The approach is for use as a supporting voluntary guide. It is designed to help companies with climate scenario analysis, but it does not provide stepwise guidance or prescriptive recommendations.

The approach needs to be reviewed and tested before disclosure guidance is developed. The Energy Forum is keen to support the TCFD's objectives to enhance disclosures about strategic resilience assessment using scenario approach. However, the Energy Forum has focused on supporting scenario analysis practice rather than disclosure and recognizes the formation of other initiatives such as the new International Sustainability Standards Board, which will influence how disclosure practice develops.

The Energy Forum concludes that collaboration and dialogue between companies, financial institutions, central banks and supervisors is vital to advancing and connecting scenario analysis approaches used by financial and real economy actors. Dialogue is needed to develop a shared understanding of the contributions that financial and non-financial companies can make to the energy transition and the associated dependencies. More work is needed to develop research and provide the infrastructure for effective business relevant scenario analysis.

2. About the project

- Introduction
- Project objectives
- Project outputs

Introduction

Climate action across societies: Many sections of society are responding to the widespread consensus that the climate is changing and to scientific evidence on the potential impacts of climate change. Governments are acting to mitigate and adapt to those impacts. Non-governmental organizations are raising awareness through reformist and more radical actions. Central Banks and financial institutions have introduced measures to assess climate risks to the financial system. Likewise, companies in the real economy that produce goods and services are changing their business models, setting climate targets and driving forward investment in net zero transformations to respond to the challenges and opportunities posed by climate change.

Real economy climate strategies informed by scenarios: Assessing how best to respond to the challenges posed by climate change and testing the resilience of any strategy depends on exploring how the future could unfold. Climate scenarios explore uncertainties about the future by modelling what different emissions pathways, timelines, mitigation options, feedbacks and technology trajectories etc. suggest about ways of achieving stated climate outcomes. Climate scenarios therefore help companies and others explore pathways, dependencies and uncertainties. In this report, WBCSD and the Energy Forum presents a common, transparent approach to the use of public climate scenarios when assessing the effect of climate-related risks and opportunities on strategic resilience.



Scenario typologies: There are many climate scenarios in the public domain. They are designed for a range of purposes including as a planning tool for governments and policy makers to inform their climate actions and policies. Although designed for different purposes, climate scenarios tend to explore three types of possible future – first where action is taken to address climate change (with different levels of ambition, speed and international cooperation), secondly a state of inertia based on what scenario developers know of committed or enacted climate policy and thirdly, futures in which climate change is not addressed.

Pathways and roadmaps: Although the three scenario typologies are common, the pathways towards the outcomes they explore and the global average temperature increase they imply are very varied. Pathways are modelled to show how mixes of technologies, policies, behavioral changes, GHG emissions reductions and interactions between them could lead to climate outcomes. In order to complement exploratory scenarios, some organizations publish “Roadmaps” designed to craft defined pathways to achieve stated climate outcomes.

The climate scenario reference approach for energy system companies: Climate scenarios can be used by companies to explore what possible futures imply for their strategies, plans and investments. In this report, WBCSD and the Energy Forum present a “Climate Scenarios Reference Approach” based on existing public scenarios, primarily designed for use by companies operating in the energy system. The approach is designed to achieve the project objectives described in this report.

Project objectives

The project is designed to develop an approach to climate scenario analysis for use by companies in the energy system that:


- Draws on and builds from a limited, common set of existing public scenarios that can be used by companies.
- Supports navigation and interpretation of public scenarios from a range of different providers.
- Provides access to business-relevant variables derived, expanded and disaggregated from public sources.
- Enhances corporate climate scenario analysis practices and the quality and transparency of strategic resilience assessment based on climate scenario analysis.
- Supports comparison and connections between scenario approaches developed for different audiences (e.g., real economy, financial institutions and supervisors) exploring the range of

uncertainty across different scenarios.

- Supports disclosure in response to the TCFD recommendation that companies should assess their strategic resilience to climate change using scenario analysis.
- Supports COP26 Private Finance priorities under the risk management pillar, particularly that scenario analysis in the real economy should be promoted through development of sector specific scenarios and guidance.

Extract from TCFD's Guidance on Metrics, Targets & Transition plans (October 2021)³

“Using a common set of scenarios and inputs (e.g.: parameters, timelines, industry-specific metrics, methodologies) increases comparability across companies, provides greater reliability and relevance and can help reduce the resources required by preparers to develop scenarios in-house.”



The project objectives are achieved by developing a common, transparent approach to the use of public climate scenarios when assessing the effect of climate-related risks and opportunities on strategic resilience.

TCFD recommended disclosure on strategic resilience

In 2017, the TCFD released its final report⁴ including the recommendation that companies should describe the resilience of their strategies taking into consideration different climate-related scenarios, including a 2°C or lower scenario.

The TCFD's 2021 status report¹ shows relatively low levels of disclosure in response to the strategy recommendation. There is a need to improve the quantity and quality of disclosure about the assessment of strategic resilience.

The Climate Scenarios Reference Approach developed by the Energy Forum does not offer guidance on disclosure. Rather, it shows how a range of existing public scenarios can be used by companies to assess strategic resilience in different futures defined as "Climate Scenarios Reference Families." Use of the approach is a preparatory step to disclosure on how strategic resilience is affected by climate-related risks and opportunities.

Table 1: TCFD recommendations and supporting recommended disclosures ⁴

Governance	Strategy	Risk management	Metrics and targets
Disclose the organization's governance around climate-related risks and opportunities.	Disclose the actual and potential impacts of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning where such information is material.	Disclose how the organization identifies, assesses, and manages climate-related risks.	Disclose the metrics and targets used to assess and manage relevant climate-related risks and opportunities where such information is material.
Recommended disclosures	Recommended disclosures	Recommended disclosures	Recommended disclosures
a) Describe the board's oversight of climate-related risks and opportunities. b) Describe management's role in assessing and managing climate-related risks and opportunities.	a) Describe the climate-related risks and opportunities the organization has identified over the short, medium, and long term. b) Describe the impact of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning. c) Describe the resilience of the organization's strategy, taking into consideration different climate-related scenarios, including a 2°C or lower scenario.	a) Describe the organization's processes for identifying and assessing climate-related risks. b) Describe the organization's processes for managing climate-related risks. c) Describe how processes for identifying, assessing, and managing climate-related risks are integrated into the organization's overall risk management.	a) Disclose the metrics used by the organization to assess climate-related risks and opportunities in line with its strategy and risk management process. b) Disclose Scope 1, Scope 2, and, if appropriate, Scope 3 greenhouse gas (GHG) emissions, and the related risks. c) Describe the targets used by the organization to manage climate-related risks and opportunities and performance against targets.

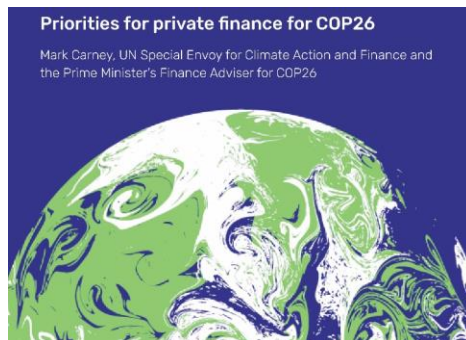
COP26 private finance priorities

The COP26 Private Finance Agenda is advanced through a framework that encourages climate change to be embedded in every financial decision through reporting, risk management and returns pillars.

The risk management pillar includes the priority that the resilience of companies should be assessed.

The associated action is to promote scenario analysis through development of sector-specific scenarios and guidance.

Figure 1: COP26 Private Finance Hub Strategy (2020)²



RISK MANAGEMENT

- Assess the resilience of companies and financial sector to climate risks.

Promote scenario analysis in the real economy through development of sector-specific scenarios and guidance.

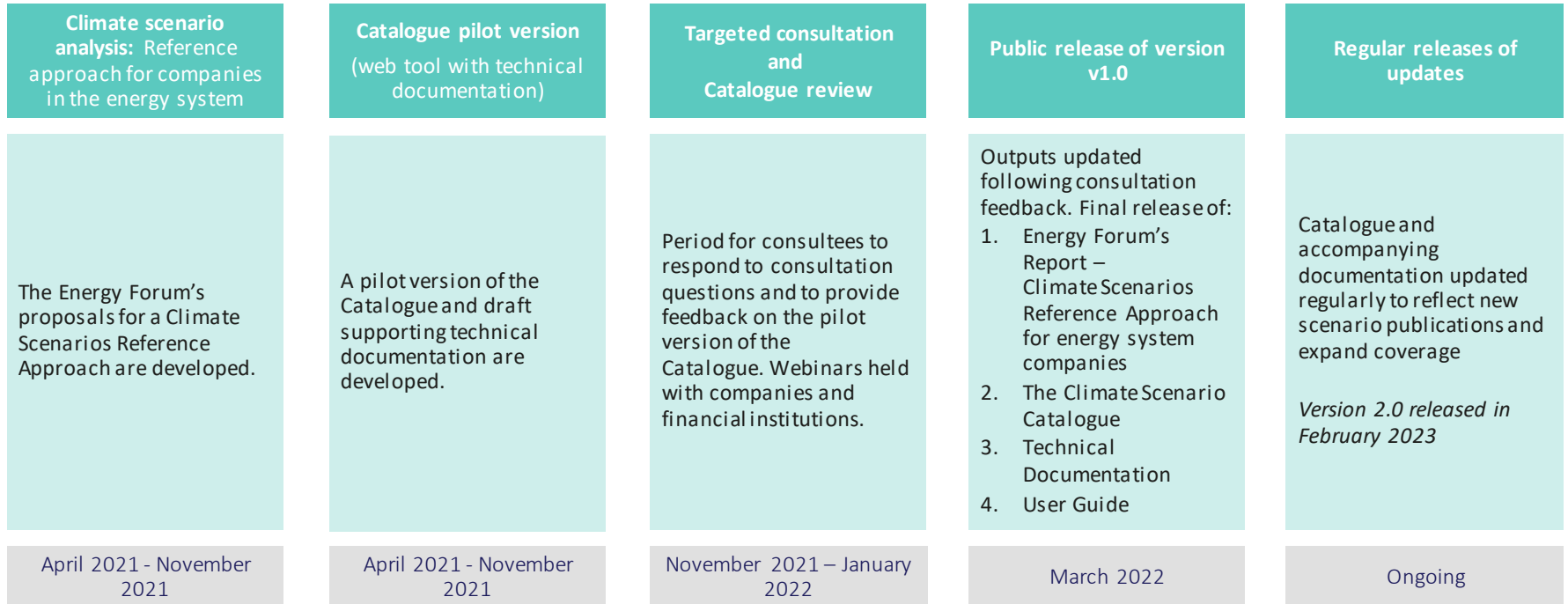
Action: companies



Project process and outputs

To advance the project objectives, the Energy Forum developed the Climate Scenario Reference Approach in this report, which together with The Catalogue, Technical Documentation and User Guide make up the project outputs.

