SCIENCE BASED TARGETS

DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

PATHWAYS AND METRICS FOR THE NET-ZERO TRANSITION IN THE OIL & GAS SECTOR

RESEARCH REPORT

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ABOUT SBTi

The Science Based Targets initiative (SBTi) is a corporate climate action organization that enables companies and financial institutions worldwide to play their part in combating the climate crisis.

We develop standards, tools and guidance which allow companies to set greenhouse gas (GHG) emissions reductions targets in line with what is needed to keep global heating below catastrophic levels and reach net-zero by 2050 at latest.

The SBTi is incorporated as a UK charity, with a subsidiary SBTi Services Limited, which hosts our target validation services. Partner organizations who facilitated SBTi's growth and development are CDP, the United Nations Global Compact, the We Mean Business Coalition, the World Resources Institute (WRI), and the World Wide Fund for Nature (WWF).

DISCLAIMER

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ABOUT THIS DOCUMENT

This paper provides an overview of SBTi's research on pathways[1] and climate-related metrics for the net-zero transition in the oil and gas sector. The analysis presented here is based on the scoping and research work carried out as part of SBTi's Oil and Gas Standard Development Project in 2024 and early 2025 (please find the latest information regarding this project on the SBTi oil and gas webpage). Later publications were also included in the assessment where considered particularly relevant.

This paper does not represent a formal Standard and does not include normative target-setting criteria. Instead, it is intended as an informative technical contribution to advance understanding and encourage open dialogue on net-zero transition metrics and targets for the oil and gas sector, in line with achieving net-zero emissions by mid-century, which is consistent with the most ambitious goal in the Paris Agreement of limiting warming to 1.5°C. The objectives of the paper are threefold:

- To present a broad overview of the oil and gas value chain, possible transition models, associated transition metrics and pathways that can set the foundation for science-based target setting in the sector;
- To share progress on the research phase done as part of the Oil and Gas Standard Development Project and increase transparency around foundational research that may inform future target-setting approaches; and
- To support adjacent efforts with appropriate references to determine science-aligned benchmarks for assessing fossil fuel exposure and transition alignment.

Following a sector overview, this paper will explore transition models and metrics for relevant oil and gas activities in order to map the full landscape of options before assessing the available scenarios and decarbonization pathways. The structure is as follows:

1. **Sector overview**
   Outlines the oil and gas value chain, highlighting key segments, typical organizational structures, and major emission sources across upstream, midstream, and downstream activities.
2. **Transition models**
   Presents examples of possible transition strategies suitable for different business models and organizational structures in the sector.
3. **Transition metrics**
   Identifies relevant indicators to assess transition progress across various value chain segments and business models.
4. **Science-based pathways and benchmarks**
   Presents an overview of 1.5° C pathways available for the oil and gas sector, and the results of the SBTi's initial analysis of these pathways, including a qualitative comparison based on key criteria.
5. **Conclusions**
   Early findings around what a 1.5°C transition could mean for the sector generally, what transition models are possible and what metrics would be needed to track them.

[1] This includes scenarios that are described as limiting global warming to 1.5°C with no or low overshoot, as well as scenarios that involve a higher overshoot earlier in the century and return warming to around 1.5°C by 2100.

1. SECTOR OVERVIEW

In 2022, 55% of the total global energy-related greenhouse gas (GHG) emissions (40 Gt CO_2e) were associated with the combustion of oil and gas (IEA, 2023, p. 4). Within the oil and gas value chains, roughly 30% of emissions are associated with the production, transport and processing (operational emissions), while the remaining 70% is related to oil and gas end-use[2] (IEA, 2023, p. 8). Meanwhile, production of oil for energy use and production of unabated natural gas[3] increased by around 8% and 25% respectively between 2010 and 2022 (IEA, 2023a, p. 276).

Most emissions from the oil and gas (O&G) sector are from the downstream combustion of fossil fuel products by end-users and occur outside of the companies' organizational boundary. Climate-alignment frameworks therefore need to take a systems-level approach to addressing fossil fuel-related emissions. These approaches often reflect three interrelated perspectives:

- **Demand:** focusing on emissions – and fossil fuel demand – reductions in end-use sectors (e.g., transport, power, industry);
- **Finance:** emphasizing the role of capital allocation, investor influence, and portfolio decarbonization;
- **Supply:** addressing the responsibilities of fossil fuel producers to reduce both operational and use-phase emissions.

This paper focuses on the supply side, investigating the role of GHG emissions reduction from the production and supply of fossil fuels in 1.5°C pathways, and the appropriate climate-related metrics to describe and track the oil and gas sector transition towards net-zero.

1.1 Oil and gas value chain activities

The oil and gas sector encompasses a wide range of activities, from exploration and production of crude oil and natural gas, as well as refining, transportation, and sales of these products.

The oil and gas value chains can be broadly categorized into three main segments, upstream, midstream, and downstream, with each segment involving distinct activities, organizational structures, and emission profiles. Although there isn't a unique definition for the sector, there is general agreement within the main industry classification frameworks[4] to consider the following three main segments including the following key activities[5]:

- Upstream: Exploration and production of oil and gas.
- Midstream: Transportation, processing and storage, including LNG liquefaction, transport, storage and regasification.

[2] Does not include emissions from use of oil and gas as a feedstock, which are additional to the combustion of oil and gas.

[3] Fossil fuel generation with CCS where the capture rate is less than 95% is included in the 'unabated' natural gas category. For (unabated) gas, IEA does not report separately on feedstock use.

[4] Such as the European Financial Reporting Advisory Group (EFRAG) and Global Reporting Initiative (GRI).

[5] This categorization is not intended to be used as a formal classification of oil and gas activities, but rather as a convention to be used in this paper when describing the sector's value chains.

- Downstream: Refining, marketing, distribution and sales.

This paper focuses on oil and gas activities related to fuel production and use across upstream, midstream, and downstream segments. It excludes emissions from the use of oil and gas as chemical feedstocks, which are additional to combustion emissions. For consistency, scenario components and metrics related solely to feedstock uses are also excluded.

1.2 Emissions across the oil and gas value chains

Figure 1 below provides an overview of the key activities within the oil and gas value chains and their contribution to the overall emissions from the sector.

This assessment is based on data from the International Energy Agency (2023, 2023b), U.S. Environmental Protection Agency (2023), and Statista (2024), and is only intended to provide a qualitative overview of the most relevant emission sources from the sector to support the identification of metrics and benchmarks applicable to oil and gas activities.

The oil and gas sector's GHG profile is dominated by scope 3 use-phase emissions, which occur when end users combust fossil fuel products. As shown in Figure 1, these emissions represent over 70% of total oil value chain emissions and approximately 80% for gas[6], making them the most material component of the sector's climate impact[7].

While smaller in magnitude, scope 1 and 2 operational emissions remain significant, especially methane (CH_4), which has a global warming potential roughly 30 times greater than CO_2 on a 100 year time-horizon (IPCC 2021). Methane emissions are mostly concentrated in upstream and midstream activities such as oil and gas extraction, separation, gas processing and distribution, and they represent nearly half of the sector's scope 1 and 2 emissions in 2022 (IEA, 2023 and 2023b). Around 40% of methane emissions globally from oil and gas operations could be avoided at no net cost (IEA 2023b) and industry initiatives such as OGMP 2.0[8] and recent regulatory measures have already driven some progress. Nonetheless, the Clean Air Task Force (CATF) notes that implementation of mitigation measures remains constrained by weak regulation and enforcement and infrastructure barriers (Clean Air Task Force, n.d.).

Flaring and fuel combustion for operations also contribute to the sector's operational emissions. Natural gas flared in 2022 resulted in around 0.5 Gt CO_{2eq} emissions, the majority of which can be mitigated through existing technologies (IEA, 2023 and 2023b). Refining and transport emissions are relatively smaller but still relevant for decarbonization through electrification and efficiency improvements, representing practical areas for near-term action (IEA, 2023b).

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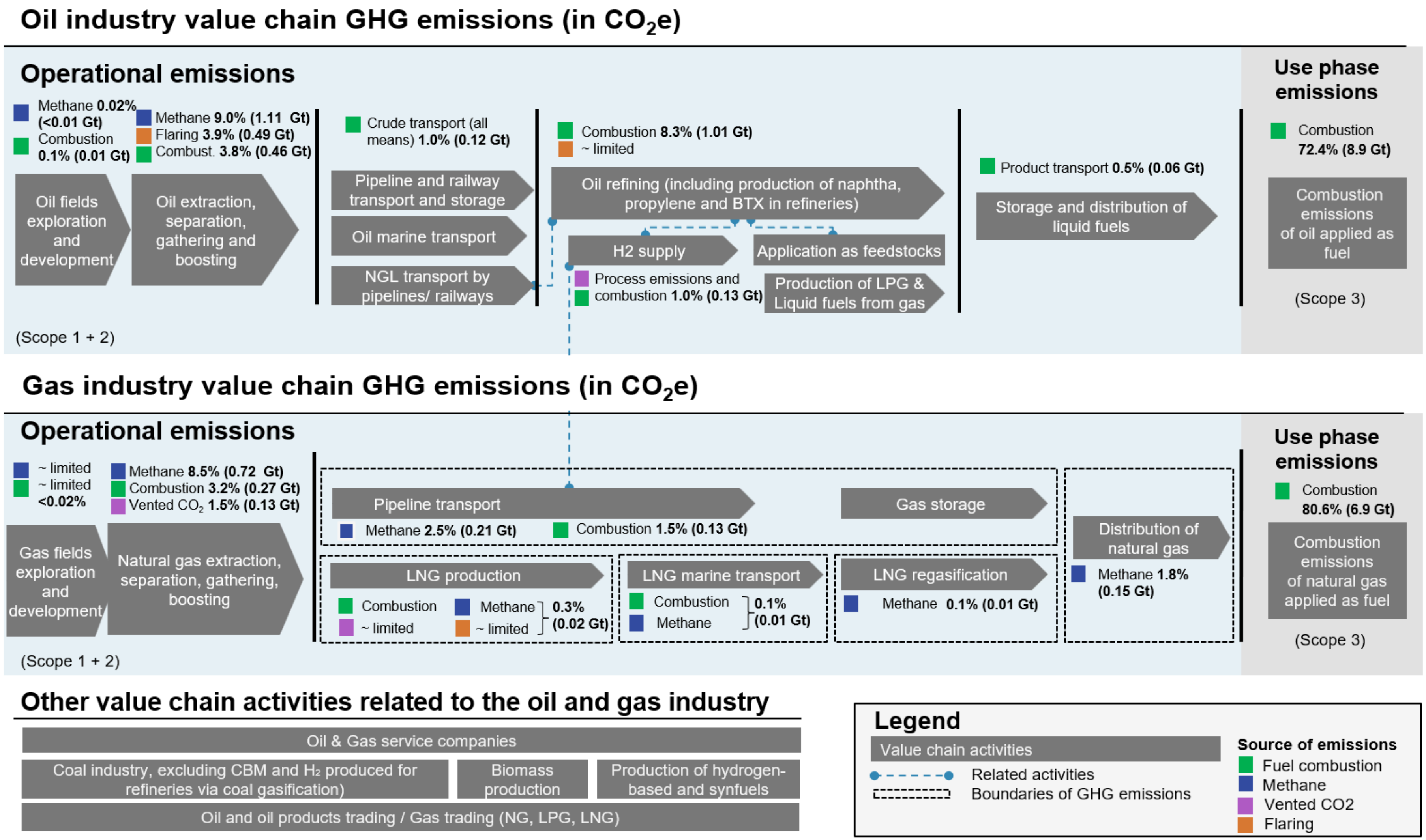
[6] Estimates vary depending on the assumed methane leakage rate and the global warming potential (GWP) timeframe used.
[7] Estimate resulting from project team analysis based on oil and gas production data from IEA NZE (2023), excluding contribution from non-fuel applications (e.g., oil and gas used as feedstock) and CCUS contribution.
[8] OGMP 2.0 (Oil and Gas Methane Partnership 2.0), a reporting framework led by the UN Environment Programme that requires oil and gas companies to measure and disclose methane emissions using increasingly rigorous, asset-level data to drive continuous reduction in methane leakage across the value chain.

