Underwriting the Transition

21 October 2024

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1 Executive Summary

Insurers are already, and will continue to, insure the transition to a low carbon economy - from enabling the financing of transition projects through to providing protection for businesses as they introduce new technologies, solutions and operational processes as part of the transition. The challenge will be whether the market can respond sufficiently quickly, and with commercial sensitivity, to changing insured's business profiles in order to facilitate the transition as it gathers pace.

Objective

This report provides an understanding of what a transition to a low carbon economy may mean in various key sectors for the market. By identifying key decarbonisation levers, we aim to identify some of the implications for underwriters in terms of coverage and changes in peril that may impact their business. Opportunities and risks, as well as more immediate short-term actions are considered. This report is best viewed in pdf using 'Fit one full page to window".

Exactly how the transition will unfold is impossible to predict and so please read the reliances and limitations that we have set out in the 'Scope and Guide to this report' section.

Scope

Given the transition needs to happen and be integrated across the global economy, it is necessarily a very broad subject. For the purposes of this inaugural report we have focused on first party property damage from a coverage perspective and on the following sectors:

1. Transportation (Aviation, Marine, Road Freight);
2. Energy (Oil & Gas, Mining, Power Generation & Distribution); and
3. Construction and Commercial Real Estate.

We have not considered geographical considerations, apart from where explicitly mentioned such as the examples around policy and regulation. In addition, the 'Just Transition' defined as "a low-carbon transition that is fair, inclusive, creates decent work opportunities and leaves no one behind" is not explicitly considered. Lastly, although nature is inextricably linked to the climate transition, we have not considered nature as part of this report.

As part of the work, KPMG climate and sector experts' opinions were obtained, as well as the opinions and views of the other industry experts and insureds, to develop a view on sectoral transition. The insurance implications of these transition pathways were discussed with underwriters from the various sectors, including separate underwriter workshops on Transportation, Energy, Construction and Commercial Real Estate. As such, the insurance views presented in this report are a collection of views from across Lloyd's underwriters and KPMG.

This report is a step in the journey to understanding how insurance needs will evolve. We make no claims that the report is comprehensive or that it is an accurate prediction of what risks may emerge in the future.

Overview

The challenges of transition

Insureds are already experimenting with new types of transportation, moving towards renewable energy sources and using low carbon materials in construction. Insurers need to be aware of insureds' current transition activity which may not naturally be part of the information provided at placement given the difficulty in defining and gaining additional details on an insured's transition journey. This ***'silent' transition*** and the data/information challenges it poses brings a risk of misalignment in terms of product and pricing in the future if these risks are unknown or misunderstood, but also an opportunity to change the way underwriters engage with insureds to become more relevant than ever.

To baseline our work, we have calibrated our view of the transition to a 1.5°C scenario to align to the Paris agreement, regulatory policy developments and to ensure consistency across all the reviewed sectors. However, the report highlights areas where these scenarios are becoming increasingly unrealistic due to factors such as technology developments not currently being commercially viable and at the scale required for assets such as maritime vessels that typically have a long production and operational life span. This points to a ***drift from the 1.5°C scenario*** toward a more disorderly transition and therefore the need for underwriters to not only consider their clients' transition path, but also how insurers will need to adapt to changes in risk ***assisting insureds in climate adaptation and resilience*** alongside the transition will become increasingly important.

Despite the reality of the difficulties of transition, international organisations and ***regulators have set decarbonisation targets***, particularly in transportation. A good example is in Aviation where there are hard targets for airlines and airports relating to the blend of Sustainable Aviation Fuel with kerosene (e.g. Refuel EU requires 70% SAF blend by 2050).

This points to an ***emerging change in risk levels***, where the price of low carbon assets increases indemnity costs at the same time as potential 'insurance green premiums' for transition technology. This is separate to the impact that the physical risk element of climate change which is forcing insurers to focus more on adaptation and how to deal with an increasing number of areas where insurance is unavailable or unaffordable.

Responding to the challenges of transition

Understanding insureds' transition journeys is key to staying relevant and continuing to insure their business. Insureds will face huge changes in their business model as the economy transitions to electrification and investment in new low-carbon assets. Insurers will need to work alongside insureds and their brokers to get a better understanding of the transition risks being faced by businesses and work closer with financial backers to be part of the implementation of future transition projects.

Insuring new transition technologies will be a challenge for underwriters. This requires a deep understanding of the new technologies and the mitigants that should be put in place to reduce the risk - ideally through participation in industry and regulatory/policy working groups.

This ***understanding will be even more important*** given the lack of historical data available on these new technologies, which is typically needed for actuarial pricing models. There will be reliance on ***core underwriting skills*** in relation to understanding these technologies and the key risk mitigants, which can then be included within the assessment of the product and its wording.

Key themes for insurers

In section 4 we have built upon the above overview and set out the key themes for insurers split into ‘Actions that could be taken now’, ‘Opportunities’ and ‘Risks’, which we have summarised below.

- Actions that could be taken now
  - **Understand client transition pathways** to build awareness of the adoption of emerging transition technologies and processes .
  - Importantly, this should include **using information from insureds and monitoring/updating the ‘in-house’ view**, taking account of regulatory and policy developments, which will become increasingly important for strategy and business planning.
  - Think about how **key technology changes could be insured** competitively in future with the right underwriting conditions in place.
  - Introduce **transition training** for underwriters focused on understanding clients’ transition pathways and how core underwriting skills can be used to address their changing needs.
  - Potentially partner with financial backers to be involved in transition projects at an early stage.
  - Think about how **pricing models can be adapted** to a more scenario-based approach, similar to some cyber pricing models, due to the lack of historical information.

- Opportunities

Lloyd’s has always had innovation at its heart. Insurers can seize the opportunities that are presenting themselves through the transition that is already upon them.

  - There is a spectrum of transition opportunities from insuring new businesses and activities at one end, to assisting existing businesses with their transition as they **adapt new technology and processes**.
  - Responding to **existing clients’ changing business models** to continue to stay relevant will strengthen existing relationships.
  - Insureds have highlighted the need for insurers to provide more complete coverages for new technology and assets. Hence, there will be opportunities for underwriters who are able **to provide such integrated coverages**.
  - With transition will necessarily come a focus on **safe decommissioning and recycling of stranded asset materials**.
  - Potential opportunities to insure **new direct air carbon capture and storage facilities**, which sectors that are hard to abate (like aviation) may have a greater propensity to adopt.

- Risks

The low carbon transition presents a prime opportunity for insurers but there are also serious risks to consider (both known and unknown at present). Among known risks, the report identifies:

  - Increasing risk of **unexpected claims from new technology and assets** thought to be 'production-ready' or due to accreditation schemes being too opaque. Insurers need to be involved in setting standards for new transition technologies and assets so they can be insured appropriately with reasonable exclusions and conditions.

- Claims may arise as a consequence of insureds needing to purchase more **expensive low-carbon assets** and potentially incurring costs for decommissioning.
- Key peril changes include **chemical fires from batteries**, which typically burn extremely hot and are difficult to extinguish, and a potential move to higher **explosion hazard fuels** such as hydrogen and ammonia where risks will be less familiar.

Sectoral analysis

In sections 5 to 12, for each sector the report sets out our view on the current state of transition, decarbonisation pathway, key levers and challenges, as well as what this could mean for insurers in terms of sector-specific opportunities, risks, immediate actions and areas to collaborate on with others.

We have summarised our expectations for the transition drivers across three sectors these in the tables below. which also provide a useful comparison across transportation, energy and construction & commercial real estate[1]. We do not expect that these will be complete or remain accurate in the future given the rapid pace of change in this field.

Transportation

For transportation we consider that the main pathway to decarbonising is in alternative fuels. For Aviation and Road Freight this lies in SAF and electrification, but for Marine it's uncertain given there are several options currently under consideration, with no agreement and almost no supporting infrastructure. The challenge for transition will be in the supply and infrastructure needed to transition to these new fuels and so ports and service stations will play a crucial role.

The insurance risks and opportunities from the transition are mainly linked to the change in alternative fuels and the infrastructure needed to support it.

Sectors	Aviation	Marine	Road Freight
Overview and global emissions	• c. 2% of global emissions, 4% when considering non-CO2 factors[1] • Estimated 1% of the world population responsible for 50% of commercial aviation emissions	• c. 3% of global emissions[1] • Handles 90% of global trade	• c. 5% of global emissions[1] • 100 times more emissions per unit of goods transported compared to shipping

[1] Note that sectors covered are not exhaustive nor mutually exclusive; emissions totals do not add up to 100%

Sectors	Aviation	Marine	Road Freight
Key trends	• Expected c.4% increase in air travel annually (until early 2040) • Sectoral net zero pledge by 2050 (ICAO) • Scale up of SAF book and claim[2] • Mandatory carbon offsetting	• 40% to 115% increase in maritime trade (by 2050) • Up to $28bn required annually to decarbonise global fleet • Establishment of green shipping corridors • Scale up of green fuel book and claim and demand aggregation[3]	• HGV demand expected to double by 2050 • Electric batteries are likely to be cheaper on total cost of ownership basis by 2030 • Scope 3 (supply chain) targets set by key logistics customers
Key abatement levers	• Sustainable Aviation Fuel • Efficiency gains in engines, operations and aircraft design • Electrification and electric vehicles • On-site renewables	• Alternative fuel such as low carbon ammonia, low carbon methanol, hydrogen fuel cells, LNG, renewable electricity, and other sustainable fuels • Efficiency across ship operations, vessels and technology • Onshore power • Electrification of equipment	• Battery electric vehicles • Vehicle and operational efficiencies • Hydrogen trucks • Procurement demand aggregation
Key challenges associated with transition	• Limited alternatives to aviation turbine fuel • SAF significantly more costly compared to conventional fuel	• Vessel life typically over 20 years • Coordination challenges associated with selection of future fuel slowing investment • Upfront investment cost which many customers unwilling to pay • Green fuels 3-4 times more costly as compared to conventional fuel	• Truck asset life typically over 20 years • Coordination challenge associated with predicting future winning technology (BEV / H2) • Upfront investment cost which many customers unwilling to pay

[2] See p25 for further detail on SAF book and claim
[3] See p40 for further detail on Marine book and claim

<table>
<tr><th>Sectors</th><th>Aviation</th><th>Marine</th><th>Road Freight</th></tr>
<tr><td>Key regulatory, policy and incentive considerations</td><td>• Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)
• Inflation Reduction Act and EU Green Deal
• EU ReFuelEU – Mandates EU fuel suppliers to min 2% SAF blend. At least 5% of Aviation Fuel mandated to be SAF by 2030</td><td>• IMO Updated Net-Zero Strategy, 2023 (mandatory emissions reduction and alternative fuel targets)
• EU Emissions Trading Scheme
• Clean shipping Act of 2023 (US)
• Fuel EU Maritime Regulation
• Green Port Initiatives
• US Inflation Reduction Act and EU Green Deal</td><td>• EU Sustainable and Smart Mobility
• Low carbon fuel standards
• CO2 emissions standard for HGVs (EU)</td></tr>
<tr><td rowspan="2">Key insurance risks and opportunities of transition</td><td>• Opportunities in providing greater security of SAF supply (e.g. insurance for SAF production projects)
• Opportunities with smaller electric aircraft (e.g. cargo drones with logistic companies)
• Distribution/pricing via airport accreditation scheme
• Industry likely to be big purchaser of carbon credits supporting carbon insurance</td><td>• Insurance for off-shore renewables as ports take greater lead
• Risk of energy supply shortages and possible BI claims
• Risk of varying port standards and infrastructure with change to alternative fuels
• Risks from routing changes for efficiency gains
• Change in risk profile of cargo as energy sources change</td><td>• Opportunities to insure new electric infrastructure (e.g. battery stations)
• Changing risks from new driving styles and electric trucks</td></tr>
<tr><td colspan="3">• Opportunities to provide integrated product coverages for new technology or assets, over more than one year
• Partnering with other firms is key to the transition (e.g. financiers) to provide integrated transition solutions
• Risks from storage and use of new alternative fuels
• Additional claim costs from replacing and repairing of new technology or assets and potentially decommissioning
• Risk changes to more explosive (e.g. hydrogen, ammonia) and harder to extinguish (e.g. batteries) alternative fuels
• Opportunities and risks in insuring new technology to ease their adoption (e.g. working closely with the relevant industry and regulatory bodies to implement the appropriate standards and controls)
• Opportunities and risks in cyber insurance as attacks become more likely, with greater connectivity driven by electrification</td></tr>
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Energy

For mining and the oil & gas sectors, transition will mean a fundamental change in their business strategies, with mining increasingly focused on transition minerals and materials. However, both oil and gas are still expected to play a large part in the transition, with gas as a transition fuel and oil derivatives (e.g. plastics) still needed for transition, but the focus is expected to switch to renewables and carbon capture, utilisation and storage (CCUS).