Figure 2: Project process and outputs



3. About the Energy Forum

- Members and project structure
- Project scope
- Principles that guide the Energy Forum's work



The Energy Forum

The Energy Forum is made up of representatives from 12 leading companies that are TCFD supporters.

Forum members aim to share their experience of developing climate scenarios and/or using scenario analysis for assessing resilience to climate risks. Their experience is used to develop a Climate Scenarios Reference Approach based on existing public scenarios.

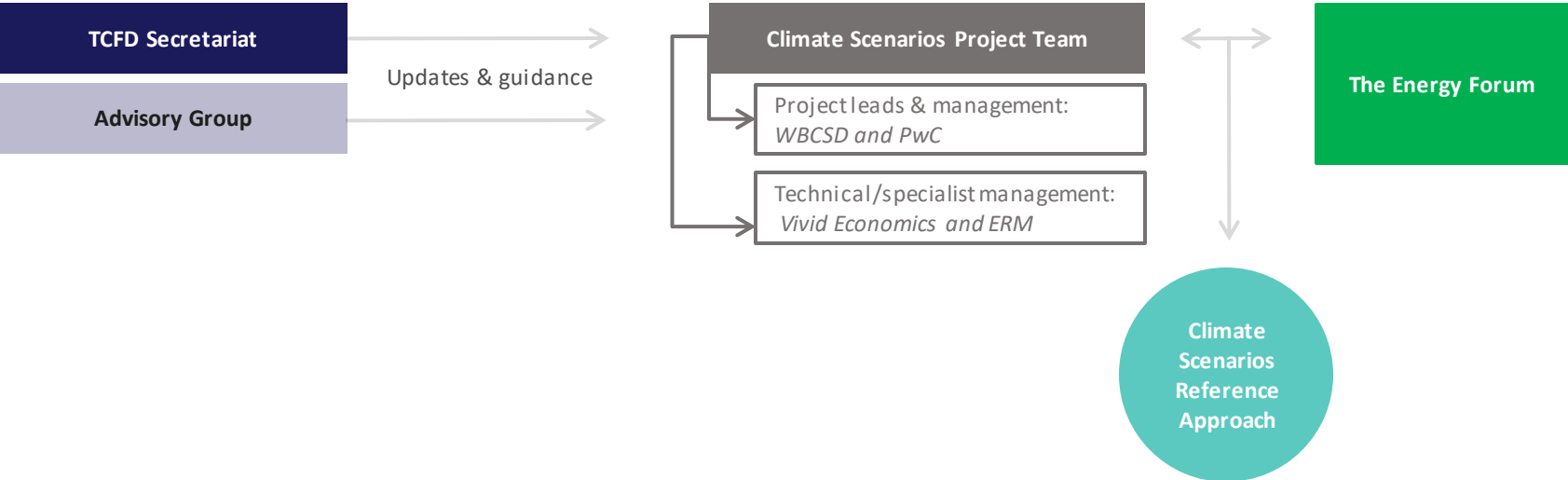
The views in this report represent a broad consensus of the Energy Forum without necessarily, in all details, representing the individual views of each Forum member or their company.



Project structure

WBCSD advanced, facilitated and coordinated the work. Vivid Economics developed the Climate Scenario Catalogue approach and a analysis and provided core technical leadership. PwC provided project management support and technical input. ERM provided technical support and led engagement with advisors. The Project Team's work is based on input and expertise from the Energy Forum and is guided by updates and advice from the TCFD Secretariat and Advisory Group.

Figure 3: Project structure



The energy system – Meaning

The ClimateScenarios Reference Approach is designed to apply to companies in the energy system. Companies in the energy system conduct activities including:

- **Production** of (primary) energy from renewable and non-renewable sources;
- **Transformation/conversion** of (secondary) energy in refineries, power stations, plants etc.;
- **Transmission/distribution** of energy between production and transformation/conversion and to end users (e.g.: by ships, trucks, pipelines, grids, etc.), including the provision of energy services;
- **Storage of energy** (e.g.: battery, pumped hydro and gas storage);
- **End use/consumption** of energy as a critical input to the business model (by industry, e.g.: steel, chemicals, non-fuel mining, construction, buildings, power and transport etc.).

The above is a simplified list of activities conducted by companies in the energy system. It does not capture all facets of the energy system or reflect the dynamic nature of the system.

Retailer businesses and individual citizens are also end users and consumers of energy and their behavior has potentially significant effects on the future of the energy system, but this project focuses on corporate end users and consumers for which energy is a critical input to the business model.

We refer to the energy system to recognize the individual and collective contributions of and dynamic interactions between companies in the energy system as the energy transition unfolds in different scenarios. Scenarios reflect differences in the speed and depth of decarbonization for different sectors within the energy system and help assess the roles that companies can play in a range of possible futures, by producing low/zero-emissions energy, embracing energy efficiency, developing and scaling investment in low/zero carbon solutions and technologies, etc.

The energy system – Project scope

Many members of the Energy Forum operate across the energy system and conduct activities in two or more of the categories listed on the previous page.

The Energy Forum is composed predominantly of energy production and transformation companies. Companies in the Energy Forum that represent end user groups have supported and provided insights into the project. They have also identified variables that need to be developed to support their resilience analyses, some of which are now included in the Catalogue v2.0. However, to enhance the utility of public scenarios for end users, more research is needed on potential changes to the type and availability of alternative materials, the implications of circular economy practices being adopted and how those potential changes affect scenarios for end users. Similarly, to increase their value to end user sectors, scenarios need to explore in more detail the way in which policy supports innovation and the deployment of breakthrough technologies.

The Climate Scenarios Reference Approach relies on public scenarios as the main source of information for the Catalogue v2.0. The expansion work carried out by Vivid Economics at the request of the Energy Forum is indicative of some of the gaps in public scenarios, including variables that cater for business-relevant scenario analysis. The “Catalogued Variables” that form part of the Energy Forum’s Climate Scenario Reference Approach primarily relate to the activities conducted by Energy Forum member companies.

Principles that guide the Energy Forum's work

The Energy Forum agreed on the following principles to guide the development of their work. Some of the principles are explained in more detail on the following page.



Simplicity – Do not add complexity by adding new scenarios. Focus on how to use existing scenarios.



Neutrality – Consider a range of possible future industry and market developments, options and solutions drawn from public scenarios.



Business relevance – Build a bridge from scenario outputs to business drivers.



Support a **common starting point and transparent approach** to scenario analysis.



Comprehensiveness – Offer an approach to scenario analysis that encourages assessment of resilience to changes in the energy system across a range of possible temperature outcomes and diverse pathways as decarbonization plans are progressed.



Support **ease of interpretation** for a range of stakeholders, particularly investors.



Simplicity

Use existing scenarios

Public scenarios often provide high-level representations of energy-economy interactions. They are typically designed to inform policy, rather than corporate decisions. They may lack key regional- or industry-level information for direct application by companies and in some cases, the assumptions and methodologies used to develop the scenarios are not clear. Therefore, using climate scenarios that do not necessarily provide business-relevant metrics or content that accounts for system, sector and value chain dynamics can be challenging for companies.

Despite these challenges, the Energy Forum agreed that it did not want to add complexity by developing new scenarios to add the existing climate scenario landscape. The Energy Forum believes that existing public scenarios, together with company-developed and other scenarios, are suitable as the basis for assessing strategic resilience to climate change. The Energy Forum's work adds value by allocating existing public scenarios to "scenario reference families" and compiling them in an online platform, known as the "Catalogue" to help companies by enabling comparisons between scenarios, their assumptions and parameters. The Energy Forum has also added business-relevant variables to the Catalogue v2.0.



Business relevance

Bridge scenario outputs and business drivers

The Energy Forum seeks to add value to existing public scenarios by identifying and developing some of the sector-specific variables most likely to impact future financial results and strategic planning. These include energy prices, technology costs, materials demand and CO₂ intensity. Examining how those variables change in different scenario reference families means that scenario outputs can be used to assess strategic resilience to particular business drivers.

In order to be business relevant, scenarios should ideally cover users' market and industry, matching the same granularity as used for business planning. As it is based on public scenarios, the Catalogue v2.0 is limited in how much granularity and sector-specificity it can provide. However, business-relevant variables have been developed and added to the Catalogue v2.0 through the disaggregation and expansion processes described in [Chapter 6](#).



Ease of interpretation

particularly for investors

Investor initiatives (e.g.: [Portfolio Alignment](#)⁵, [Transition Pathways Initiative](#)⁶, [CA100+ benchmark](#)⁷, [GFANZ](#)⁸) have been developed to help financial institutions assess the effect of climate risk on their portfolios and decision-making. These initiatives have direct and indirect effects on the way in which the results of companies' scenario analysis might be interpreted by financial institutions.

Investors need to understand scenario choices, decisions and assumptions made by non-financial companies. The structure and transparency of the Climate Scenarios Reference Approach can support this understanding. Financial institutions are increasingly using The [Network for Greening the Financial System](#)⁹ (NGFS) scenarios to support their own approaches to scenario analysis; as such, the inclusion of NGFS scenarios in the Catalogue v2.0 alongside specific energy system scenarios (e.g., [International Energy Agency](#)¹⁰ (IEA) and [International Renewable Energy Agency](#)¹¹ (IRENA)) can support mutual understanding between the approach of real economy actors and financial institutions, where appropriate.