The metrics and pathways explored in this paper generally relate to aggregate oil and gas value chains, with a primary focus on distinguishing between operational emissions (scope 1 and 2) and end-use emissions (scope 3 category 11), due to the substantial differences in their scale and available mitigation options.

To capture the specific decarbonization levers available within each of the oil and gas value chains, future work in developing a target-setting framework for this sector should look at further disaggregation into specific oil and gas activities and/or emission sources.

Figure 1. Operational emissions throughout the oil and gas supply chains. Analysis based on the International Energy Agency (2023e), U.S. Environmental Protection Agency (2023), and Statista (2024).



2. TRANSITION MODELS FOR THE OIL AND GAS SECTOR

Achieving a net-zero economy requires a major transformation of the oil and gas sector, which can be realized through various transition models, depending on the individual business strategy of the companies involved. Any comprehensive target-setting framework for the oil and gas sector should be applicable to a wide range of transition models, therefore understanding these possible models is essential to determine the appropriate metrics and benchmarks for this sector.

This section describes a range of possible transition models[9] based on a set of key characteristics and their implications within each oil and gas value chain segment, including adjacent sectors (such as renewable energy, hydrogen, or petrochemicals) that represent potential decarbonization options for oil and gas activities.

2.1 Conceptual framework and typology

The oil and gas business faces two key strategic choices towards their business models transition: what resources they use and which markets they aim to serve. They may continue relying on fossil resources or shift toward low carbon resources such as biomass, nuclear power or electricity-derived carriers such as hydrogen. In a similar way, they can remain focused on fuel markets (e.g., aviation, marine and road transport, or fossil-based power generation) or pivot toward non-fuel products, including non-combustion uses and chemical feedstocks.

A company's position across these two dimensions defines its transition pathway and ultimately its role in a low-carbon future.

Table 1. Typology of business models based on resource base and market focus.

Resource base	Business model	Fuel markets	Non-fuel markets
Fossil sources	1. Low-GHG-emission fuel application of fossil resources	☑	☐
	2. Managed divestment and decommissioning	☑	☐
	3. Continued production of fossil fuels for energy use	☑	☐
	4. Moving into alternative lower-emissions markets	☐	☑
Low-carbon sources	5. Changing to low carbon fuels	☑	☐
	6. Diversifying into non fossil fuel activities	☐	☑

While formulated from different perspectives, the models included here cover a similar transformation solution space as outlined by the Carbon Tracker Initiative (Carbon Tracker Initiative, 2023). Furthermore, the low-GHG-emission fuel application of fossil resources model considered in this paper (no. 1 in Table 1) aligns conceptually with the Carbon Take Back Obligation, as described by Jenkins et al. (2023), which extends producer's

[9] These are not intended to be exhaustive;companies may pursue transition models beyond those described in this paper.

responsibility to permanently store the carbon content of the fossil fuels they sell, holding oil and gas suppliers accountable for the full lifecycle climate impact of their products.

These transition models can provide a structured framework to test whether metrics and targets defined in a potential oil and gas sector standard can drive a credible transition towards net-zero.

2.2 Model descriptions and value chain implications

The business models presented in this paper include both diversifying business activities beyond oil and gas as well as maintaining supply of the limited residual oil and gas demand[10]. Some of these models are not compatible with a net-zero transition and should not be considered for future target-setting framework for the oil and gas sector, but are included in the assessment for illustrative purposes.

Table 2 below describes in detail each business model, including its strategic rationale and the key impacts for each oil and gas value chain segment, from upstream extraction to downstream end-use or alternative business models.

Alternatives beyond those outlined here are possible and companies may also pursue combinations of two or more models based on their relevant activities.

[10] Intended here as supplying the remaining, unavoidable oil and gas demand that continues to exist also in a deeply decarbonized global energy system.

Table 2. Overview of business models: value chain impacts and potential alignment with net-zero transition.

Model	Value chain impacts	Alignment with net-zero transition
1. Low-GHG emission fuel application of fossil resources	**Upstream:** Continued production with CO_2 abatement. Companies maintain fossil-based production, while reducing emissions through carbon capture and storage (CCS). This can include adding CCS to existing operations and producing natural-gas-derived hydrogen (e.g., blue hydrogen), where the CO_2 from the conversion process is captured rather than released. **Midstream:** Existing logistics remain, with potential integration/retrofit for CO_2/H_2transport/storage. **Downstream:** Retrofit or conversion for low-carbon processes.	**Conditionally aligned.** Compatible with a transition to net-zero if paired with continued efforts to mitigate emissions from operations via large scale CCS deployment. Excessive reliance on continued production and high dependency on techno/economic feasibility and social acceptance of CCS limits compatibility with a net-zero transition.
2. Managed divestment and decommissioning	**Upstream:** Natural production decline, investment in decommissioning, divestment of assets. **Mid/Downstream:** Phased shutdowns, asset transfer.	**Conditionally aligned.** Compatible with a net-zero transition if divestment leads to reductions rather than transfer of emissions, and is consistent with the timeframe for achieving global net-zero. Transparency on transferred assets and capital redeployment is critical.
3. Continued production of fossil fuels for energy use	**Upstream**: Maintaining or expanding oil and gas production, while mitigating impact of operational emissions (methane and flaring emission reduction, efficiency). **Mid/Downstream**: Efficiency improvements without structural shifts.	**Not aligned.** Not compatible with a net-zero transition and oil and gas supply decline from 1.5°C aligned pathways.

Model	Value chain impacts	Alignment with net-zero transition
4. Moving into alternative lower-emissions markets	**Upstream:** Continued oil and gas production with an adjusted output mix to serve new markets. **Mid/Downstream:** Conversion to alternative outputs for low-emissions end-uses (e.g., petrochemicals, materials).	**Conditionally aligned.** Reduction of direct combustion emissions is compatible with a net-zero transition, but continued fossil extraction raises risks of lock-in effect and stranded assets, depending on demand for low-carbon products.
5. Changing to low carbon fuels	**Upstream:** Asset conversion for production of alternative feedstocks (bio-based, synthetic, recycled carbon). **Midstream:** Conversion and retrofit to process alternative feedstocks and production of low-carbon fuels. **Downstream:** Delivery of lower-carbon fuels to existing customers with minimal disruption.	**Conditionally aligned.** Compatible with net-zero if feedstocks are sustainable and supply is scalable. Key uncertainties remain around land use, availability, and long-term carbon balance.
6. Diversifying into non-fossil net-zero aligned activities	**Upstream:** Phasing out oil and gas exploration and production, eventually repurpose facilities. **Midstream:** New infrastructure or asset repurposing, such as transmission and distribution of hydrogen/CO_2 or energy storage. **Downstream:** Expanding into new markets beyond fossil fuels that are aligned to a net-zero economy, such as electric mobility, power retail, or energy storage and services.	**Aligned.** Represents a structural shift compatible with net-zero, provided fossil phase-out occurs in parallel. Success depends on credible emissions accounting, renewable share growth, technological availability and capital reallocation toward low-carbon assets.

3. TRANSITION METRICS

A framework intended to measure the climate impact and performance of oil and gas companies requires the selection of suitable metrics that are representative of key inputs, actions, or outcomes. These may include emissions-based and non-emissions-based indicators, such as indicators of operational activity (e.g., production levels) or investment patterns.

These metrics can be paired with appropriate benchmarks (usually derived from emissions pathways) to define the performance over time, and a target-setting method for establishing actionable and verifiable targets.

Based on the key activities and relevant emission sources described in Chapter 1, different types of metrics are explored below which could be used to assess and track performance of companies operating in the oil and gas value chains.

3.1 Selection of metrics

The selection of the most suitable metrics for the oil and gas sector should consider both materiality and reduction potential of a particular emission source, but should also take into account the ability to directly implement and scale mitigation actions to maximize the impact of companies' efforts.

Research being undertaken within the development of SBTi's Corporate Net-Zero Standard V2 looks to put greater emphasis on actionability of targets, exploring alternative approaches that are less reliant on emissions-based scope 1, 2 and 3 targets. Available options may include some "alignment" or "non-emission" targets that could replace quantitative scope 3 emission targets, for example, and have the advantage of being easier to act on and to track. Such a philosophy should be explored in the development of any target-setting framework for oil and gas.

The set of metrics presented in this paper therefore expands beyond emissions to include a broad range of indicators that can be used to track the decarbonization of oil and gas as well as the transformation needed for the sector to align with climate goals.

Table 3 summarizes the set of metrics assessed, with a brief explanation of the requirements for their practical implementation (e.g., pathway, benchmark, or policy guidance), the business models to which they are most applicable and how they may effectively support the assessment of companies' performance and transition over time.

While all metrics are applicable to all business models, some may be more relevant for target setting and tracking performance within a specific transition path. The purpose of the table below is to highlight which metrics would be most relevant for the implementation of a target-setting framework compared to the transition models assessed, but the full set of metrics should be considered applicable in any comprehensive climate disclosure framework for the oil and gas sector.

Table 3. Overview of metrics assessed and applicability to business models (#1 to #6 as listed in Tables 1 and 2).*

* ***Number in green:*** *The metric* ***is relevant*** *for the business model.* ***Number in red****: The metric is* ***not relevant*** *to the business mode.*

Metric type	Metric	Description	Design requirements for the target-setting framework	Applicable business models	
Emissions based	Methane intensity	Quantifies fossil methane emissions per unit of energy product.	Availability of data for methane intensity reduction from 1.5°C aligned pathways, and consistent data measurement and reporting requirements.	1 (green), 2 (green), 3 (green), 4 (green), 5 (red), 6 (red)	Relevant for business models relying on continued fossil fuel production, in particular for gas, to track efficiency of companies' operations.
	Routine flaring emissions	Scope 1 CO_2e emissions from routine gas flared.	● Definition of benchmarks by sector activity including interim reduction milestones. ● Standardized definitions, accounting and reporting requirements.	1 (green), 2 (green), 3 (green), 4 (green), 5 (red), 6 (red)	Relevant for business models relying on continued fossil fuel production, to assess impact and performance of companies' operations. For managed divestment (2), serves to track transferred emissions.
	Operational methane emissions	Operational (scope 1) methane emissions	● Identification of abatement pathways by sector activity and applicable target-setting methods. ● Standardized accounting and reporting requirements.	1 (green), 2 (green), 3 (green), 4 (green), 5 (red), 6 (red)	Relevant for business models relying on continued fossil fuel production, to assess impact and performance of companies' operations. For managed divestment (2), serves to track transferred emissions.
	Operational CO_2 emissions	CO_2 emissions from operations (scope 1 and 2)	Definition of benchmarks by sector activity, including interim reduction milestones.	1 (green), 2 (green), 3 (green), 4 (green), 5 (green), 6 (green)	Relevant for all business models to assess impact of companies' operations and decarbonization of activities in line with net-zero, or tracking potentially transferred emissions in managed oil and gas divestments.

Metric type	Metric	Description	Design requirements for the target-setting framework	Applicable business models	
	Use-phase emissions (oil)	Scope 3 CO_2e emissions from combustion of sold oil products	● Deriving oil use-phase emission reduction benchmarks from 1.5°C demand-aligned pathways and benchmarks. ● Sector-specific accounting guidance. ● Full value-chain accounting methods to ensure traceability.	1 2 3 4 5 6	Relevant for all business models being at present the largest contribution to the sector's emissions. Relevant for tracking impact or proper transition towards low emission applications of sold products.
	Use-phase emissions (gas)	Scope 3 CO_2e emissions from combustion of sold gas products	● Deriving gas use-phase emission reduction benchmarks from 1.5°C demand-aligned pathways and benchmarks. ● Sector-specific accounting guidance.	1 2 3 4 5 6	Relevant for all business models, being at present the largest contribution to the sector's emissions. Relevant for tracking impact and proper phase down or transition towards low emission applications of sold products.
	Use-phase emission intensity	GHG emission intensity of the energy products sold	Definition of accounting boundary for the different energy carriers and methodology for calculating cradle-to-grave product emission intensity.	1 2 3 4 5 6	Relevant for business models aimed at decarbonizing the product mix or shifting towards non-fossil fuel activities.
	Carbon captured and stored ($MtCO_2$/year)	CO_2 captured and captured and permanently stored	Inclusion of robust lifecycle accounting methodologies and monitoring requirements to track CCS performance; potential double-counting between producers and users must be addressed.	1 2 3 4 5 6	Relevant for business models that rely on continued fossil fuel production intended for low-emissions applications, such as those paired with CCS.