The insurance risks and opportunities from the transition are mainly linked to expected changes in strategy from the mining and oil & gas firms, and the scaling-up of renewables and the global electricity grid for power generation and distribution firms.

Sectors	Mining	Oil & Gas	Power Generation & Distribution
Overview and global emission	• Critical role in transition, providing essential components of clean energy technologies such as Cobalt & Lithium	• c. 15% of total energy related GHG emissions from Scope 1 & 2[4], and additional 40% from use[5]	• c. 27% of global emissions[6] • Unabated fossil fuels currently responsible for 60% of electricity generation • 90% of electricity to be produced from renewable sources by 2050 in 1.5°C scenario
Key trends	• 500% increase in demand for critical minerals by 2050 (2018 base level) • Increasing role for circularity • Shift away from mining for fossil fuels, in particular coal, in line with phase out	• Demand for oil and gas is projected to peak at the end of the decade • Oil and gas subsidies at all time high, but expected to phase down as focus on renewables grows	• 80% increase expected in global electricity demand by 2050 • Average annual power sector investment must grow from $1tn to $2.2tn by 2030 • COP28 commitment to triple renewable energy capacity by 2030 • COP28 commitment to double rate of energy efficiency improvement by 2030 • Growth of carbon pricing schemes
Key abatement levers	• Grid decarbonisation (e.g. via on-site generation) • Electrification of equipment • Process optimisation and route optimisation	• Methane abatement • Diversification into low emission fuels, geothermal, green and blue hydrogen and CCUS	• Scale up of variable renewable energy including solar and wind; phase out of coal • Hydrogen and ammonia in the power system • Use of dispatchable low carbon power (i.e. nuclear power) • Grid developed to support increase in electricity demand
Key challenges associated with transition	• Supply chain concentration in less developed/politically unstable regions • Broader ESG challenges associated with sector including social and human rights	• Introduction of carbon pricing will increase operating costs • Potential lower access to capital as financiers come under increasing pressure	• Siting constraints limiting scaling of power systems • Energy security and affordability leading to short-term policy backtracks around scaling of renewable energy • Oil and gas subsidies remaining high

[4] "The GHG Protocol Corporate Standard classifies a company's GHG emissions into three 'scopes'. Scope 1 emissions are direct emissions from owned or controlled sources. Scope 2 emissions are indirect emissions from the generation of purchased energy. Scope 3 emissions are all indirect emissions (not included in scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions" – Greenhouse Gas Protocol FAQ - Link

[5] Note that sectors covered are not exhaustive nor mutually exclusive; emissions totals do not add up to 100%

Sectors	Mining	Oil & Gas	Power Generation & Distribution
Key regulatory, policy and incentive considerations	• Net Zero commitment by International Council on Mining and Metals • Mining Policy Framework, Intergovernmental Forum of Mining, Minerals, Metals and Sustainable Development • European Critical Raw Materials Act (CRMA) • EU Carbon Border Adjustment Mechanism • EU Green Deal (including circularity)	• COP28 Oil and Gas Decarbonisation Charter • Global Methane Pledge • The Oil & Gas Methane Partnership 2.0 (OGMP) • EU Emissions Trading Scheme • EU Carbon Border Adjustment Mechanism • US Inflation Reduction Act and EU Green Deal (renewables incentives)	• COP 28 Goal: Tripling Renewable Energy by 2030 • COP28 Goal: Doubling Rate of Energy Efficiency by 2030 • COP 26 agreement to phase out unabated coal • EU Emissions Trading Scheme • US Inflation Reduction Act and EU Green Deal • European Commission Electricity Grid Action Plan
Key insurance risks and opportunities of transition	• Opportunities will exist to assist mining with the insurance they need as they move away from fossil fuels (e.g. minerals for batteries or new construction materials) • Risk of claim costs rising as value of critical minerals and new construction materials rises • Risk profile will change with move to low-carbon processes • Increased supply chain and geopolitical risk, which will also provide insurance opportunities	• Opportunities will exist to assist firms with the insurance they need as they move away from fossil fuels (e.g. renewables, CCUS using old sites, carbon insurance for carbon credits) • Change in risk profile as firms move away from traditional oil & gas production	• As renewables continue to scale so will opportunities continue in this segment • With the expansion of the global grid, potential opportunities to insure this build and the larger grid • With the move to more intermittent energy sources, insurance could play a role in providing coverage for blackouts (e.g. BI)
	• Opportunities and risks in cyber insurance as attacks more likely, with greater connectivity combined with an increasingly uncertain geopolitical environment		

Construction & Commercial Real Estate

For construction, the transition is expected to focus on the use of timber and new low-carbon alternatives to cement, steel and aluminium. Recycling of embodied carbon-like cement will also be important.

For commercial real estate, the focus is expected to be on the retrofitting of existing buildings and the construction of new low-carbon buildings in the developed and developing world respectively.

The insurance risks and opportunities from the transition for construction are mainly linked to expected changes in demand to assist the transportation and energy transition. The move to low-carbon commercial real estate will be driven by an increasing demand from firms trying to reduce their own scope 1 and 2 emissions.

Sectors	Building Construction	Commercial Real Estate
Overview and global emission contribution	• c. 7% of global emissions[6][7] • Embodied carbon, currently accounts for 25% of total building emissions with cement used for buildings and other infrastructure making up c.8% of global carbon emissions	• c. 26% of global emissions[7] • IEA target of retrofitting 20% of the existing building stock to be zero-carbon-ready by 2030 • Energy consumption c.1/3 operational budgets
Key trends	• Global building floorspace is estimated to double by 2060 • The sector is expected to see US$4.2 trillion growth over the next 15 years • Growing role of circularity in construction • Increased focus on reduction of embodied carbon in building materials • Scale up of use of alternative materials in building	• Floor area of commercial buildings increase 58% from 2020 to 2050 • Sector to be impacted by Net Zero commitments of real estate investors and building renters/users • Green rent premium estimated at 6%, sales premium at 7.6% • Increased focus on climate adaptation in buildings
Key abatement levers	• Efficiency in operations including modular build and prefabrication • Electrification of freight and transport on construction sites • Low carbon power • Material efficiency in building design • Material reuse in buildings • Low carbon cement, steel and aluminium • Alternative building materials e.g. timber	• Decarbonisation of the grid and district heating • Energy efficiency gains in space cooling, heating, lighting and appliances • Phase out of fossil fuel-fire heating
Key challenges associated with transition	• Lack of affordable low-carbon inputs – key materials such as steel and cement still lack low-carbon alternatives at comparable prices	• Significant cost and challenges associated with retrofitting existing buildings
Key regulatory, policy and incentive considerations	• Building certifications e.g. LEED, BREEAM • EU Emissions Trading Scheme and Carbon Border Adjustment Mechanism • EU Circular Economy Action Plan and European Green Deal • EU Construction Products Regulation • EU Energy Performance of Buildings Directive (EPBD)	• Building performance standards and certification programmes (various) • US Inflation Reduction Act • Net Zero Carbon Building Commitment, and Zero-Carbon Building Accelerator (ZCBA) • EU Energy Performance of Buildings Directive (EPBD)

[6] Note that sectors covered are not exhaustive nor mutually exclusive; emissions totals do not add up to 100%

[7] This emissions figure relates to building construction only and excludes other forms of construction, e.g. infrastructure

<table>
<tr><th>Sectors</th><th>Building Construction</th><th>Commercial Real Estate</th></tr>
<tr><td rowspan="2">Key insurance risks and opportunities of transition</td><td>• Opportunities linked to the energy and transport transition which are relying on large infrastructure projects, as well as new low-carbon buildings particularly in developing countries
• Opportunities in the decommissioning of some existing buildings that removes/recycles embodied carbon
• Risk that physical risks of climate change are not appropriately taken into account in the design and build phases of a project.</td><td>• Opportunity to insure the expected increase in retrofitting of existing buildings, particularly in developed world and that climate adaptation/resilience is incorporated
• As existing buildings are increasingly retrofitted to be more low-carbon, risk that practices do not take into account different risk profiles of existing buildings</td></tr>
<tr><td colspan="2">• Opportunity for new product guarantee products in relation to new building materials
• Risk that new low carbon materials are not used in line with appropriate building regulations and/or guidelines, or they don’t exist</td></tr>
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2 Scope and guide to this report

2.1.1 Scope

In this inaugural report we have kept the scope limited to focus on educating the market in relation to the climate transition and identifying areas for future work.

The scope is as follows.

- The report covers eight sectors deemed key for Lloyd's across transportation, energy, construction and commercial real estate.
- We focus on:
  - A general introduction to the net-zero transition;
  - Sectoral decarbonisation pathways;
  - The implications for underwriters, including impacts on portfolio segmentation and perils;
  - First party property risks, with environmental liability, litigation risk and third party implications being out of scope of this report; and
  - Changes to type of business and client activities, as opposed to product coverage.
- The transition pathway for individual managing agents and any associated underwriting policies are not considered as part of this report.
- The report is geography agnostic i.e. focused on global trends, as opposed to the varying pace of transition across territories and countries.
- Although we recognise the importance of themes such as the 'just transition' and 'nature', these are not covered in this report.
- For further detail on methodology, scenarios and data see Section 13: Methodology.

Guide to this report

This report is best viewed in pdf using 'Fit one full page to window". Sections 5 to 12 of this report focus on the eight sectors agreed with the LMA. Each of these sections is intended to help underwriters better understand the potential transition for the sector and the implications that this will have for insurance (see "key insights for underwriters" below).

The report is designed so that it can be read in its entirety, or each sector as a separate section together with the key themes in the next section. The exact content for each section will vary by sector, however the broad subheadings and topics addressed are outlined below.

Sector Subheadings	Details
Current State	Outlines demand projections, breakdown of GHG emissions and associated drivers, as well as the decarbonisation potential of the sector.
Key Trends	Highlights current demand projections, key decarbonisation activities, investment requirements and implications for decarbonisation pathways, climate target commitments and key interdependencies.
Decarbonisation pathway and levers	The key part of this section is the **decarbonisation graph** at the beginning which visually sets out sectoral decarbonisation pathway to 2050 consistent with a 1.5°C scenario. We also discuss the decarbonisation levers to enable readers to understand the key assumptions that underpin the pathway. In order to understand how these pathways could impact upon underwriters' portfolios, for most sectors we have also included an **interactive segmental table** split by broad insurance segment to provide an initial view on how the abatement activities could impact upon an underwriters' portfolio.
Other considerations	Explores other relevant sectoral considerations, for example demand shift.

Rather than having a separate subheading on insurance implications, throughout each of the eight sectors we have sought to provide key insights for underwriters by including callout boxes to which we have assigned one of the following icons to make it easier to identify the topic it relates to:

- Key opportunities to assist insureds and grow
- Opportunities to work with stakeholders
- Potential risk(s) from the transition
- Immediate action(s) that could be taken by underwriters in the short term

In addition, we have referenced some of the key global and local regulations and policies throughout this report which can be found in more detail in the Appendix.

Lastly, please take note of the important reliances and limitations below that are integral to this report.

Reliances and limitations

This report has been prepared solely in connection with, and for use in accordance with, the terms of our engagement letter dated 15 May 2024 addressed to the Lloyd's Market Association (the "LMA"). This report is provided on the basis that it is for your information only and that it will not be copied or disclosed to any third party or otherwise quoted or referred to, in whole or in part, without our prior written consent. To the fullest extent permitted by law, KPMG owes or accepts no liability to any party other than the Client. Any party other than the LMA which obtains a copy of this report, or any part of it, and which chooses to rely upon it, does so entirely at their own risk.