A low-angle, upward-looking photograph of several modern skyscrapers with glass facades. The sky is filled with soft, colorful clouds in shades of purple, pink, and orange, suggesting a sunset or sunrise. The buildings are silhouetted against the bright sky, with some windows reflecting the light. A large, dark blue circular graphic element is positioned on the left side of the image, partially overlapping the buildings.

4. The Context for the Energy Forum's Work

Wider context and challenges around corporate climate scenario analysis

Drivers of and influences on corporate scenario analysis

Corporate scenario analysis practice is influenced by various factors and takes place in the context of other developments, including those listed in the boxes on this page.

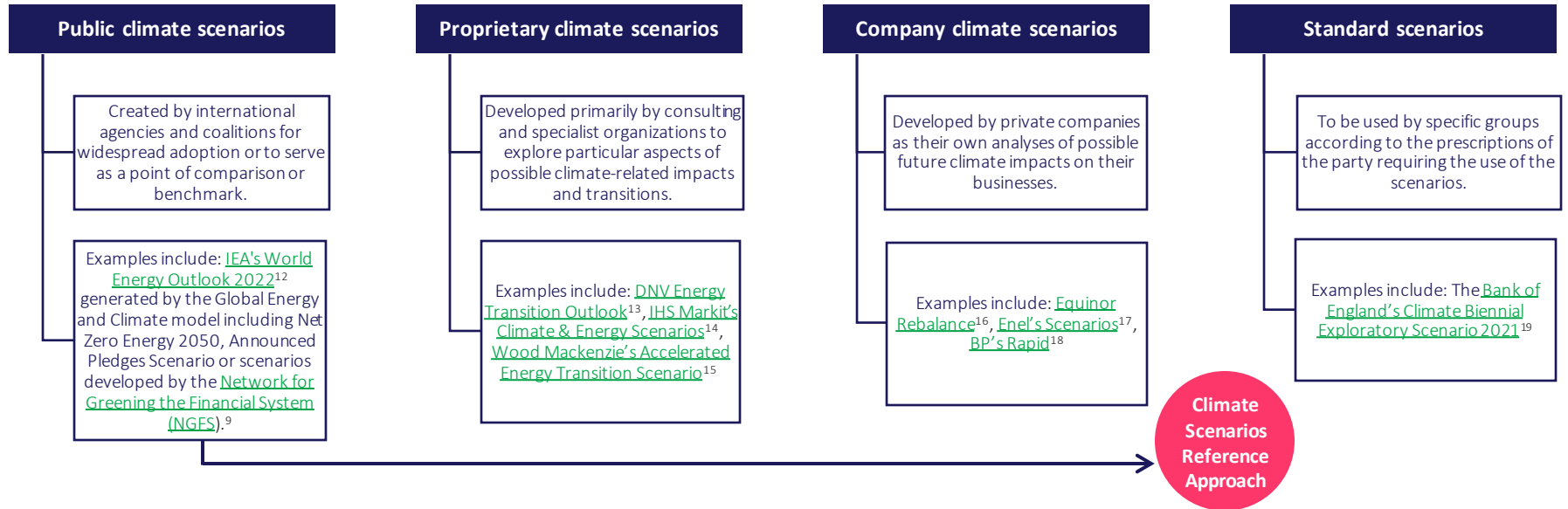
This chapter briefly considers the fast-moving context within which the Energy Forum develops its work. This includes the influence of climate scenarios and roadmaps developed by the IEA and scenarios developed for financial regulators and supervisors by the Network for Greening the Financial System, which potentially influence how financial institutions interpret corporate climate scenario analysis.



The Energy Forum's work in the wider context of climate scenarios

The Climate Scenario Reference Approach is not a new reference scenario. It is an approach to using existing public scenarios for assessing strategic resilience. It should be used to complement other types of scenarios.

Figure 4: Descriptions and examples of wider context of climate scenarios

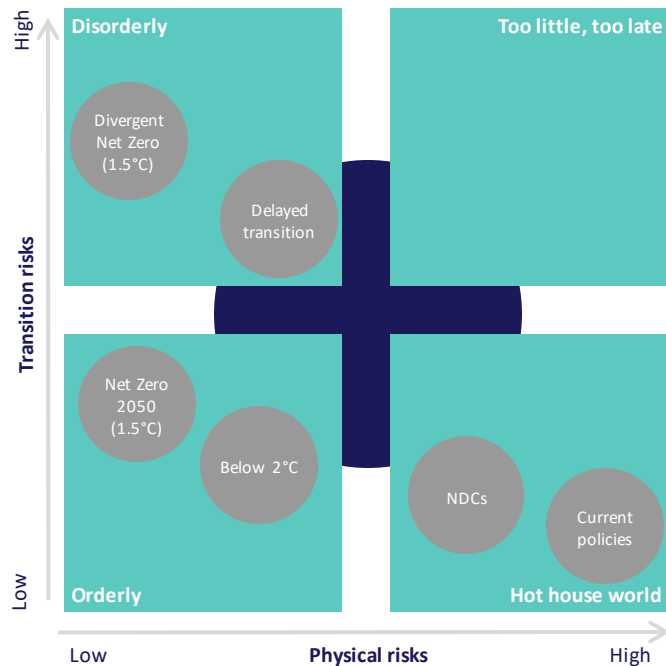


Real and financial economy scenario analysis

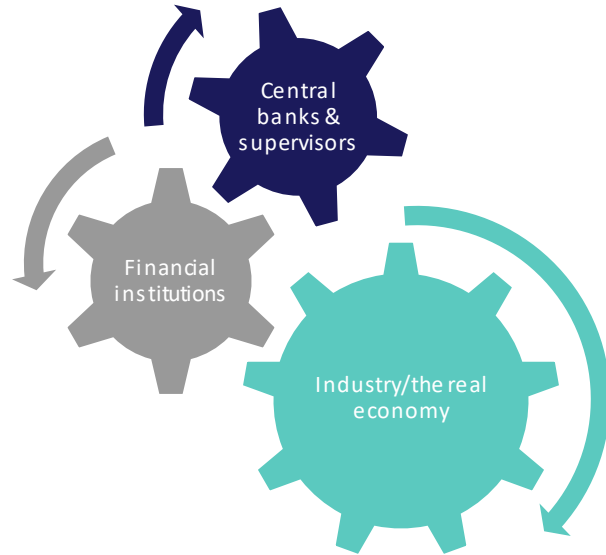
Scenario analysis is a valuable tool for understanding climate-related risks and opportunities for businesses in the real economy, for financial institutions and for financial regulators. Although climate mitigation, adaptation and resilience measures depend on complementary action by real and financial economy actors, there are clear distinctions between their practices, use cases and perspectives when applying climate scenarios.

The [Network for Greening the Financial System](#)⁹ (NGFS) has developed climate scenarios for central banks and supervisors as well as financial institutions (banks, investors and insurers) to use in stress testing and scenario analysis exercises. While not specifically designed for non-financial companies, NGFS' scenarios are broadly aligned around objectives and outcomes that are relevant to and can be used to inform companies' strategic resilience assessments. The NGFS' simple and universally applicable framing of climate scenarios has been used to inform the Energy Forum's scenario reference families.

Figure 5: NGFS scenario framework²⁰



Real and financial economy scenario analysis



NGFS scenarios have been included in the Catalogue v2.0 alongside those used more widely by energy companies, including scenarios developed by the [International Energy Agency](#)¹⁰ (IEA) and [International Renewable Energy Agency](#)¹¹ (IRENA), which provide more granular sector-specific information on key activities, dependencies, technologies and solutions that are relevant to the energy transition. The Catalogue can be used to understand where scenarios developed for financial, policy and real economy communities coalesce and diverge.

As financial firms undertake scenario analysis to conform with requirements set by central banks and supervisors, they will engage the real economy to understand implications under different scenarios. This engagement is likely to be more effective when:

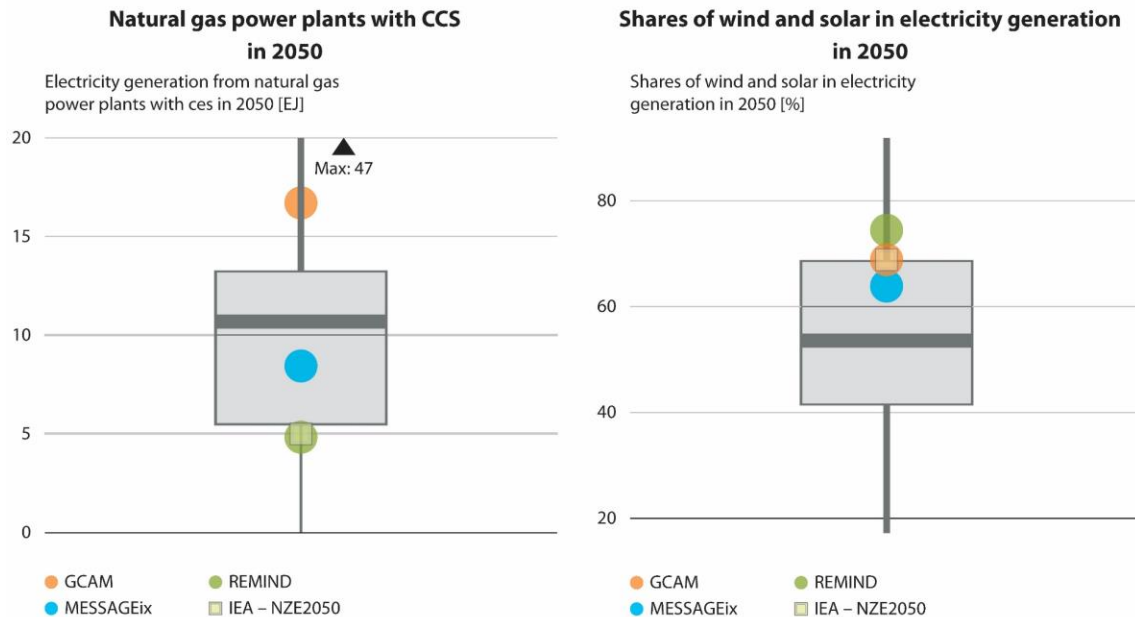
- There is a shared understanding of the way in which different climate scenarios support and inform distinct roles and capabilities of companies, financial institutions and financial regulators, respectively;
- There is agreement on the time horizons and indicative temperature outcomes according to which companies and financial institutions should use scenario analysis for decision-making and assessing strategic resilience;
- There is agreement about what types of information from corporate scenario analysis could best help investor decision-making (e.g., the implications of scenario analysis for the allocation of operational and capital expenditure).