Metric type	Metric	Description	Design requirements for the target-setting framework	Applicable business models	
Non-emissions based	Investments in new oil and gas fields development[11]	Indicator of expansion of fossil fuel supply infrastructure	• Policy guidance restricting new field approvals[12]. • Standardized definition for oil and gas projects and approval stages.	1 2 3 4 5 6	Relevant metric for business models relying on continued oil and gas production, to assess alignment with net-zero goals and monitor the risk of lock-in effect.
	Oil production	Production of fossil oil from upstream facilities	• Deriving oil production reduction benchmarks from primary energy. • 1.5°C-aligned scenarios. • Standardized accounting and reporting guidance.	1 2 3 4 5 6	Relevant metric for business models relying on continued oil production, including where intended for low emission end uses, to track fossil fuel supply decrease aligned with a net-zero transition.
	Gas production	Production of fossil gas from upstream facilities	• Deriving gas production reduction benchmarks from primary energy 1.5°C-aligned scenarios. • Standardized accounting and reporting guidance.	1 2 3 4 5 6	Relevant metric for business models relying on continued oil production, including where intended for low emission end uses, to track fossil fuel supply decrease aligned with a net-zero transition.
	Investment in low-carbon energy[13]	Capital expenditures and investment toward the development of low-carbon capacity and technologies	• Classification framework for CapEx and investment definition of low-carbon energy and technologies. • Deriving low-carbon energy investment pathways and alignment methods.	1 2 3 4 5	Relevant for business models shifting to a low-carbon energy portfolio to track how investment is provided to the development of low carbon capacity and technologies; a leading indicator of transition readiness.

[11] The SBTi Financial Institutions Net-Zero Standard (V1.0, July 2025) defines "oil and gas entities in transition" as those that are not engaging in new fossil fuel expansion activities after the publication of the financial institution's fossil fuel transition policy.
[12] See example from SBTi Financial institutions Net-zero Standard (SBTi, 2025a).
[13] Including low-carbon energy production, distribution and dedicated infrastructures. Low-carbon energy is defined as energy generated with substantially lower life-cycle greenhouse gas emissions than conventional fossil fuels delivering the same energy service.

Metric type	Metric	Description	Design requirements for the target-setting framework	Applicable business models	
				6	
	Low carbon energy production	Production of low-carbon energy	Consistent energy accounting framework, benchmarks and alignment pathways for low carbon energy generation.	1 2 3 4 5 6	Relevant for business models transitioning to a low-carbon energy portfolio to track contribution to global low-carbon energy demand.
	Low carbon energy revenue ratio	Revenues from low carbon energy / Total revenue	● Deriving pathways and methods for revenue alignment. ● Definition of low-carbon energy and technologies.	1 2 3 4 5 6	Relevant for business models shifting to a low-carbon energy portfolio to track how investment is provided to the development of low carbon capacity and technologies; a leading indicator of transition readiness.

Any target-setting framework for the oil and gas sector might include only a subset of the metrics presented in Table 3, or some may be designated as optional, providing organizations with flexibility in how they choose to measure and report their performance.

The final set of metrics will also depend on the business model and transition strategy pursued by the company. To this end, these metrics have also been preliminarily assessed against the models described in Chapter 2, to determine their relevance and effectiveness in tracking companies' performance across different business strategies and transition paths.

Emission-based metrics are suitable to measure the impact of oil and gas operations and ensure implementation of cost-effective decarbonization levers such as minimization of methane emissions and reduction of gas flaring. These metrics can be used across all transition models, provided that they are applicable to the company activities.

On the other hand, to better serve companies making a shift towards renewable resources or transitioning to non-fuel markets, non-emission metrics such as investments and production of low-carbon energy, can allow for action-based targets (to be used alongside emissions-based targets).

Final determination of standard criteria, qualifying actions, and specific metrics will be decided through the formal Standard Operation Procedure (SOP) process.

4. SCIENCE-BASED PATHWAYS AND BENCHMARKS

Pathways provide a quantitative trajectory of change in climate-relevant metrics over time, based on an internally consistent set of assumptions about key drivers, such as patterns of economic and population growth and technology development, from which target-setting benchmarks and associated milestone years can be derived.

This paper surveys a wide range of pathways from literature spanning diverse modelling approaches, regional scopes, and temperature outcomes to characterize the diversity of oil and gas transition trajectories. (See Table A.1 in Annex 1 for a complete list of scenarios).

In this chapter, we provide an overview of pathways considered by typology, including their main characteristics and assumptions and a comparison of their temperature outcomes and overshoot characteristics (4.1), followed by a comparison of the key differences in variables and trends (4.2). The quantitative assessment of oil and gas transformation, including comparison of relevant metrics in 4.2.2, considers pathways that limit warming to 1.5ºC with no or low overshoot, as well as pathways that return warming to 1.5ºC by 2100 following a high overshoot (See Table 4). Finally, 4.3 outlines the framework for pathway selection, providing a foundation for future work on science-based target setting for the oil and gas sector.

4.1 Pathways considered

The scenarios assessed in this paper draws from diverse modelling frameworks, capturing a wide range of perspectives on the transformation of the oil and gas sector in the global energy transition. The scenarios originate from a range of institutions and are underpinned by different modelling approaches, including economy-wide integrated assessment models and energy system models, which vary in their scope and treatment of climate constraints.

Institutional outlooks

Institutional energy outlooks are developed by intergovernmental or public energy agencies using bottom-up, technology-rich energy system models. They provide detailed projections of global energy supply and demand, policy and market trends, technology deployment, and investment needs, offering high sectoral granularity.

- The IEA Net Zero Emissions by 2050 (IEA NZE, 2023) presents a normative, back-casted pathway for the global energy system, outlining the scale and pace of transformation required to reach net zero by mid-century. The IEA NZE emphasizes accelerated clean energy deployment, major improvements in energy efficiency, and strong near-term action across the energy system.

- The updated NZE Scenario (IEA NZE, 2025) presented in the World Energy Outlook 2025 reflects new data showing slower than projected low-carbon technology adoption and the current reality of increasing global emissions, implying a more constrained pathway towards a 1.5°C outcome. As a result, the IEA NZE 2025 describes slower sectoral transformation in the near term, while maintaining the goal of reaching net-zero CO_2 emissions by 2050.

Integrated assessment models

Integrated assessment models (IAMs) provide representations of the energy, land-use, economic, and climate systems to generate internally consistent mitigation pathways under explicit temperature or carbon-budget constraints.

- The Network for Greening the Financial System (NGFS) develops a suite of scenarios using IAMs, to provide harmonised projections of macroeconomic activity, energy system evolution, land use, and emissions trajectory (NGFS, 2024). The NGFS scenario is designed to support financial-sector risk assessment and transition planning. The NGFS version 5 incorporates updated policy developments, technology trends, and observed emissions data. We base our assessment on the "Net Zero 2050" and "Low Demand" scenarios, which describe 1.5ºC consistent pathways driven by rapid policy-led decarbonisation and deep reductions in energy demand.

- Scenarios in the C1 category of the IPCC AR6 WGIII database (IPCC, 2023) comprise a multi-model IAM ensemble of mitigation pathways that limit peak warming to 1.5°C with no or limited overshoot. These scenarios describe stringent near-term mitigation, with rapid emissions reductions across all sectors and global net-zero CO_2 reached around mid-century. They provide a consistent economy-wide representation of decarbonisation and a robust basis for evaluating sectoral transitions within a 1.5°C-consistent global context.

Industry and corporate

Industry and corporate scenarios developed by energy companies and financial actors typically rely on proprietary, partial-equilibrium or sector-focused energy system models. Independent assessments show that several widely cited institutional scenarios, including corporate scenarios, that claim alignment with a 1.5°C goal may describe emissions pathways and overshoot dynamics that are inconsistent with Paris-aligned trajectories when evaluated using transparent, multi-gas climate assessment frameworks[14] (Brecha et al., 2022). As a result, corporate scenarios require careful interpretation when used to assess climate alignment or inform science-based target-setting frameworks.

- Shell's Sky 2050 scenario (Shell, 2023) describes a global energy transition in which society achieves net-zero CO_2 emissions by 2050, enabled by accelerated energy system transformation, large-scale deployment of clean technologies, and widespread electrification. The Sky 2050 scenario explicitly reflects continued

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[14] The work by Brecha et al. (2022) evaluated institutional decarbonisation scenarios, including corporate-led pathways and the IEA, by linking emissions trajectories to end-of-century temperature outcomes across all major greenhouse gases. The temperature outcomes of several corporate-led scenarios, including Shell Sky 1.5, BP Net Zero and Equinor, were assessed as inconsistent with the Paris Agreement, as they exceed the 1.5°C limit and fail to limit warming to well below 2°C. This reflects higher cumulative CO_2 emissions, slower near-term emissions reductions, and greater reliance on later net-negative emissions. By contrast, the evaluated temperature outcomes of the IEA Net Zero Emissions scenario were assessed to be consistent with a 1.5°C pathway.

increase in global CO_2 emissions in the near term, and follows a high-overshoot pathway that exceeds the remaining 1.5ºC carbon budget.

- The BP Energy Outlook 2020 (BP, 2020) includes a net-zero scenario as an exploratory pathway illustrating how the global energy system could evolve under stronger policy action, behavioural change, and technology deployment than implied by current policies. More recent versions of this scenario (BP, 2024) are not 1.5°C-consistent and have not been included in the analysis.
- Equinor's Energy Perspectives 2025 (Energy perspective, 2025) explores several divergent global energy futures, including the Walls and Bridges scenarios. The Bridges scenario is constructed as a back-cast, normative pathway and is explicitly designed to achieve the 1.5°C objective with no or limited overshoot, requiring rapid emissions reductions, accelerated clean-energy deployment, and coordinated systemwide policy action.

Academic and civil-society

Academic and civil-society scenarios provide independent, transparent pathways developed outside commercial or policy constraints, often emphasising equity, feasibility, and alternative mitigation strategies.

- The One Earth Climate Model (OECM) (Teske S. et al., 2024), develops high-resolution, sector- and region-specific decarbonization pathways, linking detailed projections of energy demand, technology deployment, and emissions intensities across the global economy. The OECM scenario provides granular sectoral benchmarks that support target setting, regulatory alignment, and transition-risk assessment for financial institutions and policymakers.
- The ClimateWorks Foundation's (CWF) (Monteith et al., 2023) Central scenario outlines a coordinated transition pathway built on rapid electrification, sustainable and limited bioenergy use, ecosystem protection, and behavioural and lifestyle shifts. The Central scenario serves as the primary reference case in the CWF modelling framework, complemented by an ensemble of 15 sensitivity scenarios.

4.1.1. Temperature outcomes and overshoot characteristics

Pathways differ in their global temperature outcomes and in the magnitude and duration of overshoot of the 1.5°C threshold. Scenarios that limit global temperature to 1.5°C with no or low overshoot[15] assume a global emissions peak in the early 2020s and reach global net-zero CO_2 around mid-century. More recent scenarios, including the World Energy Outlook (IEA, 2025b) and Shell Sky 2050 (Shell, 2023), reflect the reality of increasing global emissions, significantly constraining the remaining carbon budget for a 1.5°C goal[16]. These scenarios therefore imply a high overshoot of the 1.5°C threshold, despite reaching net-zero CO_2 around mid-century. For context, it is important to contrast these high-overshoot

[15] According to the IPCC WGIII, limited overshoot refers to exceeding 1.5°C global warming by up to about 0.1°C, high overshoot by 0.1°C-0.3°C, in both cases for up to several decades.
[16] The IPCC reports that for a >50% chance to limit global warming to 1.5°C, the global carbon budget is 500 $GtCO_2$ from 2020 onwards. By the end of 2024, around 160 $GtCO_2$ has been emitted, leaving an estimated 340 $GtCO_2$. Based on current global annual emissions, this remaining budget will be exceeded in less than a decade.

scenarios with the IPCC AR6 Category C2 scenarios[17], which are excluded from the scenario set assessed in this paper. The high overshoot described in C2 scenarios results from IAM cost-optimization that delays near term mitigation, relying on huge net-negative emissions in the second half of the century (IPCC, 2023). As a result, C2 scenarios exhibit higher peak warming, longer overshoot duration, slower early-century emissions reductions, and later net-zero CO_2. Importantly, the C2 overshoot profile is structurally distinct from those implied in the IEA NZE 2025 and Shell Sky 2050, which reflect delayed emissions peaking consistent with observed trends but assume more constrained CDR deployment.