In preparing this document, under the terms of our engagement letter dated 15 May 2024, we have made use of information, where applicable, provided to us by the LMA which we have not independently verified. If any information upon which we have relied is incomplete or inaccurate or further information subsequently becomes available, our views could change; however, in this event we are not obliged to update our document to reflect this.

This document makes various assumptions and which together with any applicable information provided by the LMA, provides the basis of our views. Our views shall not amount to any form of guarantee that we have determined or predicted events, whether present or future. Accordingly, the information in this document is provided by KPMG LLP on the basis that no liability is accepted for any errors of facts, assumptions and representations.

The information contained in this report is based on prevailing conditions and KPMG's view as at 16 September 2024. KPMG has not undertaken to, nor shall KPMG be under any obligation to, update the report or revise the information contained in the report for events or circumstances arising after the 16 September 2024 and the report or any information contained in the report shall not amount to any form of guarantee that KPMG have determined or predicted future events or circumstances.

KPMG's finding shall not in any way constitute advice or recommendations regarding whether or not the LMA should proceed with any proposed actions and/or commercial decisions associated with this report. All relevant issues may not have been identified, and only those issues that have been identified as part of our review are included in this report.

Note to third parties

KPMG wish you to be aware that the work it carried out for the LMA was performed to meet specific terms of reference agreed with them, and that there were particular features determined for the purposes of the engagement and the needs of the LMA at the time. The report should not therefore be regarded as suitable for use by any other person or for any other purpose. Should you choose to rely on the report you do so at your own risk. KPMG will accordingly accept no responsibility or liability in respect of it to persons other than the LMA.

3 Introduction

Climate Change – The burning platform

We are in a climate emergency. In an historic moment for global climate action, COP21 saw 196 Parties signing the Paris Agreement (PA), a legally binding international treaty on climate change, which was agreed and adopted by 196 Parties at the UN Conference of Parties in 2015 (COP21). The PA outlined that we must hold "*the increase in the global average temperature to well below 2°C above pre-industrial levels*" and pursue efforts "*to limit the temperature increase to 1.5°C above pre-industrial levels*"[8].

This also involves countries committing to their own Nationally Determined Contributions (NDC), a set of policies and measures aiming at reducing their greenhouse gas (GHG) emissions as part of climate change mitigation. While some of its most technical details are yet to be fully finalised, the PA cemented a collective goal of keeping global warming to a minimum and provided a durable framework guiding global efforts though a shift towards a net-zero world by 2050.

The world is not on track to meet the requirements of the Paris Agreement. According to latest Intergovernmental Panel on Climate Change (IPCC) report, *"Human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming, with global surface temperature reaching 1.1°C above 1850-1900 in 2011-2020*".[9] A business-as-usual scenario could result in a temperature trajectory of 4°C[10], while the International Agency outlines that Stated Policies globally set a trajectory to 2.4°C by 2100.[11] The risks that this could pose are potentially catastrophic to society and to the economy. Currently, we are experiencing the hottest eight years on record, causing a myriad of climate disasters ranging from floods in Pakistan, heatwaves and wildfires in Europe, hurricanes in Cuba and Florida and a drought over sub-Saharan Africa[12].

The Insurance sector at a point of inflection

The insurance industry could be one of the hardest hit by climate change. As extreme weather events increase due to changing climate, so will payouts. The risk models that have been previously used have repeatedly failed to properly account for climate-related damages. Damages which cost the insurance industry c.$120 billion in 2022 alone.[13] In some markets, insurers are removing coverage leaving customers without protection.

Due to these circumstances the industry finds itself at a point of inflection. Insurers are in the business of underwriting, the business of protection. Yet an insurance business cannot grow sustainably by insuring fewer and fewer hazards. Equally, companies cannot operate without suitable risk transfer. Insurers can again seize the opportunities that are presenting themselves through the transition that has already begun. Understanding the insureds' transition plans will help to better understand their changing risk profile and assist in modifying products and coverage accordingly. Analysing the credibility of these transition plans remains a challenge, often requiring in-depth subject matter experts to interpret and advise on them, but as asset managers and banks seek to do the same, insurers could work together with other financial institutions and market players to better understand insureds' transition plans.

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8 The Paris Agreement | UNFCCC
9 IPCC AR6 Synthesis Report, 2023, Hot House scenario, Link
10 ngfs_guide_scenario_analysis_final.pdf, p9
11 Secure and people-centred energy transitions – World Energy Outlook 2023 – Analysis - IEA
12 Eight warmest years on record witness upsurge in climate change impacts (wmo.int)
13 Reinsurers fuel the climate crisis while climate victims pay the price - Insure Our Future Global (insure-our-future.com)

Insurers – scaling a low carbon future

As outlined above, there is an immediate need to limit the effects of climate change, which will require deep decarbonisation across all sectors. Many of these sectors are hard to abate; dependence on fossil fuels, high energy demands, old assets, economic constraints and disparities, and limited technological maturity all inhibit swift decarbonisation. Yet insurers have the capacity to support this change via various avenues. This includes product innovation, understanding and mitigating risk as well as channelling capital to low carbon alternatives and changing incentives.

Product innovation will be explored in more depth throughout this report, and leading insurers are already capitalising on these opportunities. Parametric insurance, carbon insurance, as well as renewable energy products are examples of how the insurance industry is serving clients who are innovating in this area. Product innovation requires new ways of thinking, which can be accelerated through collaborative partnerships as well as understanding risks that challenge traditional underwriting models. The low carbon transition also presents an opportunity for insurers to get closer to their clients; to engage in transparent and informative communication, as well as assisting with risk and scenario modelling. Many insurers have begun to innovate around this idea; building advisory services that can provide valuable insights on risk modelling, identification and mitigation strategies. Through this, insurers are better positioned to provide advice on suitable insurance products, which can consequently be highly tailored.

The Transition – An uncertain future

There are many uncertainties in how the low carbon transition may evolve, in terms of regulation and policy, political will, alignment and commitment, industry collaboration and coordinated action across value chains, technological innovation and more. What is not uncertain is the need for action now, and the ability of the insurance sector to assist on the path to a low carbon economy. The aim of this report is to support insurers and underwriters to understand these key considerations, and potential trajectories, to determine their role in the transition, as well as the risks and opportunities that are facing them.

In this report, we outline the potential impact of the low carbon transition on eight sectors that are relevant to the membership of the Lloyd’s Market Association. We map out a potential decarbonisation pathway, leveraging KPMG expertise, industry views, and market insight. We detail the potential abatement levers that could drive emissions reduction between a business-as-usual scenario, and a 1.5°C scenario, in line with the Paris Agreement. We also outline relevant sector context, transition risks and opportunities, present and future regulation, and the associated implications for the insurance sector. Insurers stand at one of the greatest opportunities of the century– the opportunity to underwrite the transition to a low emissions and climate resilient future.

4 Key Themes

There are common themes that occur across the sectors that we have brought into this section of the report for brevity. We have organised this collection of ideas and thoughts into the areas set out in the previous section.

Immediate action(s) that could be taken by underwriters in the short term

Some LMA members may already be carrying out some of these actions, which we have organised into key categories.

Ways of working

Insureds have conveyed that they want to have a more integrated insurance solution from the market, particularly in relation to their adoption of new technologies/assets and so underwriters should think about how to organise themselves to be able to provide an insurance solution across coverages with a consistent approach to risk appetite.

Insurers could start partnering more with financiers, technology companies and firms supporting the transition, which could assist in underwriting and building stronger relationships with insureds.

Transition projects sometimes struggle to get financed. There are a number of reasons for this, but insurers could try and ensure the underwriting piece is seamless by working closely with financiers and brokers to get insurers involved earlier on in the design of the project and think about multi-year coverages (e.g. some form of product guarantee could be provided if this is something of concern to the financier), and would also help to create longer term relationships with the client.

Insured data and information challenges will make it difficult to implement some of the points raised in this report and so underwriters should think about how they could engage differently with their brokers and insureds on this topic.

Reinsurers are starting to consider the transition in terms of their cedants and underlying insureds and so underwriters could think about whether they should be working more closely with reinsurers to understand the risks of transition for their insureds better, to enable the right coverage to be available in future.

Distribution partners (brokers, MGA's, coverholders) are important in terms of understanding insureds' transition pathways and so it may be worthwhile insurers working more closely with them to ensure their understanding of an insureds' transition and risk appetite are aligned.

Transition plans are increasingly becoming a critical enabler to understanding the transition trajectory, and associated risk profile in the market. It is increasingly likely that insurers and other financial institutions will request and assess transition plans as part of decision-making processes, necessitating a clear view on sectoral transition and on 'what good looks like' in transition plans, and associated skills and knowledge.

Risk assessment and information

Insureds are already starting to transition their businesses in ways which insurers may not be fully aware of, resulting in transition risks already being insured. As such, insurers should try to understand their sector's/insureds' transition paths so that they can be aware of the adoption of emerging transition technologies and processes and push for additional information. This will assist in pricing transition risks appropriately and so should be incorporated into underwriting processes.

Insurers should think about introducing an ''in-house' view on decarbonisation pathways to inform underwriters and be seen as a leader in the market.

With the lack of historical claims data, more reliance will need to be placed on third party information about the risks and the insured's own processes and controls. As such, pricing models may need to be adapted to be more scenario-based.

Skill gaps

Insurers need to start to evaluate and address the current technical knowledge and skills gap which reduces appetite to underwrite newer technologies and green products. Expertise in transition-related R&D is required to understand the new risks and price accordingly.

Some insureds will need assistance in understanding their transition risks and so there will be opportunities to provide risk engineering/consulting advice.

Regulatory developments

To a large extent the pace of transition in each sector is being driven by regulators, and so insurers should keep abreast of these regulatory developments and understand what they mean for their portfolio mix in the short to medium term.

Key opportunities to assist insureds and grow

There will be a spectrum of opportunities that will emerge, ranging from those related to assisting existing clients through the transition to insuring new activities and start-ups that emerge to help with the transition.

Staying relevant

Transition opportunities do not relate just to new businesses, but to protecting existing businesses by assisting them through their transition and, in doing so, staying relevant. These opportunities will depend upon being able to respond to the changing risk profile of insureds and finding innovative ways to price or/and provide coverage for the risk.

New technology

Transition will involve new technologies and ways of working. Feedback from insureds has been for more integrated insurance solutions, across product lines, in order to adopt these new technologies/assets, providing opportunities for insurers who can better integrate their product coverages.

Transition will rely heavily on new technologies and hence R&D, which have posed serious challenges for underwriters historically. However, given the scale of change required there may still be opportunities for those who can provide innovative solutions in this area.

New activities

There could be potential opportunities to insure new direct air carbon capture facilities, which hard to abate sectors (like Aviation) may have a greater propensity to adopt.

With transition will necessarily come a focus on safe decommissioning and recycling of stranded asset materials, which should present new opportunities for underwriters across all sectors.

Business planning

Opportunities identified in this report could be considered by Managing Agents as being part of their TCX risk code business, which Lloyd's recently announced could be used to write an additional 5% of gross premiums and would have differential performance monitoring assessments.

Potential risk(s) from the transition

A number of potential risks from the transition are common across sectors.

Stranded assets: As the industry shifts away from fossil fuels, assets tied to traditional technologies may become stranded. This could mean insureds needing to purchase a more expensive asset and potentially incurring additional costs for decommissioning or subsidies for changing. Contract terms and the propensity for these risks to emerge will therefore need to be carefully considered.

New types of claim: Underwriters have typically covered processes and assets which are production-ready. As the transition brings new transition processes and activities across the economy, there will be an increasing risk of the definition of 'production-ready' or/and accreditation schemes being opaque leading to unexpected claims from new technology.

Geopolitical and War risks: Given the scarcity of some key transition materials for green technologies, as well as the likelihood of a more disorderly transition, insurance claims from geopolitical and war policies are likely to be impacted.

Cyber risks: The transition will rely heavily on new digital technologies and as these start to be connected cyber risk is likely to increase, which cyber underwriters will need to try and understand and assist their insureds in mitigating.

Transportation-specific:

Assets focused on the transition, both now and in the future, may cost more to buy and maintain. Hence, insurers will need to keep abreast of these potential additional costs when underwriting.