Scenario comparisons

Challenges sometimes occur in relation to the comparison and use of different scenarios. As scenarios explore uncertain futures, there are inevitable differences relating to design, techniques, assumptions and approaches. Although different approaches are used, scenario outputs can be similar across scenarios within the same “family” (e.g., 1.5°C scenarios). The charts here compare natural gas power plants with carbon capture and storage (CCS) and shares of wind and solar generation in 2050 across NGFS, IEA and Intergovernmental Panel on Climate Change (IPCC) scenarios.

Detailed comparisons between scenarios are beyond the scope of this report. However, various comparison studies are available for further information including [IRENA’s assessment of 18 recent scenario studies](#).²¹

Figure 6: Comparing participating NGFS Integrated Assessment Models to IPCC Special Report on 1.5°C and IEA. Source: NGFS (2021)²⁰



Source: Boxplot shows distribution of results from the IPCC Special Report on 1.5°C (2018).

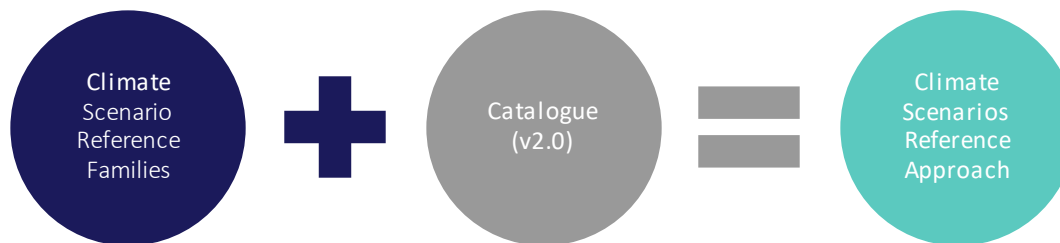
Source: Boxplot shows distribution of results from the IPCC Special Report on 1.5°C (2018).

5. The Climate Scenarios Reference Approach

- Approach
- Climate Scenario Reference Families
- Value and limitations



Climate Scenarios Reference Approach



The **Climate Scenarios Reference Approach** is **based on** a broad set of public climate scenarios that companies can use to assess their strategic resilience to a range of different futures for the **energy system** to 2050.

The term “Climate Scenarios Reference Approach” does not refer to a single new scenario. The approach allocates certain existing public scenarios to “Climate Scenario Reference Families” that reflect a broad range of possible outcomes for the energy system. The allocation of selected public scenarios to Climate Scenarios

Reference Families is shown in the Catalogue v2.0.

The Climate Scenarios Reference Approach:

- Forms a **common, transparent starting point** that can be used by companies operating in the energy system for assessing the effect on strategic resilience of climate-related risks and opportunities and for responding to the TCFD’s recommendations;
- **Is not a standard or a baseline.** It can be adapted and calibrated by companies as necessary and used to complement analysis

undertaken using proprietary and company developed scenarios;

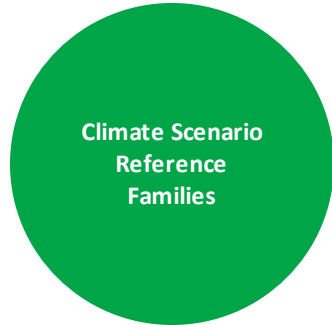
- Is **voluntary** and acts as a guide;
- Should be **helping not leading** – it is not an exemplar approach;
- Is **not intended to imply any judgement** by the Energy Forum about the probability or expectation that a particular outcome or scenario will be achieved;
- Is designed to provide a transparent and structured approach to scenario analysis so that the results can be **more easily interpreted by investors.**

Climate Scenario Reference Families

Scenario reference families encompass a broad range of possible outcomes for the energy system in the next 30 years and can be used to explore strategic resilience up to 2050 using a range of scenarios.

Scenario reference families	Definition
Paris Ambitious 1.5°C	Scenarios with outcomes designed to keep temperature rise within 1.5°C above pre-industrial levels with limited/no overshoot
Paris Aligned Well-Below 2°C	Scenarios with outcomes designed to keep temperature rise well-below 2°C above pre-industrial levels with limited/no overshoot
Current policies / BAU 2.5 – 3.5°C	Scenarios that reflect the range of current climate policies and Nationally Determined Contributions (NDCs), implying a temperature rise between 2.5-3.5°C

Rationale for choosing Climate Scenario Reference Families



In the Catalogue, a limited number of public scenarios are allocated to Climate Scenario Reference Families to help companies understand the range of uncertainty within those scenario families. The identification of three scenario reference families is not intended to imply any judgement by the Energy Forum about the probability or expectation that a particular outcome or scenario will be achieved. The families and associated scenarios allow for the assessment of strategic resilience under different climate-related scenarios, including a 2°C or lower scenario, as recommended by the TCFD.

The Energy Forum identified the scenario reference families based on:
Current practice – Most Energy Forum members that develop their own company climate scenarios include a scenario that is aligned with the Paris Agreement and therefore examine a future in which the temperature increase is kept well-below 2°C, although the scenarios reflect different views about the timescale needed to

achieve this (e.g.: [Equinor Rebalance](#)¹⁶, [Enel's Brighter Future](#)¹⁷, [BP's Rapid](#)¹⁸). Most Energy Forum members also develop bespoke scenarios designed to examine climate risks associated with higher indicative temperature outcomes (over 2.5°C). Therefore, the Paris Aligned Well-Below 2°C and Current Policies/BAU scenario reference families are consistent with existing practice by most Energy Forum members.

Activity by scientists, financial regulators, governments, investors and others to address climate change - The choice of climate scenario reference families was informed by a range of developments including the [IPCC Special Report on 1.5°C](#)²² and the sixth assessment cycle, the development and framing of the NGFS scenarios, public policy commitments on climate change, investor expectations (for example as indicated in the [ClimateAction 100+ Net Zero Benchmark](#)²³), complementary activity (for example by the [Science Based Targets Initiative](#)²⁴) and the availability of public scenarios.

Value and limitations of the Climate Scenarios Reference Approach

Value of the approach

The approach is intended to help companies by clarifying which types of scenarios are useful for assessing strategic resilience and by offering an online platform, the Catalogue v2.0, to make scenarios easier to interpret and use. The Catalogue v2.0 identifies common variables and parameters of particular significance to Energy Forum members when assessing their strategic resilience and in some cases, these variables have been developed specifically for the Catalogue v2.0. The online platform can be updated as new scenarios are developed and therefore kept current and relevant.

The approach is intended to help financial institutions understand scenario analysis choices, decisions and assumptions made by companies, the process and results of which can be more easily interpreted and compared by investors.

Limitations of the approach

The approach is not a definitive guide or optimal approach to climate scenario analysis by companies. The families and Catalogue have been developed with the objective of helping companies use a common and transparent basis for scenario analysis. But the approach deliberately does not provide stepwise guidance or prescriptive recommendations.

The approach focuses on transition risks given the relative potential impact, scale and scope for companies operating in the energy system. Public scenarios tend to cover physical risk patterns at a global or regional level. Public scenarios therefore provide some information about possible physical risk development in certain regions but are unlikely to be suitable for assessing strategic risks at an individual facility, asset or geographic location.

The approach focuses on energy supplied from a range of sources and carriers, connected with the demand from primary sectors, coupled with key technologies and emissions profiles. Limitations of the approach attributable to project scope are described in "[The energy system – Project scope](#)".

6. The Climate Scenario Catalogue Version 2.0

- Introduction and overview
- Filtering process
- Catalogue features

Introduction to the Catalogue version 2.0

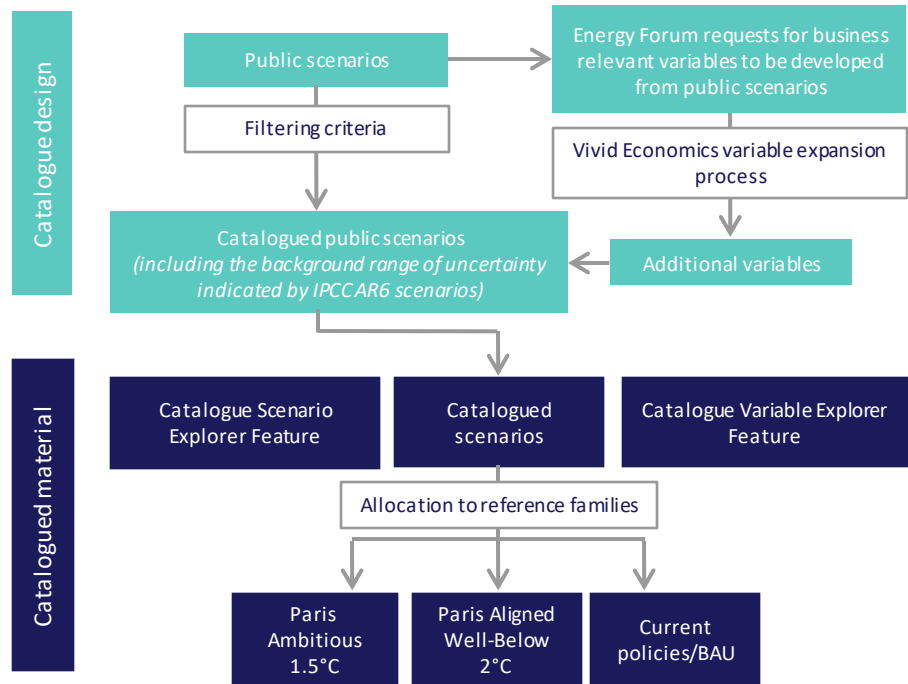
The Catalogue is an online platform containing information from selected public climate scenarios and new variables that have been developed by Vivid Economics at the Energy Forum's request. The first version of the Catalogue was released in 2022 and it was updated in 2023 with new scenarios and new features.