[17] The IPCC C2 category is an envelope of 133 scenarios that return warming to 1.5 ºC after a high overshoot.

Table 4. List of assessed pathways for evaluating oil and gas transformation and their climate outcomes.

Source	Scenario	End of century warming (°C) (peak in parentheses)	Climate category	Net-zero year	Carbon budget from 2020 onwards	System boundary classification[18]
IPCC, 2021	C1 Category	1.3 °C (1.57 °C)	1.5 °C with low or no overshoot	2050 (median)	500 Gt CO_2 (>50% likelihood)	Economy-wide IAMs
OECM, 2024	OECM	1.3 °C (1.57 °C)	1.5 °C with low or no overshoot	2050	400 Gt CO_2 (67% likelihood)	Multi-sector bottom-up model
NGFS, 2024	Net Zero	1.4 °C (1.69 °C)	1.5 °C with high overshoot	2050 (median)	N~ 600 Gt CO_2 (>50% likelihood)	Economy-wide IAM
	Low demand	1.13 °C (1.60 °C)	1.5 °C with low or no overshoot	2050 (median)	~ 500 Gt CO_2 (>50% likelihood)	Economy-wide IAM
Shell, 2023	Sky 2050	1.24 °C (1.67 °C)	1.5 °C with high overshoot	2051	~ 700 Gt CO_2	Global energy-system model
CWF, 2023	Central scenario	~ 1.2 °C (1.56 °C)	1.5 °C with low or no overshoot	~ 2045	~ 400–500 $GtCO_2$ (>50% likelihood)	Energy–economy–land hybrid model
BP, 2020	Net Zero	~ 1.5 °C (1.65 °C)	1.5 °C with high overshoot	2049	Not reported	Global energy-system model

[18] System boundary classification refers to the scope of the modelling framework from which the scenario is derived. 'Economy-wide' denotes integrated assessment models that couple energy, industry, land, macroeconomics, and climate systems. 'Global energy-system models' denote bottom-up representations of energy demand, supply, technologies, and fuels without full economy–land integration. 'Multi-sector bottom-up models' provide disaggregated treatment of selected sectors (e.g., energy, industry) but do not represent full economy-wide interactions. IAMs are the only frameworks that generate internally consistent carbon budgets and temperature outcomes because they couple energy, land, economic, and climate systems (IPCC AR6 WGIII, Chapter 3). By contrast, energy-system models apply externally defined climate constraints or IPCC-derived emissions–temperature relationships.

Source	Scenario	End of century warming (°C) (peak in parentheses)	Climate category	Net-zero year	Carbon budget from 2020 onwards	System boundary classification[18]
IEA, 2023	Net Zero Emissions by 2050	1.40 ºC (1.57 ºC)	1.5 ºC with low or no overshoot	2050	~ 500 GtCO_2 (>50% likelihood)	Global energy-system model
Equinor, 2025	Bridges	<1.5 ºC (<1.6 ºC)	1.5 ºC with low or no overshoot	Not reported	445 Gt CO_2[19] (>50% likelihood)	Global energy-system model
IEA, 2025	Net Zero Emissions by 2050	1.45 ºC (1.65 ºC)	1.5 ºC with high overshoot	2050	500 Gt CO_2 (>50% likelihood)	Global energy-system model

[19] The IPCC AR6 estimates a remaining CO_2 budget of 500 Gt for 2020–2050 across all sectors. The Bridge scenario allocates 445 GtCO_2 of that budget to energy-related emissions.

4.2 Comparison of the pathways

This section reviews the set of scenarios assessed for oil and gas transformation, focusing on two key dimensions: the granularity of key variables and the pace of transition in oil and gas production, supply, and emissions (figures with illustrative trends in Annex 2).

4.2.1 Differences in variables and granularity.

To assess the transformation of the oil and gas sector, we track a set of key variables that describe the trajectories of oil and gas supply and demand, alongside decarbonization pathways. These variables provide a consistent basis for pathway comparison and, where reported with sufficient granularity, offer the necessary inputs for benchmarking the emissions and non-emission metrics presented in Chapter 3.

Importantly, not all pathways report these variables at the same level of detail: some scenarios offer a disaggregated view of oil and gas transformation, while others only capture aggregate trends in fossil fuels. This uneven granularity limits comparability and has direct implications for target setting.

These differences are particularly relevant when evaluating emissions from the oil and gas sector, as most scenarios offer limited granularity on the emissions sources and scopes. Reporting boundaries for oil and gas-related GHG emissions vary across scenarios and precise identification of these boundaries is necessary to meaningfully compare scenario outputs. Scenarios from the IPCC and the NGFS report sectoral operational and fugitive emissions, including liquid fuel extraction and processing (e.g., oil production, refineries, and synfuel production). In contrast, Shell Sky 2050, CWF Central, OECM, and Equinor Bridges report total emissions from oil and gas fuel-end use across the entire economy (Figure A.5 and A.6). Beyond emissions, scenarios also report different metrics and boundaries for fuel supply and demand. Both Equinor Bridges and BP Net Zero report total demand, rather than supply, by fuel type, and BP Net Zero includes biomethane in gas demand data for the 2020 Net Zero scenario, limiting comparability with scenarios that report total primary energy supply by fuel type.

The IEA NZE 2023 scenario reports both total fuel-end use combustion and operational emissions, including CO_2, methane, and flaring (IEA, 2023; IEA, 2023a), providing valuable sector-specific insight into operational decarbonization pathways for oil and gas companies, and offering an explicit benchmark for scope 1 and 2 emissions performance in the sector. Sectoral operational and methane emissions data were not yet publically available for IEA NZE 2025 at the time this research was conducted, resulting in the inclusion of both IEA NZE 2023 and 2025 in the scenario analysis.

4.2.2 Differences in the pace of key transitions

This section examines how scenarios represent the transition in oil and gas within the energy system. Differences in modelling assumptions and scenario design account for much of the variation in outcomes, and a descriptive summary of general trends by scenario type is summarized in Table 5.

Table 5. Oil and gas production, emissions, and novel/technological carbon removals by scenario type.

		INSTITUTIONAL AND IAM SCENARIOS	CORPORATE SCENARIOS	ACADEMIC & CIVIL SOCIETY SCENARIOS
PRODUCTION	GAS	**~40-70% reduction**, with gas production nearing **phase-out by 2050** in some scenarios.	**~40-70% reduction**, with some scenarios showing gas production up to **66 EJ in 2050**.	Variable outcomes, from **70% reduction** to **no decline**, relying on CDR and CCS.
	OIL	**~75% reduction**, with oil production nearing **phase-out by 2050** in some scenarios.	**~50-75% reduction**, with oil production nearing **phase-out by 2050** in some scenarios.	Variable outcomes, from near complete **phase-out** to up to **100 EJ in 2050**.
EMISSIONS	GAS	Near **100% reduction** in end-use combustion emissions, reaching **net zero in 2050** or before.	**≤2 Gt yr^{-1}** in gas end-use combustion emissions by 2050, some nearing net **zero by 2050**.	**≤3 Gt yr^{-1}** in gas end-use combustion emissions by 2050, some reaching **net zero by 2050**.
	OIL	Near **100% reduction** in end-use combustion emissions, reaching **net zero in 2050** or before.	**≤4 Gt yr^{-1}** in oil end-use combustion emissions by 2050, some **nearing net zero by 2050**.	**≤4 Gt yr^{-1}** in oil end-use combustion emissions by 2050, some **reaching net zero by 2050**.
TECH. REMOVALS		**2-4 Gt** total annual technological CDR in 2050.	**2-7 Gt** total annual technological CDR in 2050.	**0-7 Gt** total annual technological CDR in 2050.

4.2.2.1 Fossil fuel reliance

Scenarios assessed in this paper indicate that primary energy supply and associated fossil fuel production[20] reduce sharply, with sustained reductions throughout the transition period. (Figure A.1 and A.2). Across most scenarios, global oil and gas supply in 2050 falls by ~50-75%, with deeper reductions in scenarios that assume stronger demand contraction and limited reliance on carbon removals.

Scenarios highlight some key differences in the pace of decline of oil vs. gas and their relative contribution to meeting future energy demands. With the exception of CWF Central, all assessed scenarios show that gas supply peaks by 2025 at the latest and then declines steeply, falling by 40-100% by 2050 from 2020 levels (Figure A.1). Within this general trend, approaches to gas strategy diverge sharply, with some scenarios (Shell Sky 2050, AR6-C1) treating gas as a transition fuel and others (IEA NZE 2023, IEA NZE 2025, NGFS Low Demand and Net Zero, BP Net Zero) projecting a near-complete phase out by mid-century.

[20] Third-party modeling and the associated figures in Annex 2 report total fuel production as primary energy (EJ). This metric is separated from volumetric quantifications of supply (e.g. bbl oil, m^3 gas) by an energy emissions factor, and decreases in fuel primary energy supply necessitate a corresponding reduction in volumetric total fuels production.

All scenarios indicate a drastic reduction in total primary energy from oil supply, with varying pace of decline. For example, in 2050, the Shell Sky 2050 and CWF Central scenarios sustain oil production at more than half of 2020 levels, in contrast to the deeper declines in production levels observed in the OECM, IEA NZE 2023, IEA NZE 2025, Equinor Bridges, and BP Net Zero scenarios (Figure A.2).

While total primary energy supply is an appropriate analogue for fuel supply, volumetric production metrics are useful to more precisely describe upstream sector activity. The IEA NZE 2023 provides particularly clear data in this regard, identifying a production decrease of roughly 75% for both oil and gas by 2050 (IEA, 2023a). Analysis show that this level of production can be entirely met by existing upstream projects; both the IEA itself and independent scenario analyses by IISD have determined that no new long-lead-time oil and gas projects are necessary to meet the demand of a 1.5°C-aligned decarbonization scenarios (IEA, 2023b; IISD, 2023). Academic analyses, including Welsby et. al. 2021, have further concluded that emissions from the expected yield of existing global oil and gas reserves exceed the global 1.5°C remaining carbon budget, advancing the conclusion that new upstream projects and their associated production are incompatible with the 1.5°C goal.

4.2.2.2 Energy system transformation

Total primary energy supply (Figure A.3), encompassing both fossil and non-fossil sources, provides system-wide context. Overall supply determines the energy mix and the contribution of oil and gas to meeting energy demand (Figure A.4). Across the assessed scenarios, total energy supply increases until 2025, and then diverges, with scenarios reporting total primary energy supply ranging from 334 to 642 EJ in 2050. The NGFS low-demand scenario reveals the steepest decline in total energy supply, reflecting model designs that incorporate strong efficiency gains, behavioural change, and accelerated electrification, which reduce energy needs (Figure A.3).

Oil and gas currently account for more than half of global energy supply (IEA, 2023c), but their share falls sharply across 1.5 °C-consistent scenarios (Figure A.4). All scenarios except CWF Central project oil and gas to supply below 30% of total global primary energy by 2050. Within this range, the IEA NZE 2025 and IEA NZE 2023 are the most ambitious, reducing the contribution of oil and gas to just 15% of the global energy supply.

The contraction of oil and gas supply is accompanied by a structural transformation in the global energy mix. Low and zero-carbon sources, including renewables, nuclear, modern biomass and other zero-emission technologies expand rapidly to meet rising growing demand and substitute for unabated fossil fuels.