Key risk changes in this sector relate to the emergence of new low carbon fuels. These fall into chemical fires from batteries, which typically burn extremely hot and are difficult to extinguish, and a potential change to more explosive fuels such as hydrogen and ammonia to which underwriters will be less familiar.

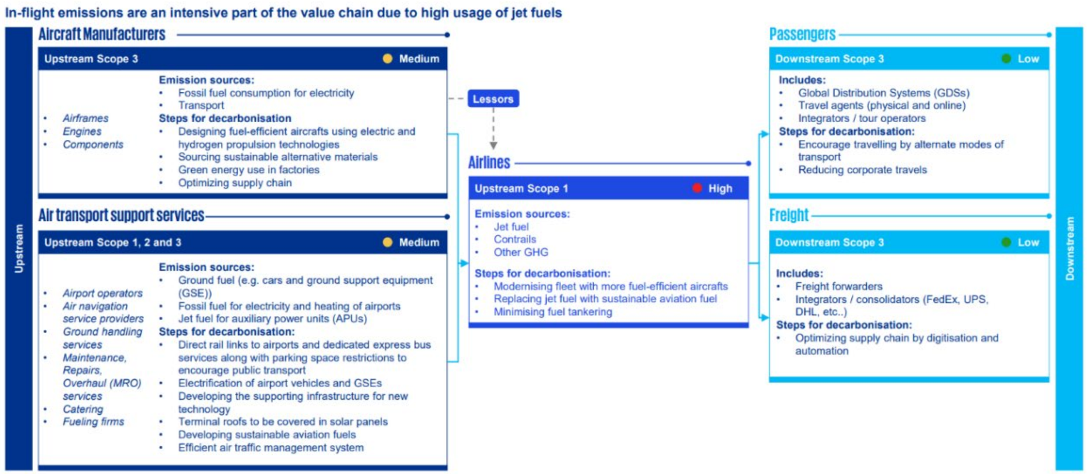
5 Aviation

5.1 Current state

Aviation accounts for just over 2% of energy related GHG emissions[14,15], or 4% of total anthropological warming impact when considering non-CO2 factors[16]. Low-cost and long-distance travel has been a significant force in shaping society and the global economy, and is also the most emissions intensive activity an individual can undertake, underscoring the differentiation of global responsibility on climate, with an estimated 1% of the world population responsible for 50% of commercial aviation emissions.[17] There are no easy options for decarbonising aviation, making it a proving ground for broader debates on emerging technologies, market-based approaches, and demand-side action.

As detailed in Figure 5.1, the sector includes airports, airlines, air navigation service providers and other activities that support services such as passenger transportation and airfreight.

Figure 5.1.1: Aviation sector value chain, key emissions sources and decarbonisation steps

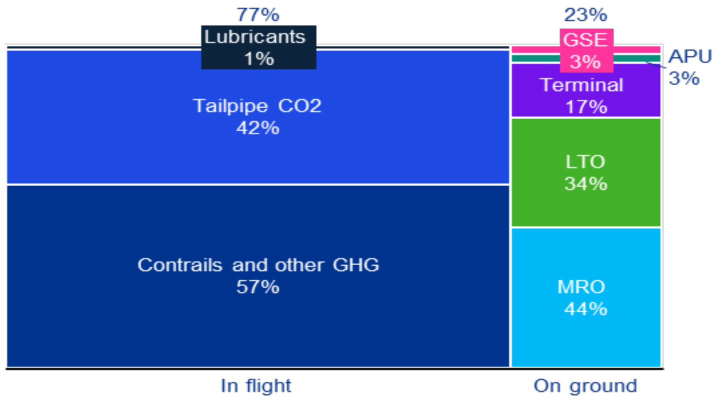


Source: KPMG research/analysis

14 Note that sectors covered are not exhaustive nor mutually exclusive; emissions totals do not add up to 100%
15 IEA, "Transport, Aviation, Link
16 KPMG, 'Contrails: an opportunity in plan sight', Link
17 Gossling and Humpe, 'The global scale, distribution and growth of aviation: Implications for climate change'. Link

Figure 5.1.2 provides a breakdown of emissions for in-flight and on-ground activities that covers airlines and air transport services which are the biggest contributors and the focus for most London Market insurers.

Figure 5.1.2: Estimated CO2 equivalent (CO2e) breakdown across the aviation sector



Source: KPMG research/analysis

Note: Ground support equipment (GSE), Auxiliary power units (APU), Landing and take-off (LTO), Maintenance, repair, and overhaul (MRO)

For an airline, in-flight operations account for 77% of GHG emissions, while the remaining 23% comes from on-ground operations. Tailpipe emissions account for 42% of in-flight emissions with contrails, mostly water vapour, and other GHGs such as nitrous oxides, sulphur dioxide and particulate matter forming the biggest portion. Business class travel typically emits double the CO2 emissions relative to economy, due to the larger associated space[18].

Considering ground handling operations at airports, the majority of emissions come from maintenance, repair and overhaul (MRO) followed by landing and take-off (LTO) cycles which together constitute a significant portion of an airport's total GHG emissions.[19]

5.2 Key trends

Demand projections: The International Civil Aviation Organisation (ICAO) estimates that the demand for air transportation will increase by 4.3% annually until the early 2040s.[20]

18 Sustainable business travel: How to cut carbon footprints | World Economic Forum (weforum.org)
19 KPMG Thought Leadership, Decarbonising ground operations: A long-haul journey (pg. 3), Link
20 International Civil Aviation Organisation (ICAO), Future of aviation, Link

Climate target commitments: 184 member states of ICAO have pledged to reach net zero emissions by 2050 directly from aviation activity and not by offsetting emissions through the purchase of credits.[21] In the next section, through our decarbonisation pathway, we offer a global sector level view which indicates that offsetting will be required to achieve this goal on a general basis, mostly driven by the inability to scale sustainable aviation fuel (SAF).

To achieve net zero goals, the sector will need to adopt technical measures such as low-emissions fuel uptake, airframe and engine improvements, operational optimisation, electrification, and demand-side management solutions.[22]

Given interdependencies across the value chain (see Fig. 5.1.1), the sector requires the well-coordinated collaboration of various players including aircraft manufacturers, infrastructure firms, service providers and distribution systems to achieve the necessary emissions reductions. If done strategically, decarbonisation measures can be an opportunity to differentiate from peers for both airlines and airports.[23]

Transition will involve new technologies and ways of working. Feedback from insureds has been for more integrated insurance solutions that they need to adopt these new technologies, providing opportunities for insurers who can better integrate their product coverages.

Due to the immaturity of key decarbonisation technologies, the aviation sector is considered to be one of the hardest sectors to decarbonise and is currently not on track to meet its climate commitments. Large-scale emissions reduction in the sector can theoretically be achieved through the adoption of SAF, however, feedstock availability, commercial viability and scalability pose significant challenges, while battery and hydrogen solutions are yet to demonstrate significant progress. Government intervention through targets, policies and regulations, specifically incentive arrangements, are needed to overcome these issues.

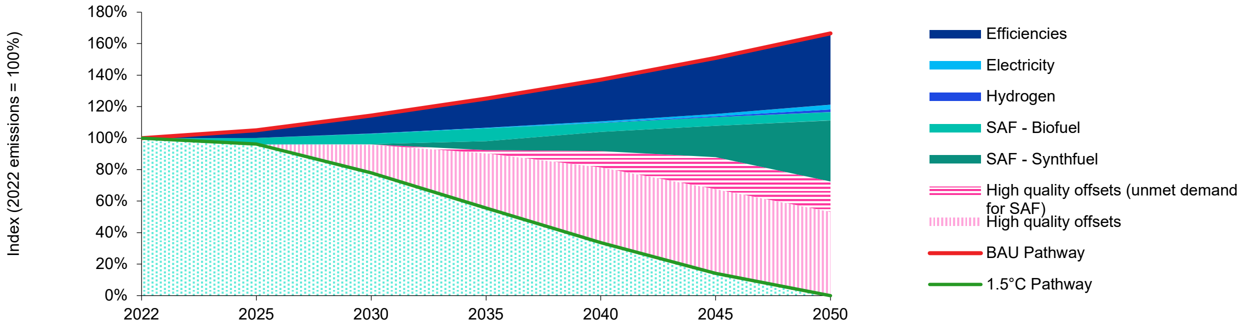
Given uncertainties over how quickly SAF can be adopted, due to scalability and commercial issues, insurers will need to monitor progress and regulatory concerns and potentially try to proactively assist the industry.

[21] International Energy agency (IEA), Aviation, Link
[22] International Energy Agency (IEA), Aviation, Link
[23] KPMG Thought Leadership, Decarbonising ground operations: A long-haul journey (pg. 4, 5 and 6), Link

5.3 Decarbonisation pathway & levers

In this section, we offer a view on the potential decarbonisation pathway for the aviation sector to achieve net zero emissions by 2050. Our research investigates fuel-related decarbonisation opportunities in-flight. It should be noted however, that reducing the impact of contrails — non-CO2 emissions which account for a significant proportion of the sector's total radiative forcing impact — is worth exploring as it offers a more immediate opportunity to decarbonise the sector.[24]

Figure 5.3.1: Potential Aviation sector decarbonisation pathway (2022-2050)



Click here for dynamic tables showing how this information may change up to 2050

Table 5.3.2: Abatement impacts on portfolio segmentation over time (illustrative)

Aviation	2050							
Portfolio Segmentation	Assumed mix of business	Abatement activities					
		Electricity	Hydrogen	SAF– Biofuel	SAF– Synthfuel	Unabated / No Change	Efficiencies
Abatement (% CO2)		**2%**	**1%**	**3%**	**23%**	**44%**	**27%**
Aviation Hull–- aircraft fuel							
Widebody	25%	0%	0%	1%	9%	15%	
Narrowbody	58%	1%	1%	3%	20%	34%	
Regional	8%	0%	0%	0%	2%	6%	
Turboprop	8%	1%	0%	0%	2%	5%	
Total	**100%**	**2%**	**1%**	**4%**	**32%**	**60%**	

Source: KPMG analysis

Notes and limitations: This analysis is highlighting a potential sectoral decarbonisation pathway for the purposes of discussion, based on analysis of available information at this point in time. The potential abatement volumes are indicative and based on ranges and assumptions, and are subject to variation based on the evolution of multiple factors, including technology, commercial viability, policy and regulation etc. The analysis is regionally agnostic, based on multiple variables such as global averages for activity, output, grid intensity among others. Assumed mix of business is illustrative as are the impact of abatement activities on different segments albeit linked to the decarbonisation challenges mentioned in this report.

[24] KPMG Thought Leadership, Contrails: an opportunity in plane sight, Link

Table 5.3.2 provides an initial view on how the abatement activities may impact upon a typical underwriter's hull portfolio based upon an assumed mix of business. The table highlights the focus on SAF, particularly for larger aircraft where there are limited alternatives, and the difficulties in decarbonising the sector albeit there are shorter term opportunities in assisting airports to provide the infrastructure for SAF and electrify on-ground operations.

Aviation is regarded as a 'hard-to-abate' sector due to the limited alternatives to aviation turbine fuel that are currently available. Decarbonisation is expected to be achieved through a combination of measures, but there remains much uncertainty as to the feasibility of each. For example, it is estimated that offsets will be required for around 30% of aviation's net zero target, although the IATA asserts that needs to be <20%.[25] However, the scale of this reduction cannot be met purely through nature-based solutions as it is realistically beyond afforestation schemes. Therefore, aviation will likely need to invest in the current nascent field of technology solutions for sequestering carbon, such as direct air carbon capture (DACC).

It should be noted that the most impactful decarbonisation lever in the aviation sector is reduction in demand, but KPMG sees a lack of ground transport alternatives and demand reduction incentives. Major growth in the sector is projected from emerging markets, where improved ground infrastructure is deemed prohibitively expensive/impractical. As such, without demand reduction, this decarbonisation scenario relies heavily on the scale up of SAF and high-quality offsets to achieve Net Zero

by 2050. However, with strong demand reduction policies in place, Net Zero can be achieved by relying less on carbon offsets.

The decarbonisation pathway shows the volume of aviation traffic still increasing over the next decade due primarily to an increasingly wealthy population.

5.3.1 Key decarbonisation levers specific to in-flight operations

The exact mix of solutions that will get the sector to net zero will likely depend on a variety of factors, from technological developments to the political landscape. In this section, we outline the main technologies that can be expected to make up a portion of that mix, as indicated in the pathway above.