This Chapter:

- Explains the **purpose & design** of the Catalogue and the **filtering criteria** applied to identify public scenarios for inclusion in the Catalogue.
- Lists **the scenarios** that have been catalogued and explains how more information can be found about their characteristics.
- Outlines **the variables** that can be found in the Catalogue according to different categories, with different sector examples.
- Explains in general terms the way in which new variables have been developed through **disaggregation and expansion**.
- Introduces the **Catalogue's main features**, in particular, the Scenario Explorer and the Variable Explorer.
- Explains the **process and conditions for accessing the Catalogue**.

For more information about the Catalogue and the detailed process by which new variables have been developed, please refer to the **User Guidance** and **Technical Document** that accompanies the Catalogue v2.0.

Figure 7: Design process of the Catalogue and materials found therein



The Catalogue v2.0 – Purpose and process for identifying catalogued scenarios

The overarching purpose of the Catalogue is to collate a limited, transparent subset of energy system-focused climate scenarios that users can review, reference and apply when assessing and reporting strategic resilience to risks and opportunities associated with climate change.

The Catalogue v2.0 provides:

1. Information from a limited number of public climate scenarios that act as a baseline against and consistent reference point for conducting scenario analysis.
2. Core sector-specific variables.
3. Features that enable comparisons of scenarios and variables.
4. Greater transparency about the choice and application of scenarios.

The Catalogue is intended to be a live repository of scenarios. Our intent is to update content on a regular basis, subject to funding and resourcing.

The filtering process is designed to identify a

limited number of public scenarios for inclusion in the Catalogue v2.0 based on criteria that ensure the quality and applicability of the selected public scenarios. The criteria do not imply any judgement about the probability or expectation that a particular scenario or the associated outcomes will be achieved. The criteria are designed to catalogue:

1. The most **recent, authoritative public climate scenarios** that suit strategic resilience assessment by energy system companies.
2. Scenarios that reflect **coalescence around feasible outcomes and plausibility constraints that are defined by biophysical boundaries**, such as the availability of specific resources or land area. For example, the catalogued scenarios indicate that sustainable bioenergy is limited to 100 EJ in 2050.
3. Scenarios with **similar background**

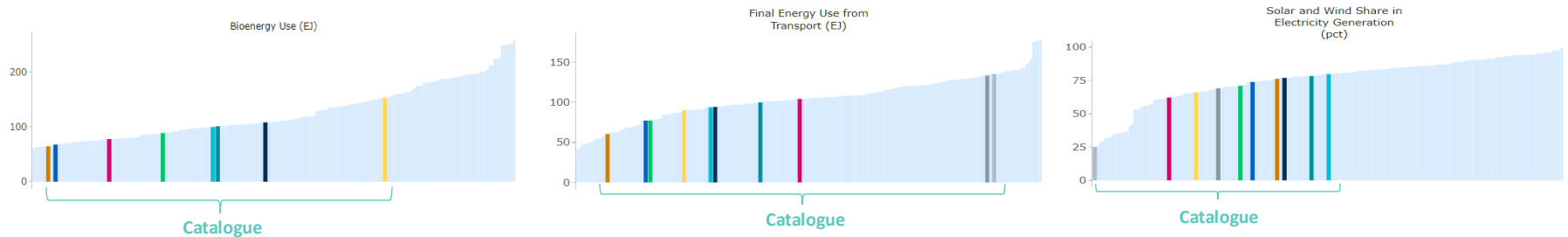
assumptions about macroeconomic, socioeconomic and technological conditions, often based on historical trends and/or projections about GDP and population changes by international authorities such as the IMF and UN. About 90% of catalogued scenarios share similar background assumptions about potential GDP changes. However, in v2.0 two alternative exploratory socioeconomic pathways are represented to illustrate uncertainties associated with GDP changes that are not captured in the other catalogued scenarios.

4. **IPCC Sixth Assessment Report (AR6) scenarios are included to provide background context** for the catalogued scenarios. In other words, the outputs from the catalogued scenarios are presented against the full background of the range of uncertainty indicated by all IPCC scenarios, demonstrating how they compare with all modelled scenarios.

The filtering process

The effect of the filtering process is illustrated in Figure 8 below. The blue background represents the full range of uncertainty across all IPCC AR6 scenarios. The bar charts represent results from catalogued scenarios. The blue parentheses show the **range of uncertainty** indicated by catalogued scenarios as a subset of all IPCC scenarios. The overall effect of the **filtering criteria** is that catalogue users can conduct scenario analyses against a transparent and limited range of uncertainty. Further information and guidance on considering the range of uncertainty when exploring variables across different scenarios is provided in Chapter 7.

Figure 8: Filtering process examples



The catalogued scenarios and allocation to scenario reference families

The Catalogue is a live online repository of selected public climate scenarios. The catalogued scenarios have been grouped into climate scenario reference families, agreed with Energy Forum members. Each family enables users to compare scenarios of similar climate ambition.

The Catalogue is primarily composed of **scenarios from authoritative institutions**, with IPCC AR6 scenarios included to provide background context. The inclusion of AR6 scenarios to the Catalogue will be considered as they emerge over time. In addition, there are two alternative exploratory socioeconomic pathways represented, a **1.5°C SSP5 High Growth** and a **1.5°C SSP3 Low Growth scenario**. These scenarios are included for illustrative purposes to show more extreme views and the **uncertainties associated with possible GDP changes** that are not reflected in the other catalogued scenarios.

Table 2 lists the scenarios that are included in the Catalogue and how they have been allocated to scenario families. The allocation and revision of scenarios to scenario families will be reviewed and updated on an ongoing basis, as new and improved scenarios are released over time.

Table 2: Scenarios included in the Catalogue v2.0

Scenario Families		
Paris Ambitious 1.5°C	Paris Aligned Well-Below 2°C	Current policies / BAU
<ul style="list-style-type: none"> • BloombergNEF – Net Zero Energy 2050 • IEA – Net Zero Energy 2050 • IRENA – 1.5C Scenario • NGFS – Divergent Net Zero • NGFS – Net Zero 2050 • Riahi et al (2017) from the AR6 Database – SSP3 (low growth) pathway • Riahi et al (2017) from the AR6 Database – SSP5 (high growth) pathway • UN PRI – Required Policy Scenario 	<ul style="list-style-type: none"> • IEA – Announced Pledges Scenario • IRENA – Transforming Energy Scenario • NGFS – Below 2C • NGFS – Delayed Transition • UN PRI – Forecast Policy Scenario 	<ul style="list-style-type: none"> • BloombergNEF – Stated Policies Scenario • IEA Stated Policies Scenario • NGFS – Current Policies • NGFS – Nationally Determined Contributions (NDCs)

Variable identification and inclusion

A core objective of the Catalogue is to provide users with insight into how business-relevant variables necessary for strategic resilience assessment change in different scenarios.

To identify a core list of variables for inclusion in the catalogue:

- An initial list of variables relevant to the energy system was compiled by the Project team through review of available scenarios and knowledge of energy system activities.
- The list of variables was further developed with the Energy Forum to reflect the variables considered most business relevant and feasible to model.

Through a series of reviews via Energy Forum discussions and member interviews, the list of variables was refined at global, regional and sector levels and finalized for inclusion in the Catalogue. The Catalogue variables are:

- **Categorized** according to their place in the energy system (inputs, outputs, indirect etc.)
- **Mapped to key business and operational criteria** identified by the Energy Forum – i.e., revenue generation, emissions abatement, macroeconomic performance, energy demand and mix.
- **Tagged** to reflect relevance to particular subsectors.

Where a variable was identified by the Energy Forum as being business relevant but not supplied in a public scenario, a process of **disaggregation or expansion** was applied to generate representative data ranges for the variable at a relevant level of granularity. An overview of the variable disaggregation and expansion approach is presented in the following pages.

All variables including those derived via the variable disaggregation and expansion process are labelled in the **full list of Catalogue variables** available to download as a spreadsheet in the Catalogue.

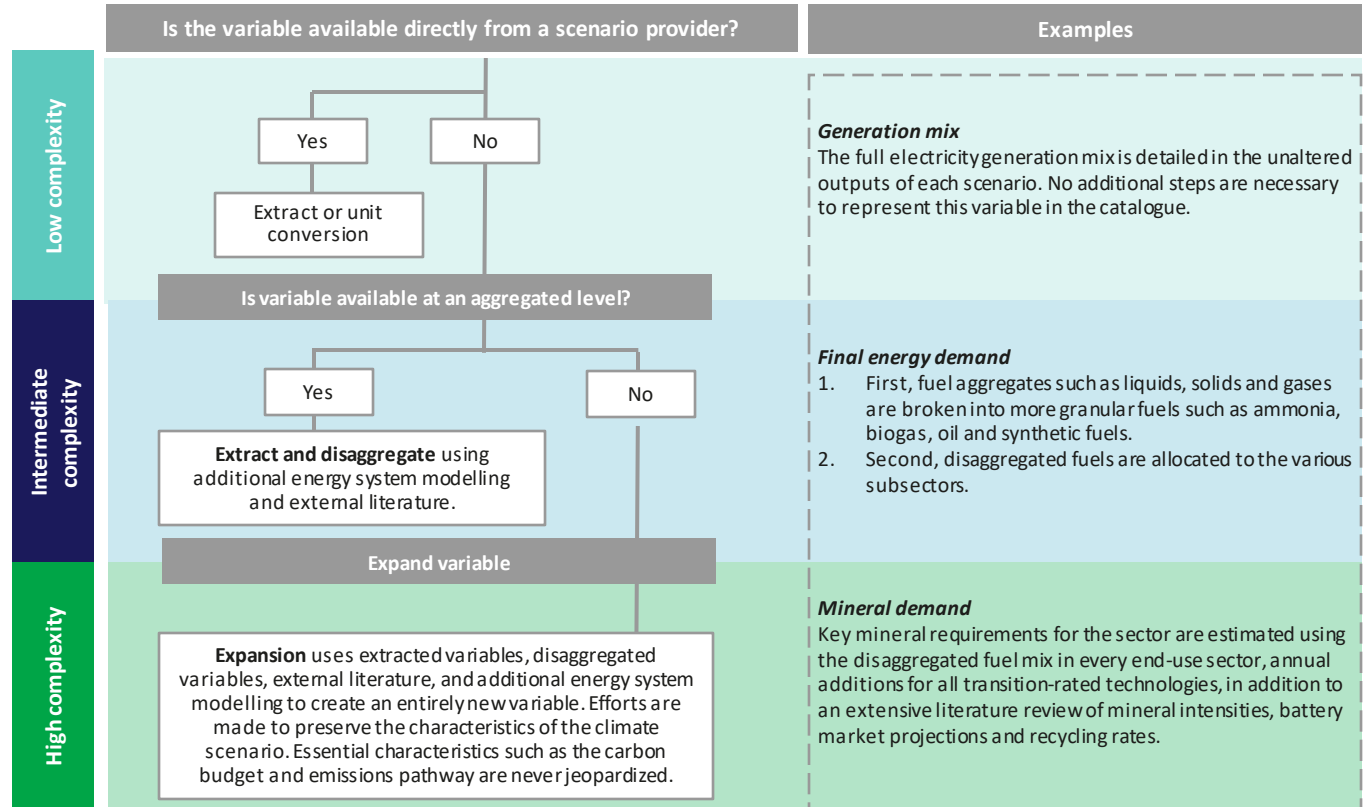
Variable development and categorization

A standardized approach was applied to categorize variables and to determine the process by which variables values are estimated.