The assessed scenarios illustrate a similar trend of transformation, though the pace and magnitude differ. Across all scenarios, low-carbon sources grow from a modest share of 10-15% in 2020 to reach a dominant share of global supply by mid-century. The IEA NZE reveals the most ambitious transformation, reaching a near-complete shift to low-carbon sources by 2050. Other scenarios, including the Shell Sky 2050, NGFS Low demand and Net Zero, and the AR6, also show a significant shift to low-carbon sources but reach lower levels between 53-67% by 2050.

Recent capital allocation trends are consistent with a broader energy system transformation. Global energy investment in 2025 is projected to reach approximately USD 3.3 trillion, of which about USD 2.2 trillion is directed toward low-carbon energy, roughly double spending on unabated fossil-fuels (IEA, 2025). Upstream oil and gas investment, at about USD 570 billion in 2024, is expected to stabilize or decline slightly, while electricity-sector investment already exceeds that in oil, gas, and coal combined. In the IEA NZE 2023, annual low-carbon energy investment rises to around USD 4.5 trillion by the early 2030s, with no new long-lead-time upstream oil and gas projects required to meet residual demand (IEA, 2023a). This redirection of capital from fossil supply toward renewables, grids, storage, and electrification infrastructure underscores how investment decisions will determine the speed and credibility of the energy transition.

4.2.2.3 Treatment of oil and gas emissions

This section provides an overview of the trends in emissions from the oil and gas sector separately for end use emissions (scope 3) and emissions from operations (scope 1 and 2).

Fuel end-use combustion emissions

All scenarios identify fuel end-use combustion emissions of less than 3 Gt CO_2 for gas (Figure A.5) and 4 Gt CO_2 for oil (Figure A.6) by midcentury, requiring a decrease of roughly 60% from 2023 levels. While all scenarios agree on this decrease, total fuel end-use combustion emissions in 2050 vary significantly between scenarios, from 0.19 Gt CO_2 (OECM) to 3.4 Gt CO_2 (Shell Sky 2050) for oil and 0.04 Gt CO_2(OECM) to 2.63 Gt CO_2 for gas (CWF). To achieve net zero, fuel end-use emissions remaining by midcentury must be addressed through removals (IPCC, 2019).

While variability between the selected scenarios is relevant to the treatment of fuel end-use combustion emissions in science-based target setting, all selected scenarios suggest that total fuel end-use combustion emissions must decline sharply in 1.5°C-aligned pathways.

Sectoral operational emissions

In addition to sustained reductions in fuel end-use combustion emissions, the IEA NZE 2023's detailed analysis of operational emissions from the oil and gas activities shows sectoral emissions decreasing over 60% by 2030 and reaching or nearing net-zero for both oil and gas by mid-century (Figure A.7). While other 1.5°C limited or no overshoot scenarios including those from AR6-C1 and NGFSv5 identify similarly large reductions in sectoral emissions for both oil and gas, these modeling outputs use different sectoral boundaries and their outputs and require normalization to be compared. When normalized to 2022 levels, selected AR6-C1 and NGFSv5 scenarios yield reductions in operational emissions from gas supply ranging from 88% at the 25th percentile to 65% at the 75th percentile (Figure A.8), and reductions in emissions from oil supply ranging from 172% at the 25th percentile to 124% at the 75th percentile (Figure A.9), aligning with the conclusions of the IEA NZE 2023.

Methane emissions account for a large share of operational emissions, but are typically reported in scenarios at the aggregate energy-system level, rather than being disaggregated to oil and gas extraction. Scenarios showing total energy sector methane emissions, report significant reductions by 2030, identifying a range of 42.5 Mt CH_4 yr^{-1} at the 25th percentile to

47 Mt CH_4 yr^{-1} at the 75th percentile, a reduction of approximately 50% from 2020 (Figure A.10). The IEA NZE 2023 reports comprehensive estimates of methane emissions by fuel type, providing critical granularity for science-based target setting in the oil and gas industry, as methane mitigation levers are unique within each fuel value-chain. This disaggregated modeling by fuel-type shows reductions in oil and gas methane emissions make up more than two thirds of total energy-system methane emissions reductions by 2030, emphasizing the importance of immediate and sustained reductions in oil and gas methane emissions for science-based target setting for the oil and gas sector (Figure A.11).

4.2.2.4 Carbon management dependence

One of the major drivers of variability in the pace of fossil fuel decline in modelled scenarios is the assumed availability and scale of technological carbon dioxide removal (CDR), particularly in the second half of the century. Scenarios that assume large-scale CDR deployment tend to relax fossil phase-out, relying on CDR to offset residual emissions (Achakulwisut et al., 2023)

As shown in Figure A.12, scenarios such as the CWF Central, Equinor Bridges, and Shell Sky 2050 allow comparatively higher sustained use of fossil fuels by relying on huge CDR deployment by mid-century to address residual emissions. Conversely, scenarios with limited CDR reliance like the IEA NZE (IEA NZE, 2023) and OECM require faster and deeper fossil fuel phase-out. When compared to IEA NZE 2023, the IEA NZE 2025 shows slower decline in combustion emissions, driven by sustained oil and gas supply (Figure A.4 and A.5) in the near term, and greater reliance on CDR to address residual emissions (Figure A.12).

The scale and pace of mitigation delivered by the abatement of fossil fuel use-phase combustion emissions with point-source carbon capture and storage (CCS) defines the relationship between total primary energy per fuel (Figure A.1 and A.2) and associated use-phase combustion emissions. Pathways vary in CCS reliance to mitigate fossil fuel use. For example, the CWF Central Scenario projects extensive reliance on natural gas with CCS, while the IEA NZE and NGFS Net Zero 2050 scenarios deploy more limited amounts, and the OECM pathway assumes none. This reliance on CCS leads to noticeably slower fossil fuel phase-out, best exemplified by the CWF Central Scenario.

4.2.2.5 Regional differences

Pathways vary in how they represent regional differences (such as between emerging and developed economies), across oil and gas supply and consumption. Analyses indicate that the pace of transition varies by economic development. Developed economies are expected to see faster reduction in oil and gas consumption, while emerging markets sustain consumption longer to meet growing energy needs (IEA NZE, 2021).

IEA (2023b) provides disaggregated regional data for the pace of change in oil and gas production under the 2023 NZE scenario. Between 2022 and 2050, fossil gas production falls across all regions, with the most significant decreases in Europe (92%), Eurasia (84%), Africa (82%). The smallest declines are identified for the Middle East (59%) and Central and South America (75%). Like gas, reductions in oil production are observed across all regions in the 2023 NZE, with Europe (89%), Asia Pacific (87%), Eurasia (86%), identified for the largest decline, and the Middle East (62%) and Central and South America (75%) identified for the smallest decline.

4.3 Frameworks for pathway selection

A wide range of emissions scenarios and pathways is available across the climate modelling literature, reflecting diverse assumptions about technological development, economic dynamics, policy ambition, and societal change. While this diversity is valuable, it also creates complexity for users seeking to identify pathways that are appropriate for science-based target setting. Navigating this landscape therefore requires clear guiding principles to support consistent, transparent, and scientifically robust pathway selection.

To address this challenge, the SBTi has developed a set of overarching principles to guide the selection of scenarios and pathways used across its standards and technical foundations (SBTi, 2025). These principles are intended to ensure that pathway choices are aligned with climate science, SBTi's mission, and the practical requirements of corporate target setting, while remaining sufficiently flexible to incorporate emerging evidence and evolving modelling output over time.

In the case of specific sectors such as oil and gas, pathway selection requires additional considerations. Economy-wide, top-down modelling frameworks provide essential system-level context, including global carbon budgets, temperature outcomes, and cross-sectoral trade-offs. However, the transition of a specific sector is shaped by distinct structural characteristics (e.g., long asset lifetimes, infrastructure lock-in, capital intensity, and the central role of investment decisions) that are not fully captured through economy-wide averages alone. As highlighted in the analysis developed in this report, oil and gas companies may pursue fundamentally different transition models, reflecting variation in resource bases, market focus, and strategic responses to decarbonisation pressures.

As a result, the direct application of generic system-level filters is insufficient to assess the suitability of pathways for oil and gas target setting. Rather than translating economy-wide quantitative thresholds directly to the sector, pathway selection should therefore emphasise sector-specific filters that are robust across alternative transition strategies. In particular, growing convergence across the scenario and benchmarking literature points to the importance of identifying no-regret actions and clear red lines that remain valid regardless of underlying assumptions about demand, market share, or technology deployment. Such red lines could relate to the avoidance of long-lived investment lock-in, the expansion of unabated fossil fuel supply, and reliance on speculative or highly uncertain mitigation options to justify continued production. Focusing pathway evaluation on these robust constraints might provide a more resilient and transparent basis for science-based target setting.

5. CONCLUSIONS

This paper provides an overview of transition models, transition metrics, and 1.5°C pathways for the oil and gas sector and preliminary insights into the challenges in setting up a rigorous, fair and comprehensive target-setting standard to be used to develop validatable corporate targets. The analysis includes the following initial conclusions around what a net-zero transition, compatible with the internationally agreed goal of limiting warming to 1.5°C, means for the sector generally, and which metrics a target-setting standard would need to employ to drive different types of transition.

On metrics, the question of which of these should apply to which type of company can be complex and will vary depending on the type of transformation the company intends to undertake. If several transition models apply, this implies that each company setting targets might require a different set of metrics and corresponding benchmarks, depending on the transition model they intend to pursue. Among the transition models explored in this paper, only those aligned with a net-zero transition should be considered in determining the appropriate metrics and corresponding 1.5°C-aligned benchmarks within a target-setting framework for the oil and gas sector.

The pathways, despite their variability, generally point to a few core trends that would be essential in any target-setting framework. A reduction in total primary energy supply and associated oil and gas production is projected in all scenarios assessed, with some pointing out that current and future oil and gas residual demand can be met without investments in new upstream conventional projects. Fuel end-use combustion emissions decline accordingly in all scenarios, with differences in the rate of decline between oil and gas driven by each fuel's distinct end-use application and the relative contribution of CCS to the mitigation of fuel end-use combustion emissions.

A number of actionable levers are available to reduce oil and gas operational emissions (scope 1 and 2). Methane emission mitigation is a key driver for decarbonizing oil and gas operations, which contribute to more than two thirds of the total energy-system methane emissions reductions by 2030 (IEA, 2023), highlighting the importance of immediate and sustained reductions which are available through cost-effective technologies. The elimination of routine flaring and CO_2 emission reductions through electrification and efficiency are also key levers for decarbonizing oil and gas activities.

Further work is needed to select the appropriate pathways for oil and gas target setting based on credibility, 1.5°C alignment and granularity of the metrics and benchmarks that they can provide. Where pathways do not provide a means to derive relevant benchmarks for target setting, other ways of deriving and justifying these may be explored.

The research presented here also highlights that the complexity of the oil and gas value chains and variety of transition models available for this sector might limit applicability of a Standard that addresses oil and gas activities as a whole. A more efficient approach may be to address oil and gas value chains separately with specific target-setting frameworks tackling a more limited set of company types and actions in the first instance, and adding further normative elements later on. The insights from this research will inform future target-setting approaches within the SBTi's oil and gas sector work.

ANNEX 1. SCENARIO LIST AND MODELLING CLASSIFICATIONS

The longlist of scenarios summarized in Table A1 is not intended to be exhaustive and should be considered in the context of ongoing research and update to scenario databases for evaluation and potential use in a future target-setting framework for the oil and gas sector. These pathways can be grouped into two wider categories reflecting the different modelling approaches. While these broad categorizations provide a relevant distinction to categorize model outputs, some modeling approaches may combine elements of both of the following categories:

- **Top-down models,** including IAM-based pathways such as those in the IPCC AR6 and NGFS scenario sets, project fossil fuel production based on system-wide interactions across energy, land use, economic activity, and climate constraints. These models provide policy-relevant insight into global environmental change.