[25] International Air Transport Association (IATA), Net Zero 2050: offsetting and carbon capture, Link

Efficiency gains in fuel production and aircrafts: Efficiencies that can be found in conventional Jet -A1 fuel production for aviation together with harnessing aircraft efficiency would account for the highest decarbonisation lever for the sector. Current aircrafts are 15% more fuel efficient and emit 40% lower emissions than aircraft from a decade ago.[26] This is driven by aircraft innovation, operational and air traffic management optimisation. The optimisation of flight paths to reduce air miles can, for example, deliver fuel and emissions savings.[27] Other short-term initiatives such as reducing the non-CO2 emissions of flights, particularly the warming effect of contrails by re-routing flights to avoid areas more susceptible to contrails formation can also be adopted.

Electric powered aircraft: In the near term, the adoption of battery electric propulsion is expected to be challenging for the sector. Current available battery energy density levels restrict their potential use to very small aircraft and short-haul flights. While the first battery powered flights have been completed, commercial viability at scale remains is unlikely in the short to medium term.

Logistics companies have already started using smaller aircraft, like cargo drones, to deliver items locally. Electric aircraft could become more prevalent in the future, providing new insurance opportunities.

Hydrogen powered aircraft: Hydrogen could be used in direct combustion jet engines, or in fuel cells to generate electricity for electric motors. Key challenges around this development include the safety of fuel storage and delivery methods, the weight of cryogenic tanks, and the redesign of airframes to accommodate the components.[28] As a result, the first hydrogen powered commercial aircraft is not expected until 2035, and it will likely be much longer until the technology becomes commercially viable at scale.

Sustainable Aviation Fuel (SAF): SAF is derived from sustainable sources of energy including solid waste, cooking oil, hydrogen etc. There are two main types of SAF; bio-SAF, which is derived from biological sources such as used cooking oils, agricultural residues and municipal wastes, and synthetic SAF (e-fuel), which is produced using hydrogen and carbon dioxide.

SAF can be blended with conventional jet-fuel to reduce carbon emissions from the sector. There is a substantial amount of regulation across the globe (including UK, EU, US, Singapore and UAE) specifically aimed at increasing the level of SAF used by airlines (see Appendix) with implications on international aviation due to the potential for extraterritorial application of domestic measures. It can reduce emissions by 80% compared to conventional fuel.[29] SAF can be used in existing aircrafts with little modification [30] but it is more expensive, and supply is yet to mature. There are challenges scaling SAF production given feedstock and food security challenges. The current planned production capacities are expected to provide only 1% to 2% of demand by 2027[31] and production of bio-fuel SAF is

[26] International Civil Aviation Organisation (ICAO), Environmental report – aircraft technology improvements (pg. 68), Link
[27] Airbus, Flight energy efficiency (pg. 1), Link
[28] International Energy agency (IEA), Aviation, Link
[29] Airbus, Sustainable Aviation Fuel, Link
[30] International Air Transport Association (IATA), Developing Sustainable Aviation Fuel (SAF), Link
[31] Aviation - IEA

expected to plateau around 2035 due to these challenges, with additional growth replaced by synthetic SAF.[32] For more detailed analysis, see KPMG's recent report 'Evolution of Alternative Fuels for Aviation'.[33]

Given the challenges around the security and scalability of SAF, insurers could assist in providing some form of insurance that would assist with supply side challenges (e.g. insurance for SAF production projects or/and 'book and claim' approach).

Insurers will need to understand the risks that can arise from the storage and use of SAF, as well as other green technologies like electric and hydrogen, and work with insureds to limit the impact on rates.

IATA Book and Claim Approach: Scaling the book and claim approach set out by IATA[34] to accelerate the production and uptake of SAF is a critical enabler for the sector. Book and claim decouples the physical delivery of SAF from its environmental benefits, which facilitates access to the SAF market, expands the market for SAF producers and helps to reduce logistical costs. A registry tracks the production and use of SAF and allocates the environmental benefits to the purchasing airline which adds integrity to the system. This will enable the more widespread use of SAF and support the sector in achieving decarbonisation targets.

Demand aggregation: The Sustainable Aviation Buyers Alliance (SABA)[35] is a collaborative initiative aimed at accelerating the adoption of SAF by aggregating demand from corporate buyers. Market demand aggregation creates a clear market signal around demand, encourages fuel producers to increase SAF production, and enables significant investment into the SAF market. SABA facilitates the purchase of SAF certificates, representing the environmental benefits of SAF, which decouple the environmental benefits of SAF from its physical use.

5.3.2 Key decarbonisation levers specific to on-land and terminal operations

As well as in-flight aviation emissions, on the ground activities also contribute to the sector's impact.

32 KPMG Thought Leadership, Decarbonising ground operations (pg. 6), Link
33 Evolution of alternative fuels for aviation
34 SAF Handbook (iata.org)
35 Sustainable Aviation Buyers Alliance (SABA) (flysaba.org)

As alternative forms of energy are used to power planes, the complexity of operations increases for airports, ground handlers and fuelling and charging activities. A number of technologies and trends are emerging to support the decarbonisation of non-flight aviation related infrastructure.

Landing and take-off (LTO) cycle electrification: Single-engine taxi-in (SETI) and single-engine taxi-out (SETO) reduces fuel consumption, by having only one engine running in an airplane while taxiing. In addition to these procedures, the electrification of Ground Handling Agent vehicles, using electric tow tugs and charging aircraft wheel-fixed electric motors, can help to reduce emissions.

Electric vehicles (EVs), Artificial Intelligence (AI), the Internet of Things (IoT) and smart chargers: These technologies can be leveraged to increase efficiency through the real-time visibility of ground support equipment (GSE). Smart chargers can, for example, use geo-locations to minimise apron journeys. Similarly, 5G can strengthen GPS fleet management solutions and improve fuel consumption, maintenance, and minimise aircraft engine use during the landing and take-off cycles.

On-site renewable power: Renewable energy generation from solar is attractive due to declining cost and protection against outages and blackouts arising from system independence. Measures must, however, be taken to ensure that glare from the solar panels do not compromise pilots' vision.[36]

Auxiliary Power Units (APUs), Fixed Electric Ground Power (FEGP) and Pre-Conditioned Air (PCA): APUs provide electrical power to the plane for services such as air-conditioning, as well as providing back-up generation in the event of primary engine failure. On average, APUs are responsible for 3% of on ground emissions. As such, many airports are enforcing limitations on APU run durations. A pre-conditioned air unit (PCA) is used for air-conditioning when the aircraft is at contact gates. Instead of taking power from an APU, which runs on aviation turbine fuels, these units source power from FEGP. Significant reductions are achieved if FEGP is renewable electricity based.[37]

In order to assess and underwrite the risks associated with the new aviation technologies, insurers must keep abreast of the innovations in the industry. This may involve investing in specialised training for underwriters and risk assessors, or through partnering with technology and aviation industry experts.

The global Airport Carbon Accreditation scheme (see Appendix) certifies at what stage of carbon management an airport is at, to provide an incentive to decarbonise.

[36] International Civil Aviation Organisation (ICAO), Climate Resilient Airports (pg. 10), Link
[37] PHL, Pre-conditioned air unit, Link

There may be potential opportunities to provide insurance via certification providers, linked to the risk assessment of the rating.

5.4 Other considerations

Demand shifting: Demand reduction measures such as frequent flyer levies or tax breaks for train travel have significant emissions reduction potential but are politically sensitive.[38] A potential shift in demand could also be driven by regulation such as the ban in France on domestic air flight.[39] Additionally, improved availability and affordability of other, lower emissions, alternatives such as high-speed rail could lead to decreased demand for aviation in certain countries.[40] While the IATA forecasts that the demand for air travel is expected to increase significantly by 2040, it could be rapidly curtailed in the event of strong climate policy action.[41]

Carbon off-setting: From 2027, almost all international flights will be subject to mandatory offsetting requirements, representing more than 90% of all international aviation activity (see Appendix).[42]

Aviators are likely to be big purchasers of 'credible' carbon credits, increasing the opportunity for insurers to provide carbon insurance to the carbon credit market.

Stranded assets: Assets that are not compatible with low carbon fuels technology may become stranded assets, with significant financial implications for the sector.

38 Chatham House, 'Net zero and the role of the aviation industry'. Link
39 International Air Transport Association (IATA), French domestic flight bans and carbon emissions reductions, Link

40 United, Corporate responsibility report (reputational risk section), Link
41 IATA, 'Global Outlook for Air Transport.' Link
42 KPMG, 'Aviation Sector – Transition Plan'. Link

Physical impacts of climate change: Physical risks due to extreme weather events like storms or extreme heat can lead to disruptions in flight scheduling and planning.[43] Between 2013 and 2019, the average delay of a flight affected by storms was approximately 18 minutes.[44] Similarly, colder temperatures in northern climates could lead to flight cancellations if aircraft are not certified for extremely low temperatures.[45] Climate-related hazards can also impact aviation demand indirectly due to changes in passenger or cargo demand resulting from extreme weather events at destinations.[46]

Additionally, aviation turbulence has strengthened due to global warming, with increases of severe turbulence estimated at 55% from 1979 to 2020, and moderate turbulence by 37%. Turbulence currently costs the industry $150-500m annually in the US alone.[47]

Physical impacts of climate change specific to on-land and terminals operations: Extreme weather events such as storms or heatwaves could lead to increased occurrences of infrastructure damage, disruption of operations or temporary airport closure and reduced accessibility for ground and air transport. What is more, sea-level rise could potentially require the relocation of coastal airports. Extreme heat events could increase cooling expenses for airports.[48]

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43 International Civil Aviation Organisation (ICAO), Effects of Climate Change on Aviation Business and Economics (pg. 1), Link
44 Eurocontrol, The impact of climate change on aviation, Link
45 International Civil Aviation Organisation (ICAO), Effects of Climate Change on Aviation Business and Economics (pg. 2), Link
46 International Civil Aviation Organisation (ICAO), Effects of Climate Change on Aviation Business and Economics (pg. 1), Link
47 Mark C Prosser, Paul D Williams, Graeme J Marlton and R. Giles Harrison. Evidence for Large Increases in Clear-Air Turbulence Over the Past Four Decades. Geophysical Research Letters. https://doi.org/10.1029/2023GL103814
48 International Civil Aviation Organisation (ICAO), Climate Resilient Airports (pg. 2), Link

6 Marine sector

6.1 Current state

The Marine sector, comprising maritime transportation and port operations, handles over 90% of global trade and plays a crucial role in the global economy.[49] The sector is a significant emitter, accounting for close to 3% of global GHG emissions annually[50], with nearly all the energy demand from the sector currently supplied by fossil fuels.[51]

Like Aviation, the sector is considered hard-to-abate, with limited levers to decarbonise. It is estimated that if no additional measures are taken, CO2 emissions from this sector could rise by 90% to 130% of the 2008 emissions level by 2050.[52] Most of these emissions are produced during the operations phase of the value chain, and a significant portion of this is attributable to the upstream phase of fuel production. The International Council on Clean Transportation estimates that well-to-tank (WTT) or upstream emissions of international shipping fuel consumption is over 20% of lifecycle emissions.[53]

For the sector to be on track to help limit temperature rise to 1.5°C, it must achieve emissions reductions of around 15% from 2022 to 2030 (as per the International Energy Agency Net Zero Emissions Scenario), while the International Maritime Organisation (IMO) has outlined reductions of 70% by 2040 relative to 2008.[54,55,56] Achieving substantial emissions reduction in the maritime transport sector will require efforts by all stakeholders across three value chains; the maritime fuel value chain, the shipbuilding value chain and the maritime operations value chain which includes vessel manufacturers, infrastructure, service providers, distribution systems and customers.[57]

However, solutions are being considered and evaluated. Alternative fuel is the critical decarbonisation lever for the sector, but there remain significant challenges in scaling it. Vessels have a long technical lifetime of up to about 35 years. Therefore, the characteristics of vessels deployed in the coming decade will determine the emissions trends of the sector by 2050. If carbon lock-in[58] is to be avoided, there is an urgent need to deploy low-emissions vessels in the near-term, which requires significant investment (which in itself presents difficulties due to there being no clear and proven answer as to what to invest in, at this point).