Each variable in the catalogue was either extracted, disaggregated, expanded or partially expanded according to a process that is summarized in the standardized decision tree represented here.

The Technical Documentation provides further details about the categorization and estimation approach and principles, and about the quality assurance checks applied to disaggregated, partially expanded and expanded variables.

Figure 9: Decision tree used for variable development and categorization, with examples



Variable coverage in the Catalogue

The catalogue contains variables across a range of scenarios, sectors, sub-sectors, technologies and categories, over time.

Table 3: Description, example variables, and sector-specific examples of categories included in the Catalogue

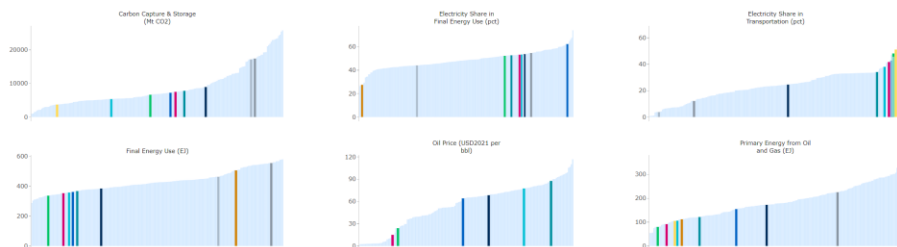
Category	Energy capacity and service	Emissions	Carbon capture and sequestration	Demand and consumption	Investment	Cost and price	Macroeconomic and climate indicators
Description	Installed energy generation capacity, annual additions, energy Intensity	Total scope 1 emissions per sector across fuels and technologies	Direct GHG emissions captured and sequestered across fossil fuels and sectors	Demand for energy, materials, cars, buildings, minerals, agriculture	Annual investment required for core elements of the transition	Cost of primary energy and price of fossil fuels	Climate damage and productivity indicators, macroeconomic assumptions such as GDP and inflation
Example variables	Annual power total capacity and required additions across fossil fuels, and renewables	Carbon intensity, industry scope 1 emissions, energy demand emissions	Direct greenhouse gas emissions captured from gas with carbon capture and storage in electricity generation	Demand for lithium from primary and recycled source, demand for synthetic liquid fuel consumption in transport	Annual investment into CCS, electricity Storage	Cost of primary energy (LCOE), cost of energy storage (LCOS)	GDP, inflation, climate damages, unemployment, productivity
Sector specific examples	Utilities / O&G – Annual additions of biomass with and without CCS	Construction – Annual scope 1 building emissions	Chemicals – CCS volume associated with all fuels for chemical sector	Mining – Demand for cobalt from primary or recycled source	Utilities – Annual investment into electricity transmission and distribution	O&G – price of oil, gas and coal mining – price of copper, lithium, nickel and cobalt	Cumulative climate damages and policy costs

The Catalogue – What are its features?

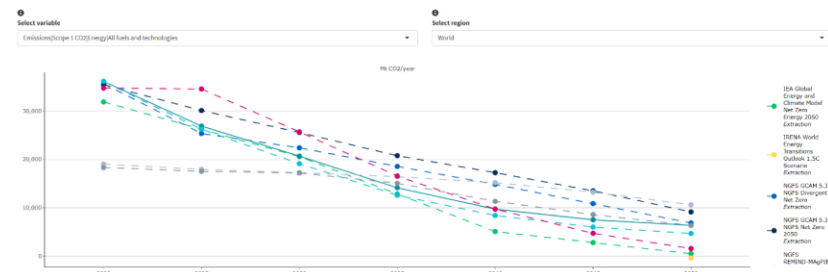
The Catalogue comprises three primary features:

1. The **Scenario explorer** – which shows how selected scenarios compare within a selected family with an optional sector lens. This allows the user to examine the distribution of scenarios within a scenario family and review the range of uncertainty associated with key variables across those scenarios. The scenario explorer helps users to interpret differences between scenarios in terms of inputs, structure and outputs.
2. The **Variable explorer** function – which presents variables in the Catalogue allowing the user to examine variable uncertainty by comparing key variables across alternative scenarios of the same family and over time.
3. The **Data download** – which allows the user to download selected data from the Catalogue.

Scenario explorer



Variable explorer



Technical Documentation and User Guide

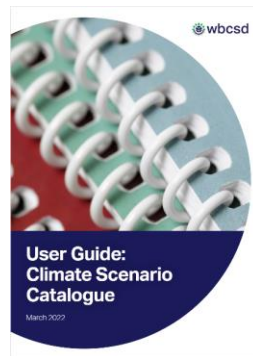
Further details relating to technical approach and Catalogue features can be found in the Technical Documentation and User Guide.



Technical Documentation

The Technical Documentation provides users with further information on the following processes:

- Scenario vetting;
- Model and variable descriptions;
- Variable disaggregation and expansion process and methods.



User Guide

The User Guidance provides further information on:

- Accessing the Catalogue;
- Navigating the Catalogue;
- Catalogue functionality;
- Key features (including the scenario & variable explorer features);
- Downloading data.

7. Business use

- Scenario use
- Principles to guide the use of the Catalogue
- Catalogue uses
- Transparency



Introduction

Scenario analysis can support different applications, stakeholders and business processes.

The Catalogue contains a limited number of scenarios selected according to the filtering criteria. However, each scenario family still comprises multiple scenarios that reflect a range of uncertainty about the future and companies will therefore have to make choices from across those ranges when conducting their analyses.

Choices will depend on a variety of factors and this Chapter explains some of the factors that should be considered when making choices from the range of uncertainty across scenarios and families. As the Catalogue is primarily designed to facilitate analyses based on ranges of uncertainty, this report does not consider how single, particular scenarios may be identified for analysis.

- 7.1. describes some **business uses of scenario analysis**
- 7.2. outlines some **general principles for making choices from the Catalogue** and provides high-level commentary on how choices might be influenced by the effect of different scenario construction, assumptions, modelling techniques and variable definitions.
- 7.3. considers **some of the ways in which the Catalogue can be used**, in particular to:
 - a. Explore ranges of uncertainty within and between scenario families using the scenario and variable explorer features;
 - b. Choose variables based on climate risk and opportunity assessment;
 - c. Explore uncertainties over near and longer-term timescales.
- 7.4. considers how to ensure **transparency** about the basis for **choices made from the Catalogue**.

7.1 Business use of scenario analysis

Climate change scenarios are a powerful tool for understanding climate change, charting response strategies, and supporting climate policy making.

Rather than a single scenario providing a forecast, scenarios analyses are typically used in combination to contrast different futures and choices.

Scenarios therefore are not about predicting the future, but comprise projections of what can happen or pathways of how to reach certain goals.

By examining variations in potential performance across a range of scenarios, organizations recognize that there is no single “solution” for the multiple possibilities of future states and transition pathways. Rather, there is a need for organizations to plan for and demonstrate strategic agility and capability to prepare for potential risks and to seize opportunities.

Organizations explore questions such as:

WHAT CAN HAPPEN?

WHAT SHOULD HAPPEN?

For scenario users, the outputs from scenarios are sets of variables that change over the range of the scenario horizon. Against the context of factors and developments highlighted on page 24, these variables can be linked to material risks and opportunities and leveraged to inform a range of business, strategy and reporting activities.

Some example areas of the application and leverage of scenario analysis are highlighted opposite.

Example business areas for the application of scenario analysis

Testing resilience against temperature outcomes, transition outcomes and investor needs

Internal strategic planning, transition planning and adaptation planning

Estimating climate-related financial impacts

Assessing opportunities

Risk assessment

Sensitivity analysis and stress testing

External disclosure

7.1 Business use of scenario analysis

Drivers and value to conducting scenario analysis

- **Drivers of climate scenario analysis**
 - External: Disclosure and regulatory requirements
 - External: Investor pressure
 - External: Reputation and stakeholder management
 - External: Sustainable/Transition Financing
 - Internal: Business model impacts
 - Internal: Risk and opportunity management
- **Business value derived from climate scenario analysis**
 - Informing climate transition strategy & investment
 - Business transformation planning & financing
 - Cost savings and efficiencies
 - Supply chain resilience
 - Reputation building
 - Service and product offering

Scenario analysis enables businesses to:

Establish an ongoing iterative process for analysis, supplementing risk management and sustainability assessment processes. For example, to identify new pockets of risks and key sensitivities of the scenario that were not initially included or identified.

Move beyond forecasting to enable Board and management to consider potential business vulnerabilities, opportunities and operational responsiveness to a range of potential future states. For example, developing strategies to address the “what if” and “how to” questions of the impacts of climate change.

Identify how risks and vulnerabilities will be sufficiently mitigated. For example, scenario-based stress testing may leverage more detailed information on climate risks to help identify new risks and to re-prioritize risks that build strategic resilience.

7.1 Business use of scenario analysis

A range of business stakeholders rely on insight from scenario analysis to deliver business strategies and management responses to climate change and transition risk and opportunity.