- **Bottom-up models,** including institutional and corporate outlooks such as the IEA NZE or BP Energy Outlook, capture disaggregated fuel types, emissions sources, and regional production characteristics, providing the level of granularity required to assess activity-level mitigation options, infrastructure lock-in risks, and investment decisions across the oil and gas value chain.

Table A1. Initial longlist of scenarios for evaluation.

Scenario name	Modelling classification	Institution / Reference
SR1.5 1.5 °C Pathways (P1–P4, LED)	Top-down IAM-based global mitigation pathways	IPCC SR1.5 (2018)
AR6 WGIII C1 Category (AR6-C1)	Top-down IAM-based global mitigation pathways	IPCC AR6 WGIII (2022)
AR6 WGIII C2 Category (AR6-C2)	Top-down IAM-based global mitigation pathways	IPCC AR6 WGIII (2022)
Net Zero Emissions by 2050 (NZE)	Institutional energy outlook (bottom-up energy system)	IEA (2023, 2025)
One Earth Climate Model (OECM)	Academic/civil society pathway (sectoral/energy bottom-up assessment)	Futures (2022)
Network for Greening the Financial System (NGFS) Phase 5 Scenarios (NZ2050, Low Demand, Below 2°C, Delayed Transition, NDC)	Top-down IAM-based global mitigation pathways (applied in finance)	NGFS (2024)

Scenario name	Modelling classification	Institution / Reference
Accelerated Energy Transition (AET 1.5)	Industry/corporate scenario (proprietary bottom-up sectoral)	Wood Mackenzie (2021)
Fast Transition Scenario (INET)	Academic/civil society pathway (bottom-up empirical/statistical diffusion)	Institute for New Economic Thinking (Rupert Way, 2022)
Unextractable Fossil Fuels in a 1.5°C World (Unextractable)	Academic/civil society pathway (top-down IAM variant, TIAM-UCL)	UCL (Welsby, 2021)
EU Net-Zero Energy System Pathway (EU-NZ)	Institutional energy outlook (top-down EU JRC multi-model)	Publications Office of the EU (Tsiropoulos, 2020)
Growth Positive Net-Zero Pathways (Growth)	Academic/civil society pathway (top-down macro-socioeconomic)	Sitra Studies (Drummond, 2021)
Global Energy and Climate Outlook (GECO)	Institutional energy outlook (top-down POLES-JRC)	European Commission (Keramidas, 2023)
Shell Sky Scenario (Sky 2050)	Industry / Corporate scenario (bottom-up)	Shell (2021)
Climate Works Foundation (CWF)	Academic & civil society pathway (synthesised from Top-down IAMs and commissioned modelling)	Climeworks foundation (2023)
World Energy Transition Outlook (IRENA)	Institutional energy outlook (bottom-up energy system)	IRENA (2023)
Oil and Gas Pathways to Net-Zero (Oil and Gas Pathway)	Academic pathway (bottom-up sector-focused energy-system modelling)	China University of Petroleum (Zhoujie, 2023)
World Energy Outlook	Institutional energy outlook (bottom-up energy system)	WEO (2025)
Equitable Phaseout of Fossil Fuels (Equitable Phaseout)	Academic/civil society pathway (top-down equity-based allocation)	Civil Society Equity Review (2023)
Paris-Aligned Phaseout Pathways (Phaseout Pathways)	Academic/civil society pathway (top-down budget allocation)	IISD (Calverley, 2022)
BP Net Zero	Industry / Corporate scenario (bottom-up)	BP (2024)

Scenario name	Modelling classification	Institution / Reference
BP Net Zero	Industry / Corporate scenario (bottom-up)	BP (2020)
Energy Transition Outlook (ETO)	Industry/corporate scenario (independent research); Top-down	DNV (2023)
Energy Perspectives (Bridges, Walls)	Industry / Corporate-led	Equinor (2025)
World Oil Outlook (OPEC)	Industry / Corporate-led (top-down)	Organization of the Petroleum Exporting Countries (2022)
ExxonMobil Global Outlook (Exxon)	Industry / Corporate-led	ExxonMobil (2024)
International Energy Outlook (EIA)	Institutional energy outlook (government, WEPS+, top-down)	U.S. Energy Information Administration (2023)
EnerFuture Scenarios (Enerbase, Enerblue, Energreen)	Institutional energy outlook (top-down POLES-based)	Enerdata (2024)
Fossil Fuels in Transition,ETC (ACF, PBS)	Academic/civil society pathway (think-tank synthesis)	Energy Transition Commission (2023)
Net-Zero Scenarios and Cases (S&P)	Industry/corporate scenario (proprietary market analysis)	S&P Global (2023)
Global Energy Scenarios (Rystad)	Industry / Corporate-led	Rystad (2023)
New Energy Outlook (BNEF)	Industry / Corporate-led	BloombergNEF (n.d.)
South Africa Just Energy Transition Plan (JET IP)	National transition pathway	South African Government (n.d.)
Nigeria Energy Transition Plan (NETP)	National transition pathway	Nigerian Government (2022)
Angola Energy Transition Plan (AETP)	National transition pathway (top-down policy/strategy document)	IEA (2015)
Ghana National Energy Transition Framework (GNETF)	Institutional (bottom-up)	King's College London (Sefa-Nyarko, 2024)

ANNEX 2. FIGURES

This annex presents a selection of illustrative trends to support a comparison of the pathways assessed, as described in section 4.2. Each figure below may include only a sub-set of scenarios, selected based on availability of data for the metrics presented.

Figure A.1. Primary energy supply (EJ) from gas in selected scenarios.[21]

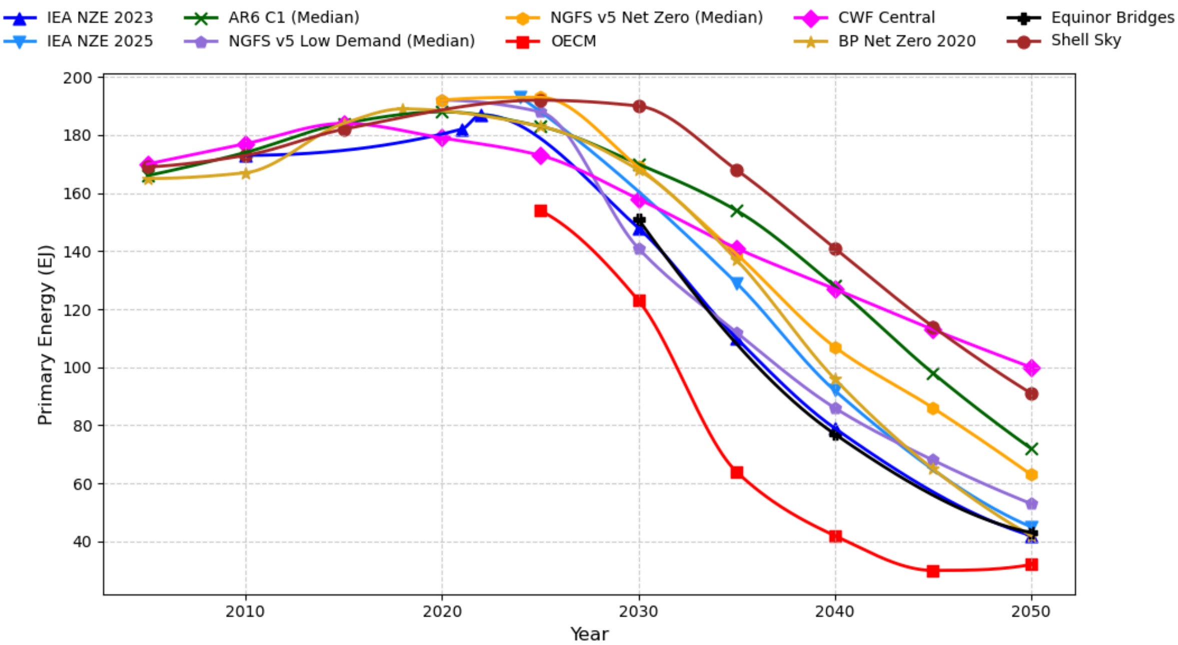
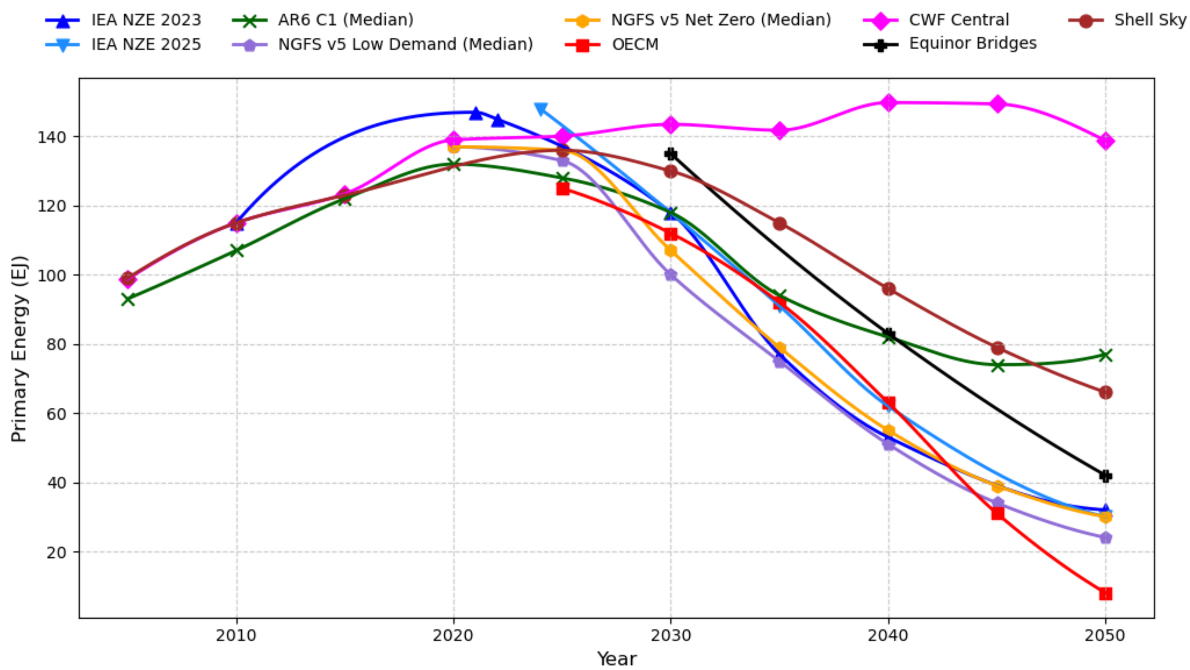


Figure A.2. Primary energy supply (EJ) from oil in selected scenarios.



[21] Equinor and BP scenarios report total primary energy metrics as demand rather than supply. Because of the limited quantitative difference between global hydrocarbon supply and demand, it has been included in figures A.1 and A.2 for illustrative purposes.

Figure A.3. Total primary energy supply (EJ) in selected scenarios.