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49 International Renewable Energy Agency (IRENA), Pathway to decarbonise the shipping sector by 2050 (pg. 36), Link
50 Note that sectors covered are not exhaustive nor mutually exclusive; emissions totals do not add up to 100%
51 International Renewable Energy Agency (IRENA), A pathway to decarbonise the shipping sector by 2050 (pg. 10), Link
52 UN Trade and Development (UNCTAD), Decarbonising the maritime sector: Mobilising coordinated action using an ecosystems approach, Link
53 International Council on Clean Transportation (ICCT), IMOs newly revised GHG strategy: What it means for shipping and the Paris Agreement, Link
54 International Energy Agency (IEA), International shipping, Link
55 World Economic Forum (WEF), Shipping is targeting zero emissions, Link
56 2023 IMO Strategy on Reduction of GHG Emissions from Ships
57 UN Trade & Development (UNCTAD), Decarbonising the maritime sector: Mobilising coordinated action using an ecosystems approach, Link
58 Carbon'lock in' refers to assets with long lifespans that effectively "lock in" their associated greenhouse gas emissions for years or decades to come

The key task is to transition away from fossil-based fuels like Heavy Fuel Oil (HFO) and maritime diesel to lower-emission alternatives such as low carbon ammonia, low carbon methanol, hydrogen fuel cells, LNG, renewable electricity, and other sustainable fuels.[59] The challenge lies in identifying which low carbon fuel alternatives will be most viable in the future as it is critical to diversify the sector strategy and risks towards a common goal, and scale production and infrastructure in sufficient time.

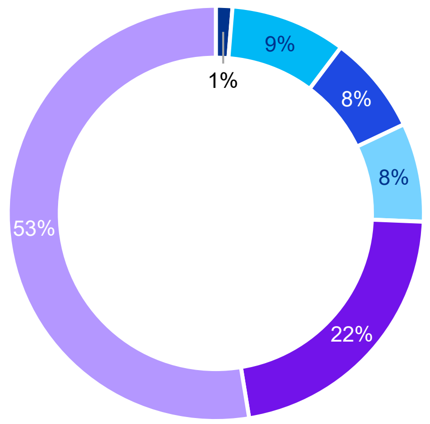
Green fuels currently cost three to four times as much as conventional fuel[60], and customers are not currently willing to pay for it due to several reasons. Customers looking at their Scope 3 (value chain) emissions who have a Science Based Target (SBT) or Net Zero Target in place tend to focus on low abatement cost categories first (such as purchased goods and services) since their upstream emissions for logistics can be relatively small compared to their total Scope 3 emissions, minimising initial focus on this area. The sector is fragmented, with numerous providers, which makes it difficult for customers to drive or support the decarbonisation of the sector. The availability and supply of alternative fuels and development of infrastructure is also fragmented.

The lack of consensus on the winning future fuel and uncertain policy signals pose a significant challenge to investments as assets cannot be easily replaced.[61] Coordination across the value chain is critical to unlocking these challenges to change economic incentives to enable the scaling of alternative fuel, and to align supply and demand. In particular, this includes mechanisms such as the successful negotiation and adoption of the Green Balancing Mechanism, which would bridge the cost gap between conventional and green fuel through a ‘feebate’, and the aggregation of demand for green fuel, as started by the Zero Emission Maritime Buyers Alliance (ZEMBA). Traditionally, the transnational nature of the sector calls for a universal approach and agreed regulatory framework. These issues are delaying decarbonisation efforts within the sector. [62]

Ports, as nodes of the global shipping industry, can play a leading role in accelerating the decarbonisation efforts of shipping lines, particularly through incentive policies targeted at port calls and bunkering. By offering incentives for the adoption of low-emission fuels and greener practices, ports can act as catalysts for decarbonising the entire maritime sector, both on their own and as component parts of green shipping corridors.[63]

59 International Renewable Energy Agency (IRENA), A pathway to decarbonise the shipping sector by 2050 (pg. 21), Link
60 Green Balance Mechanism — World Shipping Council
61 UN Trade & Development (UNCTAD), Decarbonising shipping: How to speed up the transition and ensure it’s fair, Link
62 UN Trade & Development (UNCTAD), Decarbonising shipping: How to speed up the transition and ensure it’s fair, Link
63 International Renewable Energy Agency (IRENA), Pathway to decarbonise the shipping sector by 2050 (pg. 37), Link

Figure 6.1: Activity emission sources for ports



Source: KPMG research/analysis

Note: The emissions profile is developed based on the data of Port of Los Angeles, and may vary in other regions and ports based on factors such as geographical location, size and types of activities conducted

Technological transformations such as providing ships with onshore power when docked, rather than relying on generators, can help pave the way for more ambitious decarbonisation initiatives in the sector.

In particular, the European Union FuelEU Maritime Regulation will require the use of Onshore Power Supply (OPS) or an equivalent zero-emissions technology by 2030, for those container and passenger ships in scope.

Additionally, the electrification and automation of port equipment and transportation can help in reducing emissions from freight and logistics operations. Within this category, the scaling and deployment of Battery-Electric Container Handling Equipment is critical for untethered machinery (typically representing 70% of Container Handling Equipment), accounting for a significant portion of total Scope 1 and 2 emissions for terminal operators.[64] The electrification and automation of port equipment and transportation can help in reducing emissions from freight and logistics operations. However, a key challenge lies in the financing of these large machineries which require large CAPEX investments.

64 APM Terminals and DP World spearhead roadmap for accelerating electrification of port operations in bid for net-zero - APM Terminals

6.2 Key trends

Global trade trends: International shipping, which accounts for 70% of the sector's emissions, enables up to 90% of all global trade.[65] By 2050, maritime trade is expected to increase between 40% and 115% from 2020 levels, leading to a significant rise in emissions if action is not taken.[66] If adequate mitigation policies are not adopted and global trade trends upwards, sectoral emissions are also expected to grow between 50% and 250% by 2050 from 2008 levels.[67]

Though International Renewable Energy Agency (IRENA) predicts a rise in activity levels across its shipping energy scenarios, the proportion of cargo type varies. In 2018, 32% of all cargo types were coal and oil tankers. This is expected to drop in all scenarios by 2050 and is projected to be as low as 3% under a 1.5°C scenario. Across all scenarios by 2050, general dry bulk, such as grains, minerals and metals, will be the most transported and thereby expected to have the highest energy demand.[68]

Figure 6.2.1: Disaggregation of activity levels based on cargo type and IRENA scenarios

Source: International Renewable Energy Agency (IRENA), A pathway to decarbonise the shipping sector by 2050 (pg. 74)

Note: 1. Base Energy Scenario (BES) represents IRENA's shipping energy scenario which is primarily dependent on fossil fuels

65 International Renewable Energy Agency (IRENA), A pathway to decarbonise the shipping sector by 2050 (pg. 10), Link
66 International Renewable Energy Agency (IRENA), A pathway to decarbonise the shipping sector by 2050 (pg. 20), Link
67 International Renewable Energy Agency (IRENA), A pathway to decarbonise the shipping sector by 2050 (pg. 20), Link
68 International Renewable Energy Agency (IRENA), A pathway to decarbonise the shipping sector by 2050 (pg. 74), Link

2. Planned Energy Scenario (PES) represents IRENA's shipping energy scenario which demonstrates moderate decarbonisation, as fossil fuels such as HFO, MGO and VLSFO are replaced by LNG

3. Transforming Energy Scenario (TES) represents IRENA's shipping energy scenario where LNG is the primary fuel with renewable fuels being increasingly deployed

4. IRENA 1.5ºC Scenario (1.5-S) represents IRENA's shipping energy scenario which demonstrates deep decarbonisation efforts

Increased demand in green technologies is likely to continue to increase the insurable cargo value of critical minerals and new construction materials.

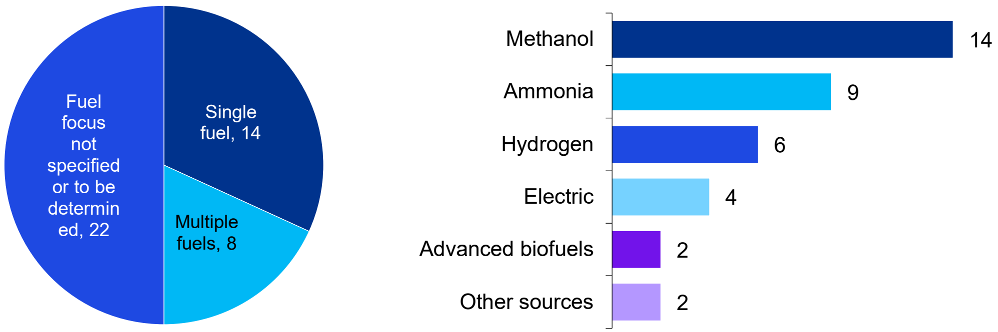
Investment requirements and implications: Up to US$28 billion could be required annually to decarbonise the global fleet, with additional investment required for alternative fuel infrastructure.[69] Although some of this cost includes asset upgrading and replacement which would be necessary in a business-as-usual scenario, this could lead to a rise in shipping costs. As most global trade is dependent on international shipping, a rise in shipping cost could have negative impacts on the global economy.[70]

Green shipping corridors: Shipping companies, port operators and governments are trying to address uncertainty around fuel mix by developing green shipping corridors where fleet mix development can be coordinated with alternative fuel supply infrastructure development. As of 2023, there were 44 green shipping corridor initiatives across the world.[71]

Figure 6.2. 1: Green Corridor Initiatives: Fuel and Energy Focus Areas

Breakdown of green corridor initiatives by fuel focus

Energy sources considered by green corridor initiatives



[69] UN Trade & Development (UNCTAD), Decarbonising shipping: How to speed up the transition and ensure it's fair, Link
[70] International Renewable Energy Agency (IRENA), A pathway to decarbonise the shipping sector by 2050 (pg. 10), Link
[71] Global Maritime Forum, Annual Progress Report on Green Shipping Corridors, Link

6.2.1 Key trends in on-land and port terminals operations

Onshore power utilisation: Globally, ports are increasingly adopting shore power systems, allowing docked ships to connect to onshore power sources instead of using generators and fuel.[72] In the future, ports are expected to prioritise generating renewable energy, such as solar and wind power, to meet their energy needs sustainably.

Equipment electrification: Electrifying yard equipment, such as cranes, is gaining popularity as ports strive to reduce their carbon emissions. The use of electrified equipment is expected to continue to grow.[73]

Changing energy needs of vessels could lead to risks in energy supply at ports (e.g. bunkering and/or cable issues) which could lead to an increase in Business Interruption claims.

Adoption of intermodal transportation: Rail freight is increasingly recognised as a more sustainable alternative to diesel-powered trucks in terminal yards for transporting goods. Ports might increase integration with rail transport to move the shipping goods. The Port of Valencia is leading the way in promoting intermodal transport, having cut its carbon emissions by 30% between 2008 and 2019, even while increasing cargo levels.[74]

6.3 Decarbonisation pathway and levers

The Maritime sector will be expected to play a significant role in decarbonising the economy given the world's dependency on international trade. To accelerate decarbonisation efforts within the sector, the International Maritime Organisation (IMO) devised a strategy to reduce sectoral emissions by at least 20% by 2030 and at least 70% by 2040 from 2008 levels, and Net Zero by 2050.[75]

The key considerations in the transition for the Maritime sector are cost and allocation; solutions exist but customers typically do not want to pay for them. As such, global regulations (e.g. via the International Maritime Organisation) have a key role to play to bridge the cost of conventional versus green fuel making it much easier for customers to buy green logistics.

There are a variety of potential solutions for decarbonisation, each of which entails a degree of uncertainty, with success depending on investment and innovation. The primary proposed decarbonisation solution is the adoption of alternative fuels. Solutions are likely to be more geographically constrained as well as heavily dependent on the vessel type and size.