Table 4: Use of scenario analysis by business roles and functions

Role / function	Use of scenario analysis
Board	Provide understanding and awareness of how climate change and transition pathways will reshape risk landscapes, and to be assured that these are reflected in corporate strategy as foundations for long-term stability and business resiliency.
Executive management	Inform key management actions, business objectives and operational approaches necessary to future-proof the business model. To address the evolution of corporate environment and to deliver viable corporate performance in response to climate transitions and net-zero pathways.
Sustainability	Provide additional context to inform and extend materiality assessment processes, horizon scanning, stakeholder engagement and climate action.
Strategy & business planning	Anticipate the evolution and impact of climate transition and business challenges and to contribute to the development of adaptation (or transformation) strategies and business resiliency plans based on a range of potential outcomes and pathways. Also, testing a proposed strategy under a range of climate scenarios and market developments to determine what different outcomes could be achieved.
Risk Management	Identify, assess and prioritize climate-related risks and mitigants to inform and support design and delivery of business performance and strategic objectives over varying time horizons and transition pathways.
Investor relations	Describe to external stakeholders the scenario analysis process implemented by the company to assess the resilience of its business model to energy/climate mitigation and adaptation measures. Additionally, represent to investors and raters, the climate narrative and transition plans founded on scenario analysis and transition pathways.
Finance	Estimate climate-related financial impacts and performance of detailed financial and economic modelling to inform investment, funding, capital management, capital expenditure, operational expenditure and asset management.
Human Resources	Inform cultural and behavioral change and resourcing needs to deliver climate transition strategies and performance. Enable development of reward, development and recruitment strategies necessary to build key talent pools, skillsets and infrastructure to support business transition.

7.2 General principles for making choices from the Catalogue

The following general principles are designed to assist companies when making choices from the Catalogue.

Table 5: Principles that facilitate making choices from the Catalogue

Principle	Commentary
1. Match choices to the use case	The Catalogue and scenario analysis more generally can be applied for a range of use cases. The focus of this project is to test resilience against transition pathways, to assess climate-related risks and opportunities and for strategic, transition and adaptation planning. Choices from the Catalogue should be matched to use cases e.g.: for stress testing and tail risks a disorderly or accelerated transition scenario might be best matched to the assessment. Choices from the Catalogue also depend on the availability, quality and granularity of data and outputs required for the analysis.
2. Explore and compare a range of uncertainties and avoid blind spots	A range of uncertainties can and should be explored across a range of scenarios within a family (e.g., a range of oil prices) so that the upper and lower ranges of uncertainty (i.e., the best and worst cases implied by scenarios) can be tested rather than basing assessments on average or median outcomes or values implied by scenarios. Scenarios can be compared but primarily to ensure a valid and thorough intercomparison of different viewpoints rather than to assume consensus. Comparisons should take account of the extent to which modelling approaches can affect scenario outputs.
3. Match narrative and scenarios so that there is coherence with/within each scenario family	Ensure coherence between analyses and the scenarios on which they are based. Avoid arbitrary application of scenarios, including fusing or hybridization of elements between and across a range of scenarios with different narratives and storylines. Avoid selecting variables from different sources that would not achieve the stated outcome of the scenario (e.g., resulting in a breach of assumed carbon budget).
4. Analysis must be traceable to a scenario or scenario family	Consistent application of results from a chosen scenario family or stated scenario means using them according to their main assumptions and features. However, this does not preclude calibration of outputs for specific corporate circumstances or needs or taking account of specialist knowledge about particular technologies or industries etc.
5. Take account of interactions between scenarios and variables	Features of scenarios and variables that inform assessment of business risks and opportunities can interact to mitigate or amplify risks, enhance opportunities or give rise to indirect impacts. Therefore, although the Catalogue lends itself to exploration of changes in particular business-relevant variables, interactions with other factors may prompt the need for further analyses.

7.2 Interpreting scenarios – Design and build, assumptions and definitions

A comprehensive description of how to interpret scenarios based on different design and build approaches is beyond the scope of this report. However, some fundamental principles to consider when using the Catalogue are summarized below.

Climate scenarios are built using complex models. Different **modelling approaches** are used to develop climate scenarios, including integrated assessment models, economic optimization, technology simulation and mitigation models. There is no single "best" approach to modelling climate change scenarios, and different types of models will focus on different ways in which socioeconomic, technological and policy developments interact with and affect a changing climate.

Approaches to **model development** vary, ranging from top-down to bottom-up assessments of energy use or economic output, or jurisdiction-based models to consider the specific circumstances of a region or individual country. Limitations to current **modelling functionality** mean

that simplifications are often applied to models depending on the design, the scope and the scenario objectives. For example, scenarios designed to consider future macroeconomic developments might simplify energy system assumptions. Similarly, some more complex models may include land use interactions and feedback loops, which will impact on the modelling results and outputs.

Furthermore, the choice of definition and calculation method for certain variables also contributes to differences in model outputs as explained in the "Spotlight on carbon pricing."

Differences in scenario outputs can therefore be attributable to design parameters, modelling approaches, variable definitions and assumptions underlying the scenarios. This means that scenarios that explore the same type of future (e.g., net zero) and that use similar assumptions (e.g., around energy prices and capacity) can produce different outputs on account of the different modelling techniques and approaches that have been employed.

7.2 Interpreting scenarios – Design and build, assumptions and definitions

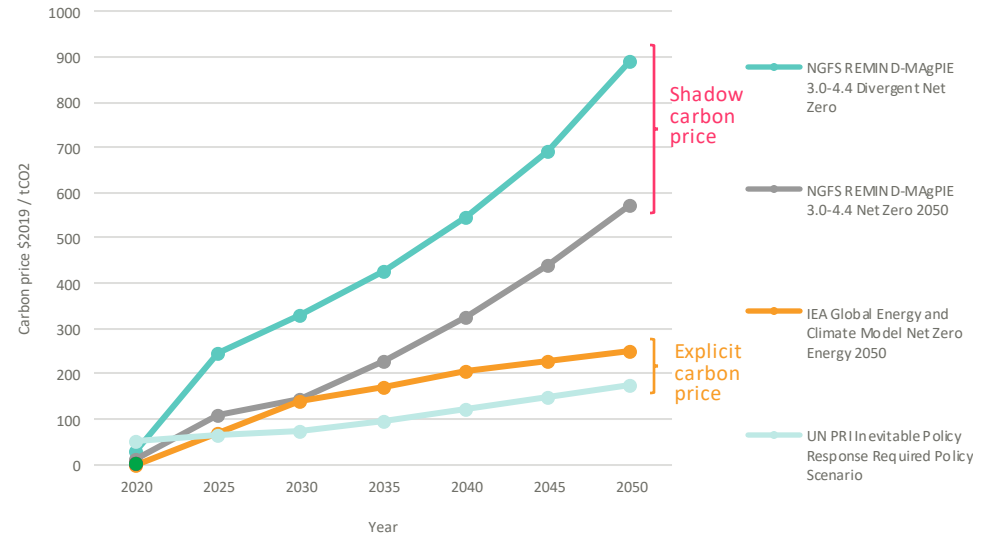
Spotlight on carbon pricing

Carbon pricing is a market-based mechanism that incentivizes low-carbon investments by internalizing the cost of GHG emissions. Climate scenario models express carbon pricing in two different ways:

1. **Explicit carbon price** (e.g., within the IPR & IEA net zero emissions scenario). The carbon price is a **direct cost** applied to emissions at the point where they occur. For example, this could be through an Emissions Trading Scheme or carbon tax, or other energy policies designed to reduce emissions.²⁵
2. **Shadow carbon price** – (e.g., NGFS & IPCC High Growth). The carbon price is the **sum of all policy measures (both direct and indirect)** to reflect the marginal cost of a abatement, or the cost of reducing emissions. For NGFS scenarios, the carbon price is a model output, meaning it is very sensitive to input assumptions (e.g., policy timing, technology assumptions, sectoral distribution) and there is a large range of uncertainty across different scenarios²⁰.

The definition used within a model, in addition to the modelling approach and assumptions taken, can produce significant variability in the carbon price output within and across scenario families. Figure 10 illustrates the variability in prices across explicit and shadow carbon prices for the 1.5°C scenario family.

Figure 10: Comparison of carbon price evolution between shadow and explicit carbon prices within the 1.5°C scenario family. Source: Vivid Economics



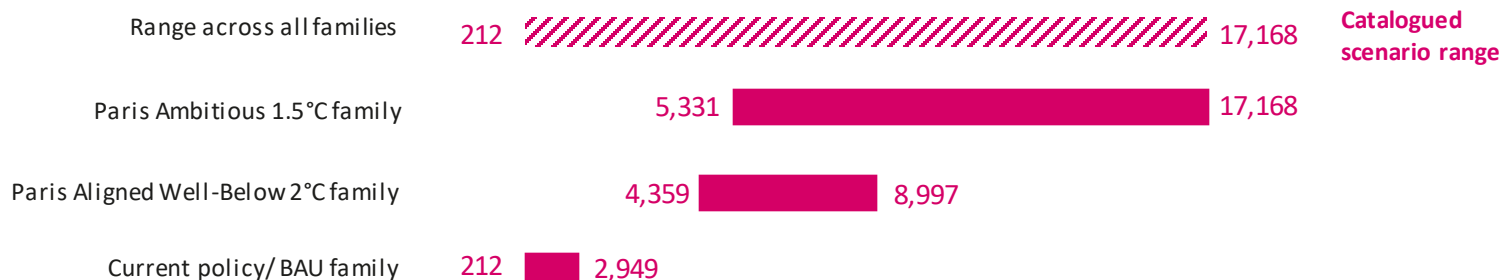
*Note that the explicit carbon price in the IEA net zero emissions 1.5°C scenario and UN PRI IPR Required Policy Scenario is shown for the European Union and the United Kingdom. All other data is at a World level.