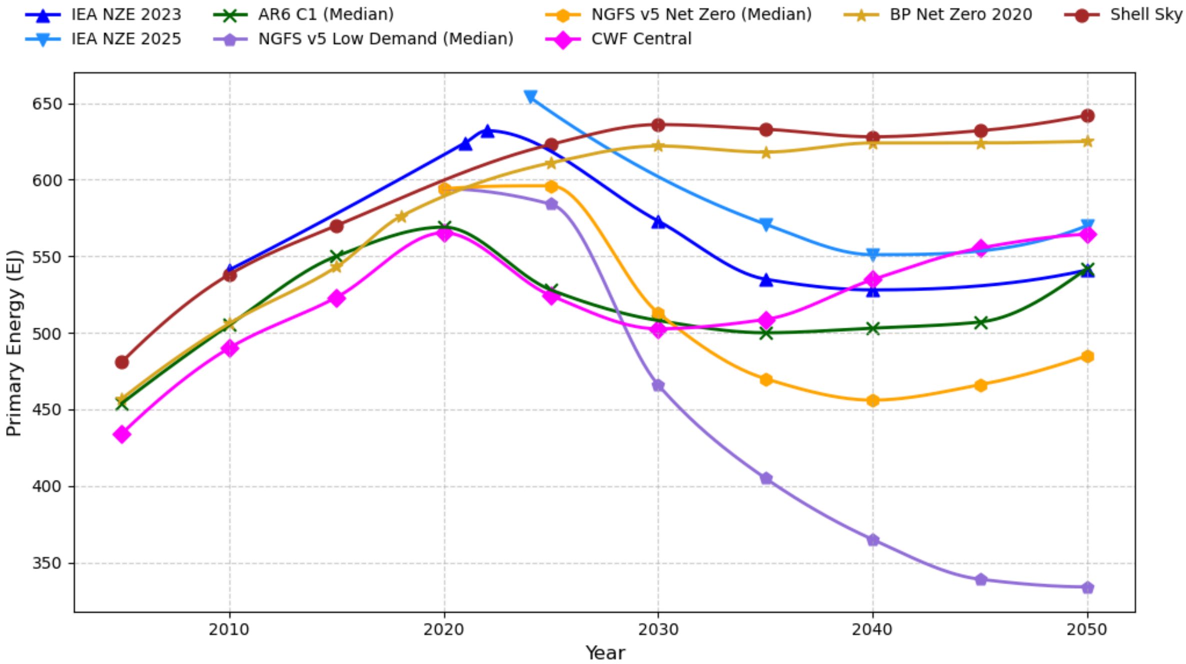


Figure A.4. Oil and gas share of total primary energy supply in selected scenarios.

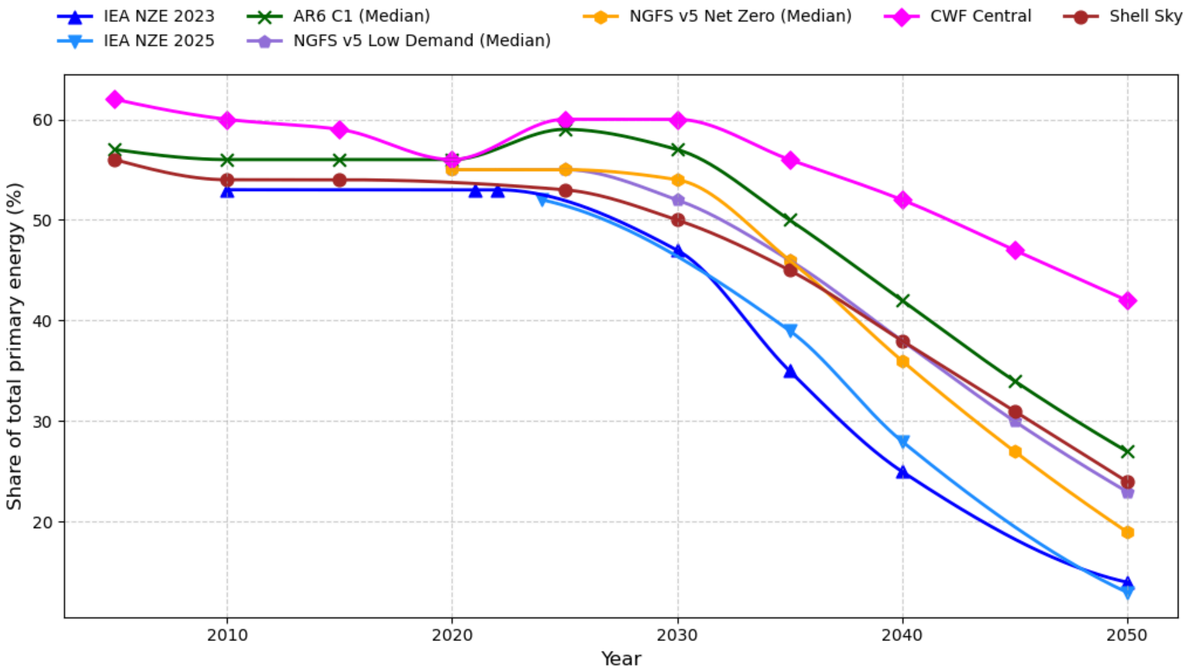


Figure A.5. Gas total fuel end-use combustion emissions in selected scenarios.

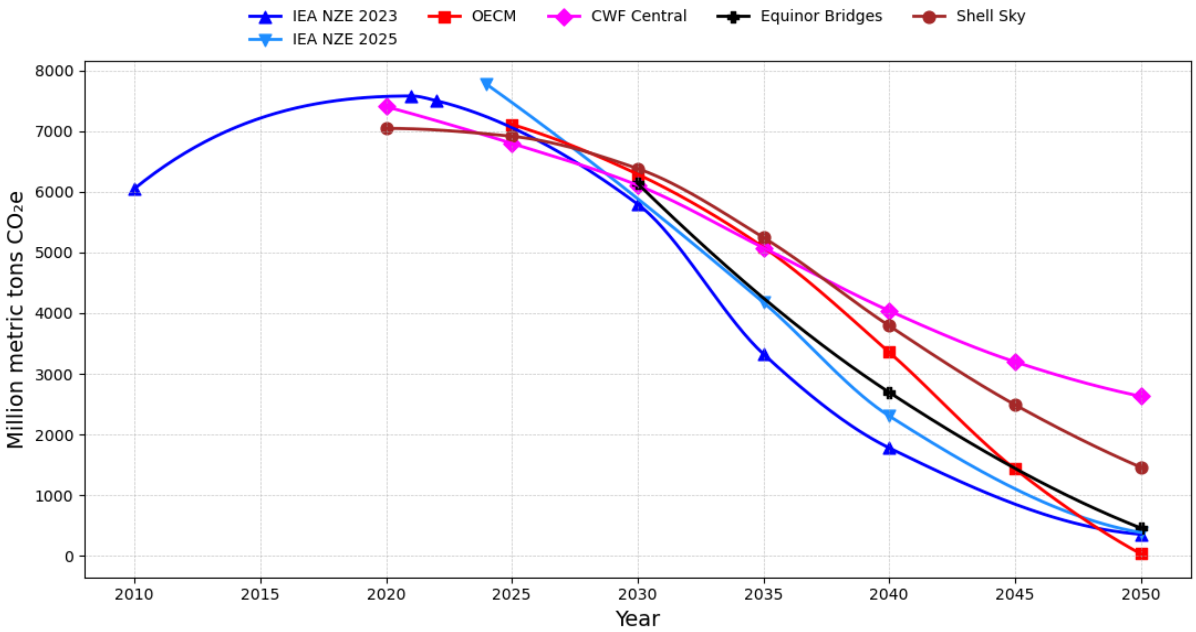


Figure A.6. Oil total fuel end-use combustion emissions in selected scenarios.

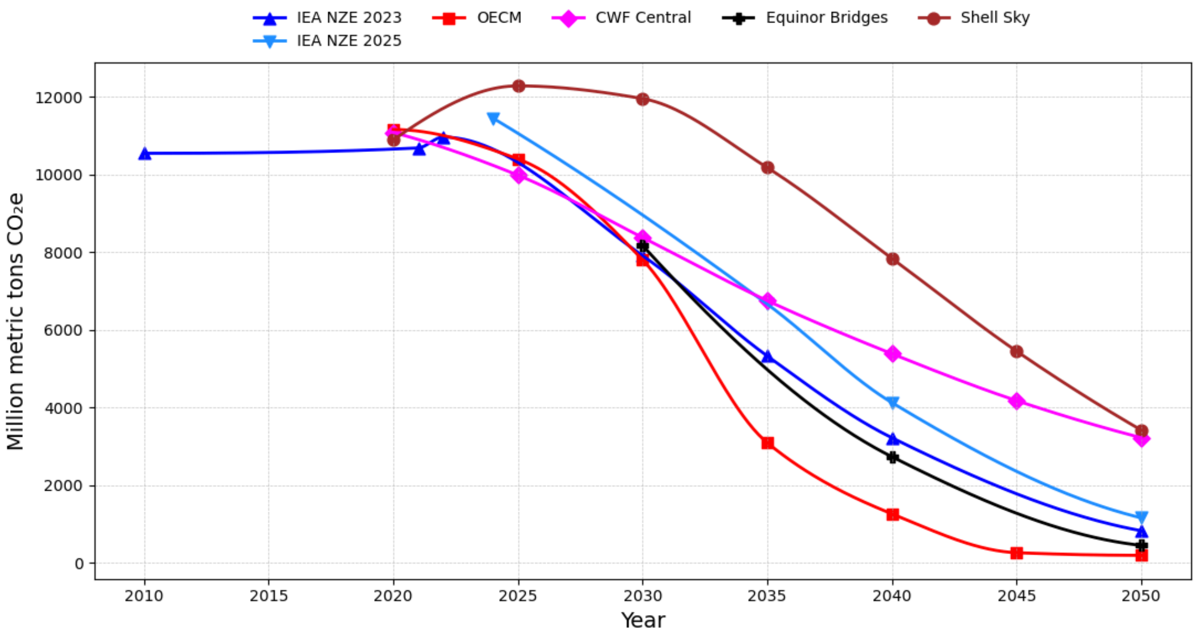


Figure A.7. Emissions from oil and gas operations in IEA NZE.

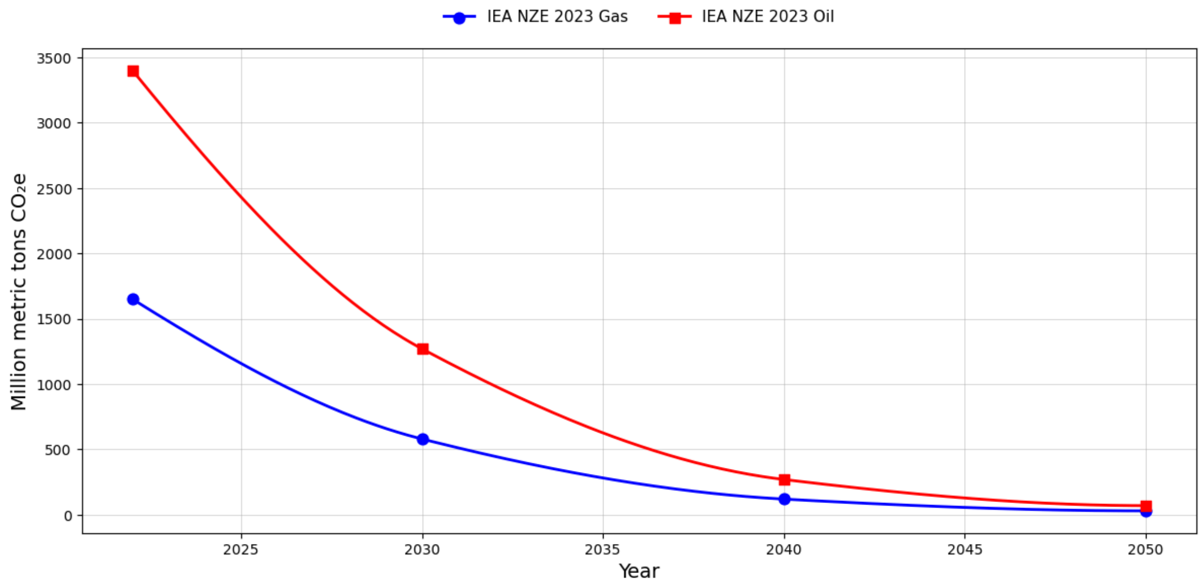


Figure A.8. Normalized operational emissions from the gas supply (including flaring/associated gas) in selected IPCC and IEA 1.5 °C scenarios.