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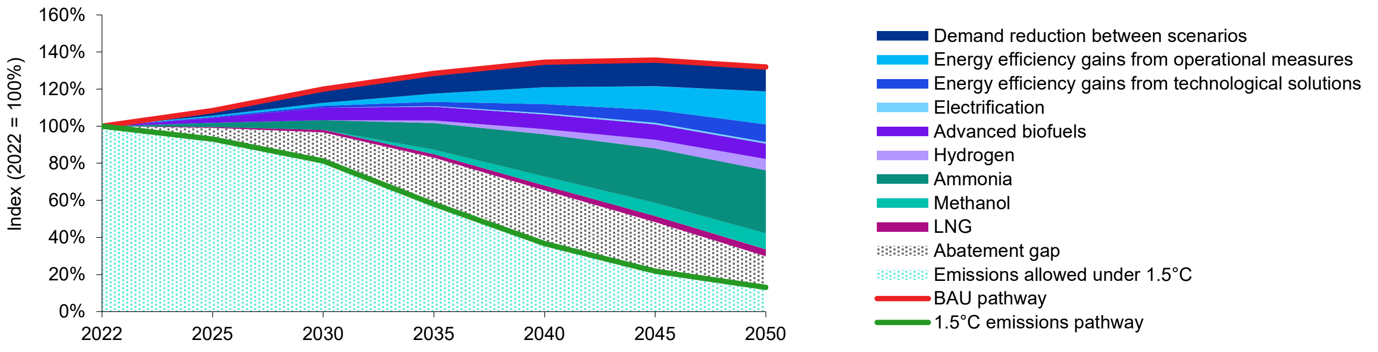
72 Seatrade Maritime News, Ports and ministers commit to 2028 shore power deadline, Link
73 Identec Solutions, The green port concept, Link
74 Identec Solutions, Green port concept, Link
75 International Maritime Organisation (IMO), 2023 IMO Strategy on Reduction of GHG Emissions from Ships, Link

Given that this is a hard-to-abate sector, the use of offsets to close the emissions gap in order to keep to 1.5°C will likely be needed. Offset credits reliant on nature-based solutions might not be enough to respond to the world demand, and the sector may need to add technology-based solutions such as Direct Air Carbon Capture (DACCS) to the offset mix.

There is currently no consensus around what the low carbon fuels of the future will be for Marine. Hence, there will be opportunities for those underwriters who keep abreast of developments and can adapt their insurance offerings to the emerging fuel mix of the future.

In this section, we offer a view on what the decarbonisation pathway for the maritime sector could be in order to achieve net zero emissions by 2050. The decarbonisation pathway addresses both international and domestic shipping.

Figure 6.3.1: Potential Maritime sector decarbonisation pathway (2022-2050)



Click here for dynamic tables showing how this information may change up to 2050

Table 6.3.2: Abatement impacts on portfolio segmentation over time (illustrative)

Marine		2050								
		Abatement activities								
Portfolio Segmentation	Assumed mix of business	LNG	Methanol	Ammonia	Hydrogen	Advanced biofuels	Electrification	Unabated / No Change	Energy efficiency gains from technological solutions	Energy efficiency gains from operational measures
Abatement (% CO2)		3%	6%	26%	5%	6%	1%	33%	7%	14%
Marine Hull - vessel fuel										
Container ship	29%	1%	2%	14%	3%	2%	1%	6%		
General Cargo ship	18%	1%	1%	9%	1%	1%	0%	5%		
Tankers	18%	1%	1%	1%	1%	1%	0%	12%		
Dry bulk carriers	18%	1%	1%	5%	1%	1%	0%	8%		
Multi purpose vessels	6%	0%	0%	2%	0%	0%	0%	3%		
Reefer ship	6%	0%	0%	2%	0%	0%	0%	3%		
Roll on / roll off vessels	6%	0%	0%	0%	0%	0%	0%	5%		
Total	**100%**	**4%**	**8%**	**32%**	**6%**	**8%**	**1%**	**41%**		

Source: KPMG analysis

Notes and limitations: This analysis is highlighting a potential sectoral decarbonisation pathway for the purposes of discussion, based on analysis of available information at this point in time. The potential abatement volumes are indicative and based on ranges and assumptions, and are subject to variation based on the evolution of multiple factors, including technology, commercial viability, policy and regulation etc. The analysis is regionally agnostic, based on multiple variables such as global averages for activity, output, grid intensity among others. Assumed mix of business is illustrative as are the impact of abatement activities on different segments albeit linked to the decarbonisation challenges mentioned in this report.

The above table provides an initial view on how the abatement activities may impact upon a typical underwriter's hull portfolio based upon an assumed mix of business. The table highlights ammonia as an alternative fuel, but it's key to understand that, unlike Aviation, it's currently unclear which of the alternative fuels will become the dominant transition fuel(s) therefore opportunities in assisting ports to provide the infrastructure and electrify in-port operations sit within the medium-term.

6.3.1 Key decarbonisation levers

In a business-as-usual scenario, emissions grow in line with increased demand for international shipping. However, a mix of energy efficiency in operations, alternative fuels, electrification with grid decarbonisation, technology solutions and high quality offsets and removals can help the sector to keep to 1.5°C.

Energy efficiency from operations, technological solutions and network optimisation, such as improved vessel design, voyage optimisation, increasing yield of cargos and fleet strategies including leveraging successful alliances with partners to achieve deliver on these areas, could contribute to emissions reductions of 15% by 2050.

Additionally, efficiency from technological solutions such as hull propulsion, engines and alternative power systems can add 8% to the emissions abatement. Technology solutions such as Maritime Autonomous Surface Ships (MASS) for autonomous vessels can make shipping more efficient, reducing the pressure on busy routes and reducing emissions.

Alternative fuels

Beyond energy efficiency gains, low carbon fuels are an essential lever for the decarbonisation of the sector.[76] Currently, only 1.2% of the global fleet utilises alternative fuels for operations and almost the totality of the final energy demand from the sector is met by fossil fuels such as heavy fuel oil (HFO), marine gas oil (MGO), and very-low sulphur fuel oil (VLSFO).[77] The production of future fuels are expected to scale by the mid-to-late 2020s, but greener fuels currently cost three to four times more than conventional fuels.[78]

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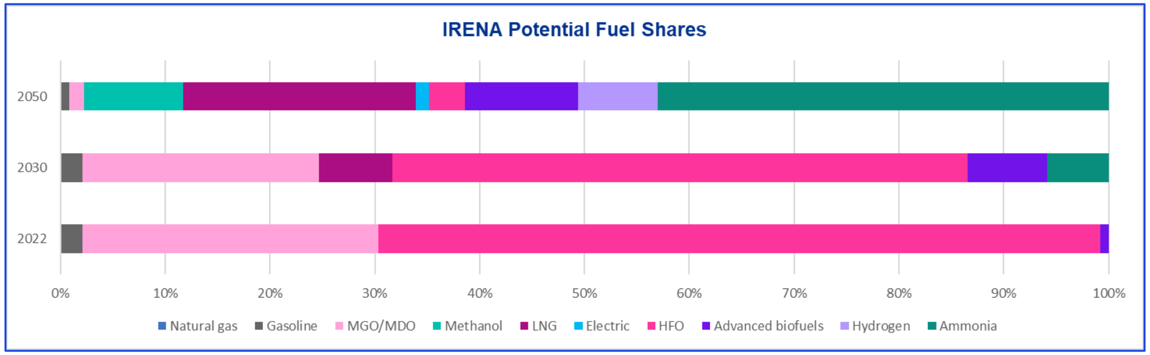
76 KPMG, Evolution of transport fuels, Link
77 UNCTAD, Decarbonising Shipping (pg. 14), Link
78 Green Balance Mechanism — World Shipping Council

There is considerable uncertainty about the development of alternative fuels in the market including the potential ultimate contribution of each fuel type to the transition pathway of the sector, their timelines and the commercial viability of each alternative. Looking ahead, the adoption of alternative fuels in the sector faces a number of challenges, including variable levels of readiness, reliability, performance and cost compared to conventional oil-based fuels, the availability of key inputs to scale production, as well as coordination across the value chain. There are also considerations around associated infrastructural constraints and investment requirements, which may in turn influence an increase in shipping costs.

KPMG Expert perspective: For this analysis, we have leveraged the International Renewable Energy Agency (IRENA) view on potential pathways[79] (as outlined in the figure below). However, the KPMG expert perspective is that currently the sector is prioritising methanol as the alternative fuel of choice, due to its density and ease of handling, with less retrofits. This can be seen in the market at present, as Maersk completed its maiden voyage using methanol in 2023[80]. KPMG experts believe that this will continue until 2030 – 2035. However, beyond 2035, as bio inputs to methanol become scarce, and in competition with other sectors, ammonia will be the predominant alternative fuel of choice. LNG could continue to be the dominant lower carbon fuel in emerging markets owing to cost and availability advantages. KPMG experts also believe that the choice of alternative fuels and the pace of adoption could be fragmented based on vessel types and regions. For further detailed analysis on the evolution of alternative fuels for the Maritime sector, see KPMG's recent report **Evolution of Transport Fuels.**[81]

Figure 6.3.1.1: IRENA Potential Fuel Shares



79 IRENA, Decarbonising Shipping, 2021, Link
80 Maersk secures green methanol for maiden voyage of the world's first methanol-enabled container vessel | Press Release
81 KPMG Thought Leadership, Evolution of Transport Fuels: the role of alternative fuels on the path to sustainability, 2024, Link

Biofuels and biodiesel have the potential to reduce GHG emissions by more than 90% compared to traditional fuels, with further reduction possible when used in combination with CCUS technologies. Adoption does not require substantial retrofitting in current vessel tanks however, there are challenges around their scalability. As biofuels scale up, they create a negative impact risk due to potential shortages in sustainable biomass availability. Additionally, other industries using biofuels as part of their transition may lead to price increases as demand outstrips supply, as well as a demand hierarchy where sectors compete for available fuel.

Hydrogen can be used in existing ships by retrofitting. Currently hydrogen is mostly produced from fossil fuels and CCUS, however it is expected that the availability of hydrogen produced from clean sources through electrolysis will increase in the future. Hydrogen can be stored in large volumes for long periods of time. However, there are challenges associated with this fuel since it is extremely flammable and has a larger ignition range than traditional fuels. Also, hydrogen has a very low energy density and must be significantly compressed and cooled before it can be stored and transported in fuel tanks. Hydrogen adoption may vary greatly by geographies given that government support is required to make it cost competitive compared with traditional fuels.

Ammonia has the potential to play a key role in the decarbonisation of the sector. Among its advantages, it does not emit carbon upon combustion and given that it has about half the energy density of bunker fuel, it doesn't need to be stored in high-pressure or cryogenic tanks. Ammonia production however is dependent on government intervention to overcome high costs, and as such, it is expected to start scaling from 2030. There are a number of challenges around this fuel which need to be overcome, in particular, safety considerations including its high toxicity, flammability and corrosion creating a risk to human and aquatic life. Its production and manipulation therefore requires stable systems to avoid negative impacts.

Methanol is already widely produced and used globally, with green methanol produced with renewable energy sources attracting a growing amount of interest. It is liquid at ambient temperature and pressure, making it a favourable marine fuel in terms of storage. Use of methanol requires little engine modifications and safe handling of methanol as a low flash-point fuel on vessels is currently an established practice in the sector, meeting the operational safety and engine compatibility requirements for a marine fuel. When produced with carbon sourced from bioenergy sources (e-methanol) or existing biowaste, it achieves near zero emissions. However, challenges remain around its scalability and cost, mainly associated with costs of electrolisers, low carbon electricity and availability of biomass. IRENA notes that if there is a considerable reduction in the cost of direct air carbon capture (DACC) and Bioenergy with Carbon Capture (BECCS), methanol rather than ammonia may be the key future fuel for shipping.[82]

Liquified Natural Gas (LNG) is a fossil fuel with lower emissions than heavy fuel oil and is expected to play a limited role in shipping's energy transition, however it is still considered as a lever as outlined in IRENA's future fuel mix projections[83], due to limited lower-carbon alternatives at scale in certain contexts. Its main risks are associated with methane leakage, but there are also considerable retrofits to existing infrastructure required as LNG must be stored at cryogenic temperatures.[83] While current infrastructure serves the demand for fossil based LNG, it is suitable for bio-LNG as supply matures.

82 IRENA, Decarbonising Shipping, 2021, Link
83 IRENA, Decarbonising Shipping, 2021, Link (p38)

Other levers

Maritime Book and Claim: A critical mechanism that has the potential to enable the scaling of low carbon fuels for the Maritime sector, addressing key coordination and geographic challenges. Book and claim decouples specific carbon attributes from low carbon fuels, and transfers them separately to a buyer for a price. This allows for a for more efficient distribution and use of certified sustainable fuels without the need for extensive and costly physical segregation. Buyers can claim the environmental benefits without physically possessing the fuel.