7.3.a Exploring ranges of uncertainty within and across scenario families

Variation in ranges of uncertainty can be attributable to a variety of reasons including the logic behind scenarios (as explained in the scenario descriptions in the Catalogue) or because of different modelling techniques and calculation methods. The example below shows the range of uncertainty relating to the **amount of annual carbon capture and storage (CCS) across all energy fuels and technologies** in the year 2050 within and across families. The overall trend is indicative of assumptions about increasing CCS capacity in lower temperature scenarios. However, other factors could influence the range of uncertainty. In this case, the wide distribution could be attributable to how

different scenario developers view the potential of CCS technologies. Within the Paris Ambitious family, NGFS scenarios indicate a range of uncertainty between 5,331 and 8,934 MtCO₂/yr, whereas the IEA Net Zero Energy 2050 scenario suggests a value of 6,624 MtCO₂/yr. The IEA Announced Pledges Scenario represent the low end of the Paris Aligned family range at 4,359 MtCO₂/yr while NGFS Delayed transition (using GCAM model) represents the high end at 12,622 MtCO₂/yr. This range of uncertainty will likely depend on assumptions regarding how CCS prices develop and the assumed rate of development in the underlying technologies.

Figure 12: CCS across all energy, fuels and technologies in 2050 (MtCO₂/yr) – range across all catalogued scenarios



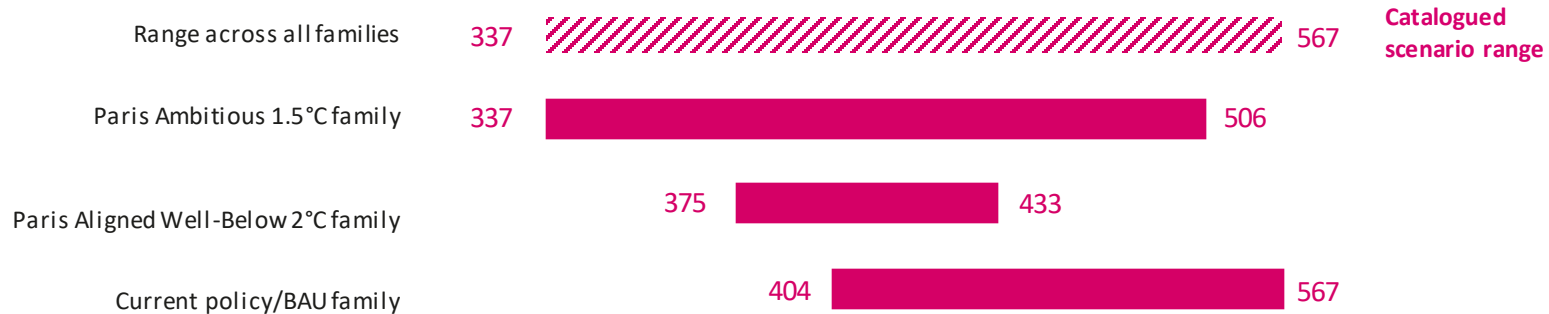
7.3.a Exploring ranges of uncertainty within and across scenario families

The Scenario and Variable Explorer features in the Catalogue can be used to explore the range of uncertainty about particular variables within and across families. The example below shows what catalogued scenarios within each family imply about changes in **Final Energy Use in 2050** and how that range of uncertainty changes across the families. The range of uncertainty in the Paris Ambitious 1.5°C family is taken from scenarios developed by BNEF, IEA, NGFS, UN PRI, and Riahi et al (2017) from the AR6 Database. The range of uncertainty in the Paris Aligned Well-Below 2°C family is based on IEA, NGFS,

and UN PRI scenarios. The range of uncertainty in the BAU family is based on BNEF, IEA, and NGFS.

The differences between these scenarios depend on assumptions such as electricity in final energy use as well as shifts in key sectors such as buildings, industry, and transport.

Figure 11: Final Energy Use in 2050 (EJ) – range across all catalogued scenarios



7.3.b Exploring variables related to risks and opportunities

A core aspect of TCFD Scenario Analysis is **linking risks, opportunities and drivers to scenario variables**. One way of using the catalogue is to explore the way in which variables connected to risks and opportunities change in different scenarios and families. The table below provides illustrative examples of climate-related risks and opportunities and associated variables available in the Catalogue.

Table 6: Material risks and opportunities, with corresponding variables included in the Catalogue

Material risk and opportunities	Catalogue variables
Changing energy mix, provision and use	Primary, secondary and final energy demand and capacity
Changing infrastructure needs	Investment in transport, transmission and storage
Prices and costs	Commodity price and levelized cost of energy (LCOE)
Changing demand	Commodity (e.g.: metals) and product (e.g.: electric vehicles (EVs) & low carbon buildings) demand
Development of technology	CCS with different fuels
Introduction of regulation	Shadow carbon pricing and policy costs
Compliance with changing emissions standards	Emissions associated with technologies and fuels

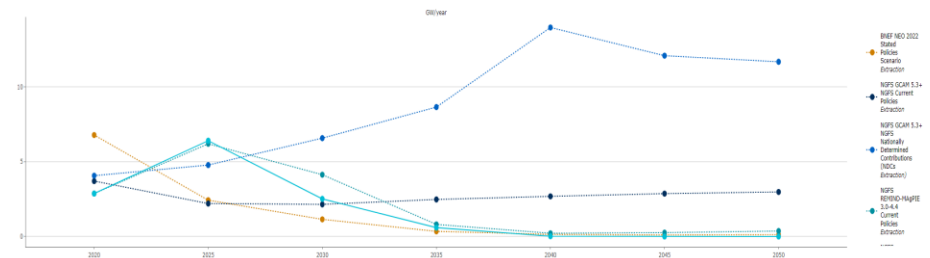
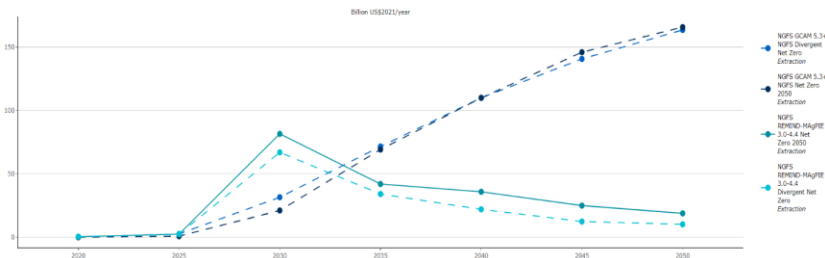
7.3.c Exploring different time horizons

The Catalogue allows users to explore changes in variables and scenarios at intervals up to 2050. In some cases, changes in the near-term may be indicative of current knowledge and data whereas longer-term changes with greater uncertainty may reflect trends that align with the characteristics and design of the specific scenario.

In the left example below, the **annual investment in energy sector CO₂ transport and storage** within the Current Policies/BAU family scenario family shows different trends across different time horizons. Two scenarios show increases in investment to 2050. The other two scenarios peak in 2030 and decrease thereafter. Considering different time horizons allows us to see these trends.

In the right example below, different trends in **bioenergy capacity additions** within the Current Policies/BAU family are seen. Whilst all scenarios show some increase in capacity additions to 2025, just one of the scenarios has a large peak in 2040. If one were to only look at the data points for 2020 and 2050, these vastly differing trends would not be seen, highlighting the importance of exploring different time horizons.

Figure 13: Examples of variations in scenarios across time horizons in the Variable Explorer
 (Left: CO₂ Transport and Storage in the Current Policies/BAU family ; Right: Bioenergy Capacity Additions in the Current Policies/BAU family)



7.4 Transparency about choices

The Energy Forum's report does not offer guidance on external disclosures about scenario analysis. However, where the Catalogue is used to inform external disclosures, organizations should be transparent about the basis on which it has been used, including:

- Which selections inform the analysis (e.g., which scenario families were used and time horizon(s) were chosen etc.).
- Whether analysis has been based on the range of uncertainty within particular families and/or on particular scenarios within families and/or on particular variables that are linked to risk and opportunity assessment.
- Whether there are particular factors that have influenced choices such as the intended use case, the availability of data in the scenario (including through disaggregation or expansion processes) and evidence of coalescence about physical limits to the way in which the future might unfold.
- Whether any outputs from the Catalogue have been calibrated or augmented to take account of specialist knowledge about a particular industry or technology or in response to limitations of scenarios.



8. Conclusions



Conclusions

A step towards advancing sector-specific approaches to climate scenario analysis

The Energy Forum and Project Team have developed a Climate Scenarios Reference Approach as a contribution to support scenario access and use. The principles, scenario families and Catalogue v2.0 offer a common and transparent basis for scenario analysis. The Forum and Project Team are aware that more work is required in order to advance sector-specific approaches to climate scenario analysis, through collaboration and dialogue, and the development of analysis and research.

Power of collaboration and dialogue

The Energy Forum is supportive of the TCFD's ambition and recommendations for companies to use scenario analysis as a tool for assessing strategic resilience. As an evolving discipline, Forum members and the Project Team valued the opportunity to exchange ideas, perspectives and develop an approach through a collaborative process. The Forum welcomes the initiatives being advanced by the international organizations, the energy sector, central banks and supervisors, financial institutions and others to develop and enhance scenario analysis practices across all parts of the economy. But more can and should be done to explore scenario-related connections and distinctions across real and financial economy applications, to encourage greater transparency, build understanding and raise awareness.

Business relevance

The Energy Forum decided that although public scenarios have some limitations for the purposes of assessing corporate strategic resilience, it is simpler and more efficient to use them as the basis for such analyses. Certain business relevant variables have been added to the Catalogue, through disaggregation, expansion or partial expansion, but a lot more can be done to support business use, assessment and evaluation of scenarios. The Energy Forum welcomes input from other companies on both the supply and demand side of the energy system on data and scenario variable needs.

An agreed research agenda and action plan are needed to complement and enhance the Energy Forum's work

Certain matters that are relevant to scenario analysis, but outside the scope of this project were identified by the Energy Forum and Project team as justifying further research. However, some recurring themes were noted, including how to support decision making and interpretation of scenario analysis results by bringing greater transparency to the assumptions and underlying narrative that affect the development of and outcomes from scenarios. The Energy Forum and Project Team also concluded that more could be done to explore roles and contributions across key value chains and supply and demand in scenarios. This includes how possible outcomes are supported or inhibited depending on how the actions of and interactions between different groups are aligned or otherwise.

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