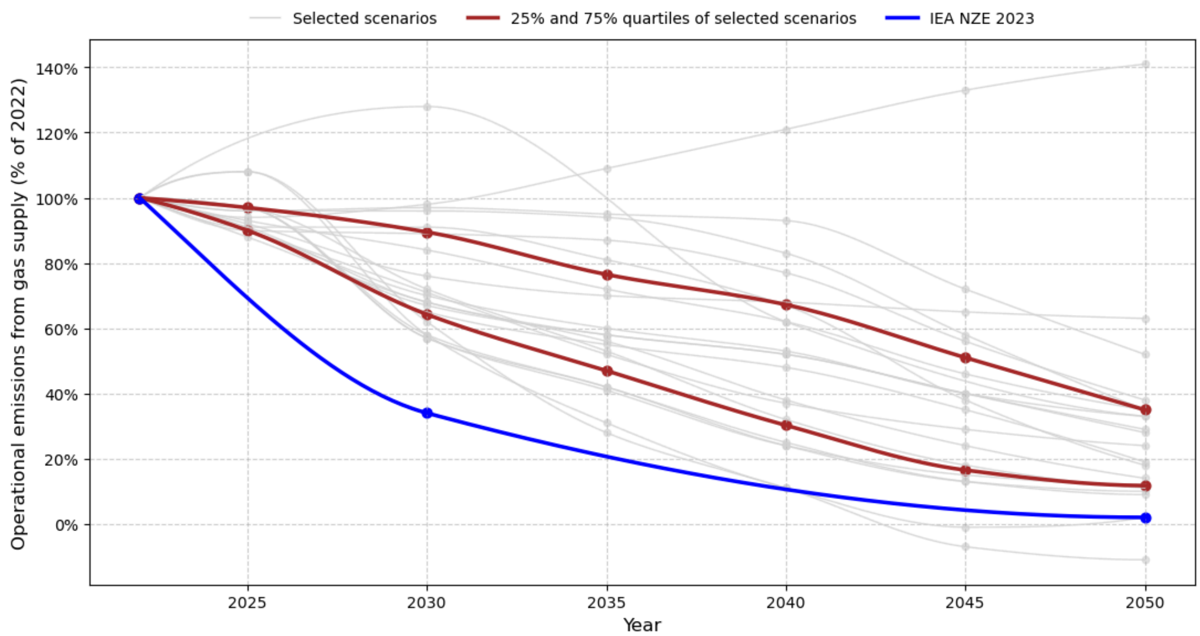


Figure A.9. Normalized emissions from the oil supply (including production of synfuels) in selected IPCC and IEA 1.5 °C scenarios.

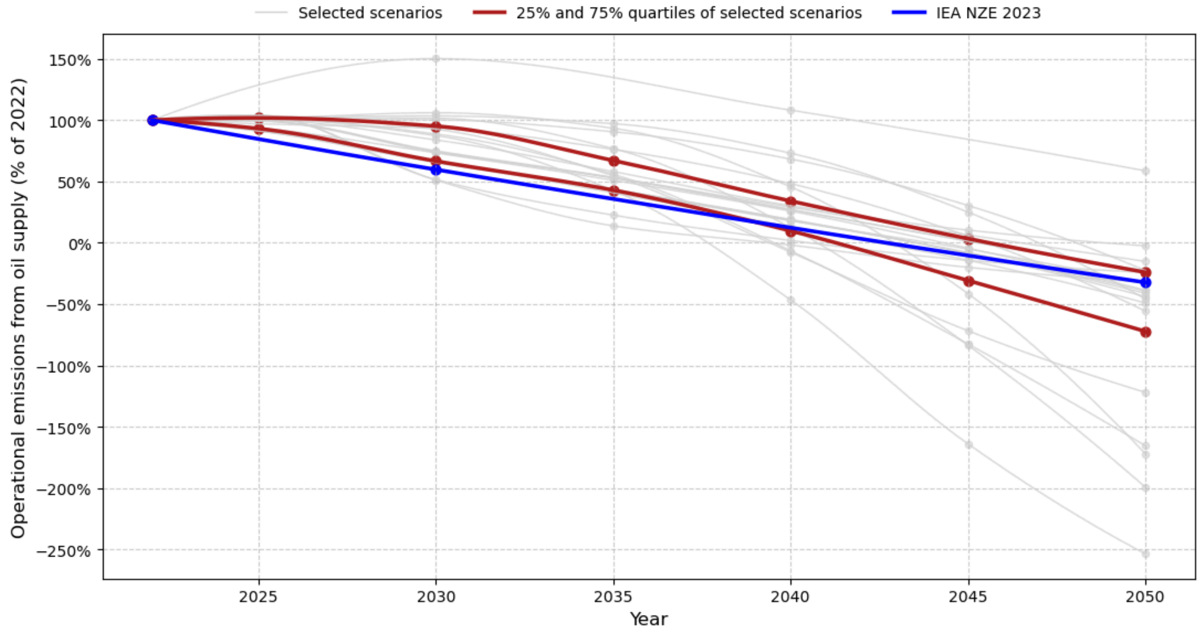


Figure A.10. Operational methane emissions from the supply of fossil fuels (incl. coal) in selected IPCC and IEA 1.5 °C scenarios.

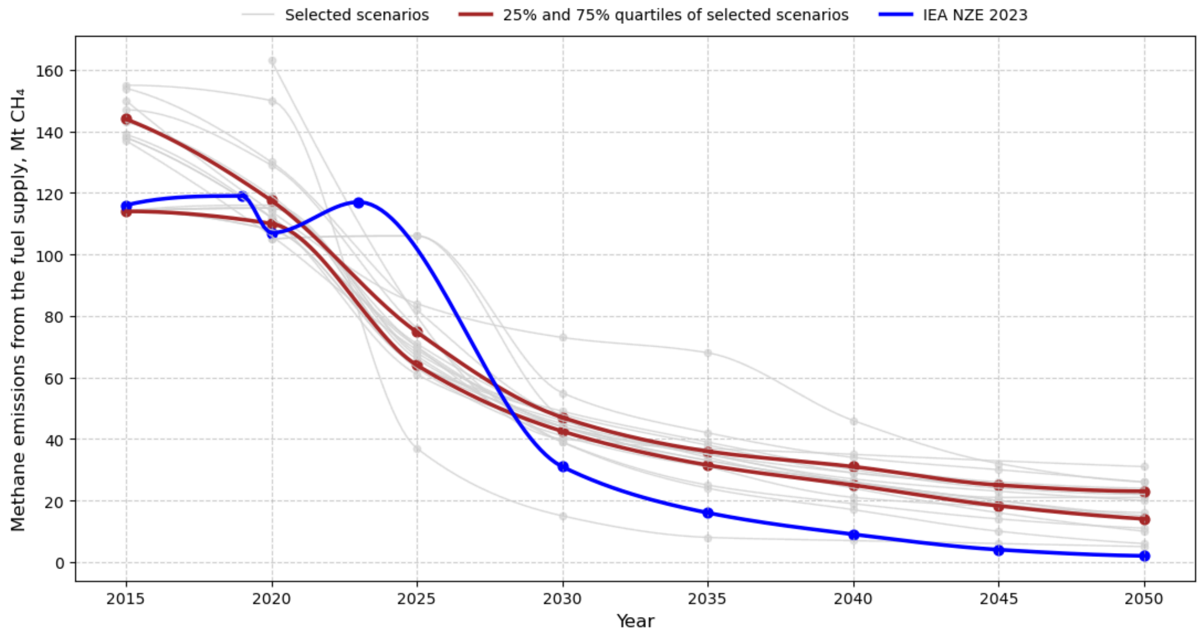


Figure A.11 Operational methane emissions by fuel-type in IEA NZE 2023.

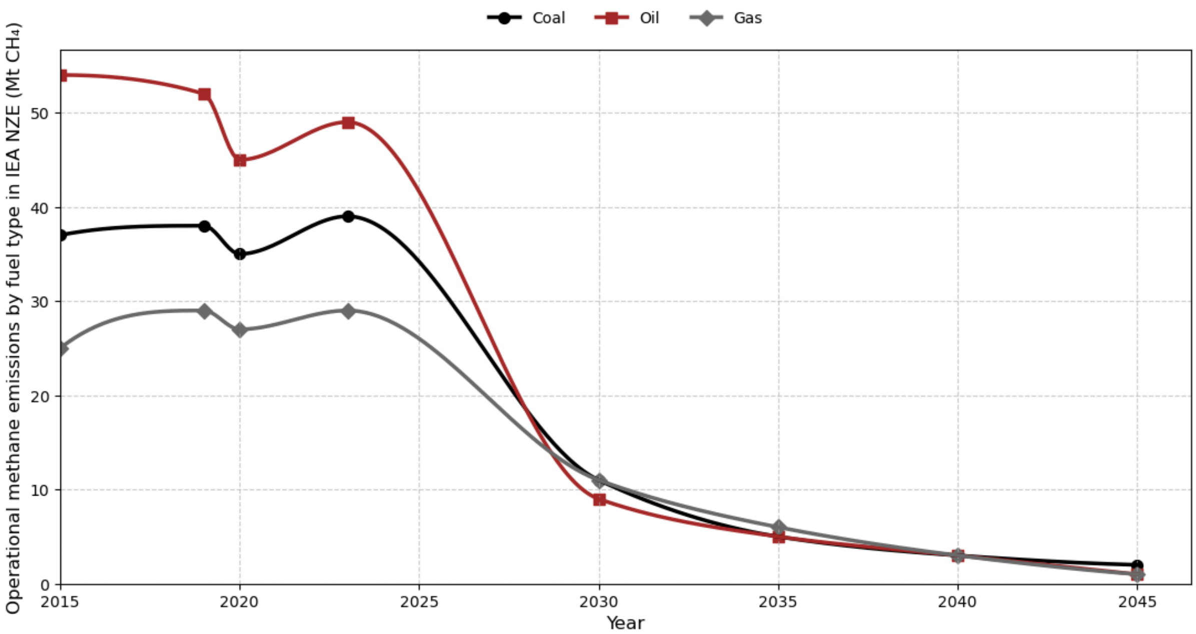
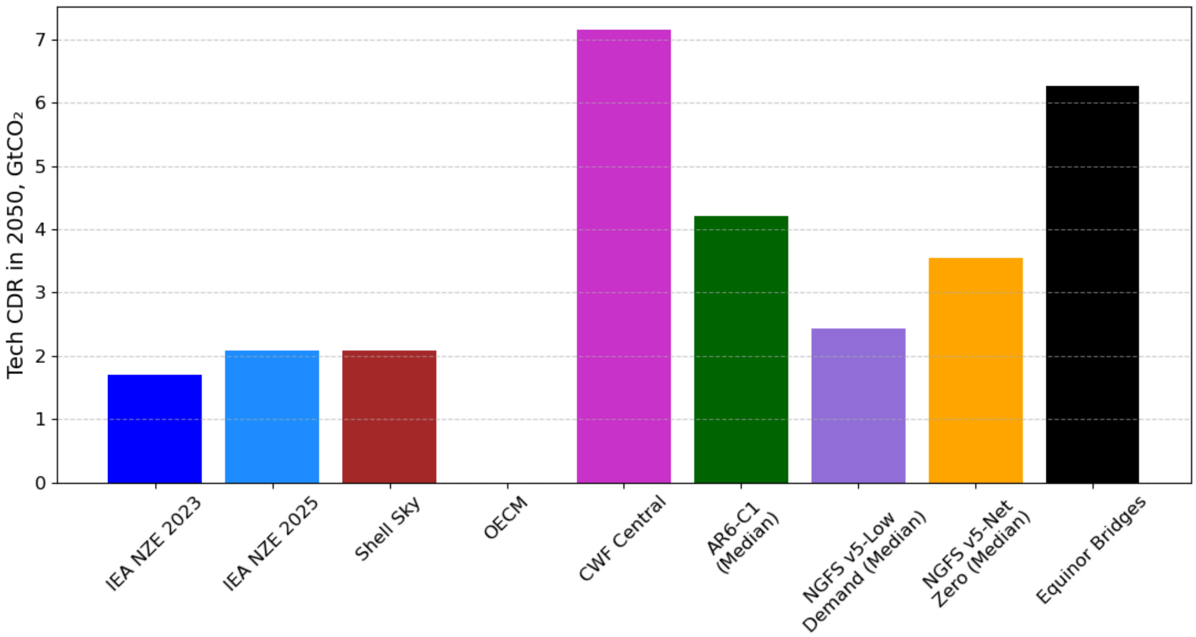


Figure A.12. Novel/technological carbon removals at 2050 in selected scenarios. Scenarios include a different mix of novel removal technologies including direct air capture and storage, bioenergy energy carbon capture and storage, and enhanced weathering.



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DRIVING AMBITIOUS CORPORATE CLIMATE ACTION