This is an approach that is already common practice, currently being coordinated and promoted by the Maersk Mc-Kinney Moller Centre for Zero Carbon Shipping (MMCZCS), which has established an industry registry.[84] According to the MMCZCS, "*Book and claim can help solve the mismatch between supply and demand for low-emission alternative fuels by allowing alternative fuels to be consumed where there is a supply, and allocating the benefits and costs to where there is a demand.*"[85] However currently customers who buy low emissions transport cannot claim the reductions to demonstrate progress to Net Zero/Science Based Targets. Therefore, the sectors (and others) are working to make this practice accepted by the GHG Protocol and the Science Based Targets Initiative.

Green Balancing Mechanism: A critical lever for the sector is the establishment of a green balancing mechanism under the International Maritime Organisation, which would make green fuels competitive with fossil fuels, through a 'feebate'. A fee would be collected for conventional fuel to be reallocated to green fuel, on a well-to-wake basis. Fuels with greater emissions reductions would receive greater financial allocations, to drive parity between the average cost of fuel. This will have a cascading effect where green fuel will be cheaper, customers will buy more, and green fuel production will scale. The establishment of a Green Balancing Mechanism is a key point of discussion at the Maritime Environment Protection Committee (MEPC82) meeting in late 2024.[86]

Electrification: Electrification of shipping, or running on blended fuels with batteries, could be a successful lever for smaller ships, fishing boats and ferries, as well as ships running near shore or inland. There has been significant progress in electric ferries for passenger and public transport, with solar powered ferries established for inland transport. [87]

6.3.2 Key technologies specific to on-land and terminals operations

Cold shoring: Under the EU Fit for 55 programme, demand and supply side policy will drive the adoption of onshore power, also known as 'Cold Shoring'. Beginning in 2030, Alternative Fuels Infrastructure Regulation (AFIR) will mandate major ports on the Trans-European Networks to have onshore power available for container and passenger ships, while the FuelEU Maritime Regulation will mandate in-scope ships to meet their electric power demand while moored through onshore power beginning in 2030.

Renewable energy generation: The installation of solar panels has been the most popular renewable energy source because of the availability of technology. Floating offshore wind (FLOW) and fixed-bottom offshore wind technologies are also increasingly being adopted.

84 Maersk Mc-Kinney Moller Centre for Zero Carbon Shipping Maritime Book & Claim – System Overview, 2023, Link
8585 Maersk Mc-Kinney Moller Centre for Zero Carbon Shipping Maritime Book & Claim – System Overview, 2023, Link P2
86 Green Balance Mechanism — World Shipping Council
87 Evolution of transport fuels (kpmg.com)

Electric cargo handling equipment (CHE): Cargo handling equipment (CHE) plays an important role in port operations and includes various equipment such as yard tractors, container handlers and cranes, which contribute the bulk of CHE emissions. Converting these to electric technologies, including connecting tethered machines to the grid, and battery electric for untethered machinery (typically 70%), can significantly reduce emissions and help meet regulatory standards such as the one put forth by the US Environmental Protection Agency (EPA).[88]

Automated Intelligence of Things (AIoT): AIoT combines artificial intelligence with the Internet of Things infrastructure and facilitates operational optimisation. Smart ports, e.g. Guangzhou, China, demonstrate capabilities to minimise emissions, optimise energy efficiency and eliminate spillages.[89]

Shoreside bunkering: Bunkering infrastructure that supports alternative fuels is a critical enabler to the decarbonisation of the sector. As of 2023, there are 50 demonstration projects globally for each of hydrogen and ammonia bunkering infrastructure. However, a lack of clarity on the potential future fuel for the sector, and associated coordination across geographies and value chain players, is delaying efforts.[90]

6.4 Other considerations

Physical impacts of climate change: Climate change poses significant physical risks to the sector as it impacts sea conditions. The sector is expected to face shifts in navigation season length and increased frequency of storms. These could have adverse effects on the sector such as forced re-routing, shipping delays, supply chain disruptions, increased asset damage, and the risk of asset stranding as vessels cannot cope with new adverse conditions.[91]

Marine routes could be altered to try and reduce energy consumption, which will need to be taken into consideration in underwriting, particularly if this increases exposure to war risks.

Port standards: Like shipowners, ports face uncertainties around regulatory requirements and the deployment of future fuels. If they do not have the necessary infrastructure set-up to support the shipping industry of the future, there is a risk they might lose out to other better equipped ports or face rapid and costly retrofits to keep pace with a changing technology mix. In terms of their own operations, ports will need to keep up with emerging standards and expectations in terms of their handling equipment, electric vehicle fleet, and storage facilities.

Large scale changes at ports may be required if there are regulatory mandates for the amount of alternative fuels at certain ports, which could substantially change their risk profile. Insurers should keep abreast of emerging legislation in this area.

88 US Environmental Protection Agency (EPA), Cargo handling equipment best practices, Link
89 Marine Insight, Smart port technologies, Link
90 International Energy Agency (IEA), International shipping, Link
91 BMT, The Impact of Climate Change on the Maritime Sector, Link

New market opportunities: Ports worldwide are experiencing a surge in opportunities due to the global shift towards renewable energy. As an example, the EU and UK have already set ambitious offshore wind capacity targets for 2030, placing ports at a central stage for achieving them. Ports are expected to serve as key hubs for the storage, assembly, and distribution of wind turbine components, as well as managing the logistics of offshore wind projects, thereby contributing to the accomplishment of renewable energy goals.[92] In terms of shipping, cargos are expected to trend away from fossil fuels and towards other commodities including critical minerals and renewable fuels. This could lead to the opening of new routes and new opportunities.

The transition will necessarily change the type and value of cargo transported, with the demand for low carbon fuels and critical minerals used in batteries (which can be more expensive) increasing. This will change the risk profile of cargo, which underwriters will need to carefully monitor, particularly if they already have limited information on their cargo.

Ports will be integral in this transition as they will be used as a hub to build and maintain offshore wind. This is likely to be a sector which will see a lot of growth.

[92] Royal Haskoning DHV, Wind energy opportunity for ports, Link

7 Road Freight

7.1 Current state

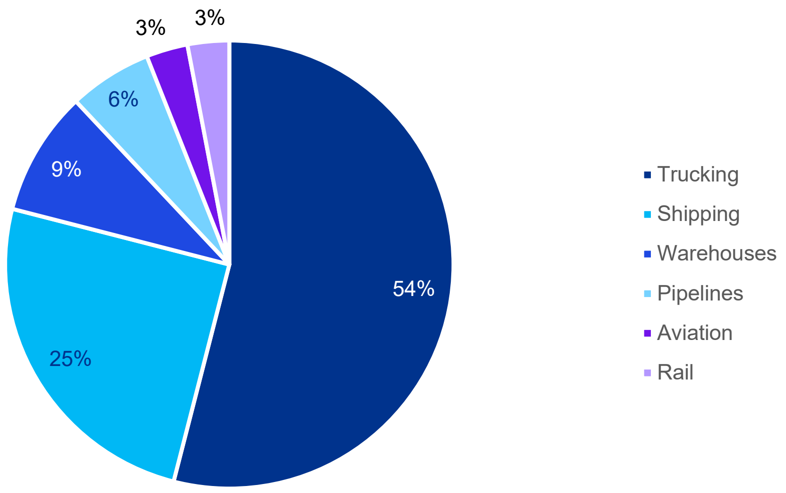
Road freight plays a vital role in the global economy, facilitating the movement of goods both within and between global regions. With the majority of this transportation undertaken by internal combustion engine (ICE) vehicles, road freight accounts for roughly 5.2% of global emissions.[93, 94] While road freight is convenient and allows suppliers to react to shifting patterns of demand, it is an inefficient mode of transport compared to rail or shipping in emissions terms, the latter of which produces just 1% of the emissions associated with road freight per unit of good transported.[95]

According to the International Energy Agency (IEA), the demand for both passenger and freight transportation is projected to more than double by 2050.[96] This growth is expected to be driven by increasing mobility needs in developing countries across Asia, Africa and Latin America, fuelled by expanding economies, growing populations and rising living standards. Demand for heavy goods vehicles (HGVs) in particular is expected to double by 2050.[97]

While other sectors are reducing their reliance on fossil fuels, nearly all freight transportation still depends on oil and gas. If appropriate measures are not taken, GHG emissions from the sector are expected to double to almost 3 $GtCO_2e$.[98] To align with the Net Zero Emissions (NZE) Scenario outlined by the IEA, the transport sector must reduce its emissions by approximately one-quarter by 2030 from 2022 levels.[99, 100]

93 Note that sectors covered are not exhaustive nor mutually exclusive; emissions totals do not add up to 100%
94 MIT Climate Portal, Freight transportation, Link
95 MIT Climate Portal, Freight transportation, Link
96 IEA, ‘The Future of Rail’, Link
97 Mission Possible, ‘Making zero-emissions trucking possible’ (pg. 9) Link
98 Mission Possible, ‘Making zero-emissions trucking possible’, Link
99 International Energy Agency (IEA), World Energy Outlook 2022 (pg. 146 to 150), Link
100 MIT Climate Portal, Freight transportation, Link

Figure 7.1.1: Activity emission sources for the logistics sector



Source: World Bank Library, Unlocking green logistics for development (pg. X-XI), Link

Achieving these emissions reductions requires a multi-faceted approach. Electric vehicles are expected to play a key role along with alternative fuels such as hydrogen and biofuels.

Like retail cars, road freight vehicles are likely to become more reliant on expensive inbuilt technology, which may increase the cost of property damage and business interruption claims if not mitigated.

Efficiency improvements in transportation systems can also play a crucial role in achieving decarbonisation targets. This includes optimising routes and improving fuel efficiency. Beyond technological and infrastructure advancements, the promotion of mode shifts to less emissions-intensive modes of transportation such as freight rail will also be key. And finally, promoting behaviour change through raising awareness, offering incentives, and creating infrastructure that supports sustainable freight options is vital for a transition to sustainable transportation practices.[101]

[101] International Energy Agency (IEA), World Energy Outlook 2022 (pg. 146 to 150), Link

7.2 Key trends

Rising freight demand: The continued growth of mobility needs, increase in population, online shopping and home deliveries means that over the last two decades alone, the industry saw an 80% increase in the global consumption of diesel due to rising road freight. This trend in demand is expected to continue with emissions increasing as a result.[102]

Total cost of ownership (TCO) trends: When considering alternatives for decarbonisation, cost trends will play a significant role. Based on a TCO study conducted in the US, diesel-powered trucks are currently the cheapest, but by 2030 battery electric alternatives will likely be lower. Hydrogen powered trucks are likely to remain the most expensive due to the high price of green hydrogen fuel.[103]

Demand-driven decarbonisation approach: Value chain (Scope 3) emissions account for close to 80%-90% of all emissions for most companies. As organisations aim to reduce these emissions, significant focus will be placed on road freight which could lead to investment and incentives. The World Economic Forum (WEF), for example, is aiming to develop demand across the value chain to prompt favourable policies and investments into zero-emissions vehicles and supporting infrastructure.[104]

Increasing investment by market actors: Globally, 88% of freight and logistics leaders are investing in reducing their environmental impact, particularly in terms of carbon. Freight and logistics companies are recognising that integrating climate considerations into their operations can have significant financial and reputational advantages. By investing in sustainability-focused projects and initiatives, such as reducing carbon emissions and increasing energy efficiency, companies can gain a competitive edge and attract environmentally conscious customers.[105]

Charging infrastructure: Range anxiety for electric vehicles, and the fragmented roll-out of charging infrastructure in public areas, homes and places of work, are critical barriers to the scaling of electric vehicles, compared with in Internal Combustion Engines.

7.3 Decarbonisation pathway and levers

In this section, we offer a view on what the decarbonisation pathway for the heavy road freight sector could be in order to achieve net zero emissions by 2050.

Road freight activity is expected to grow compared to current levels with a consequent increase in emissions over time. Some of the emissions growth might be mitigated by a mode shift to rail, as it offers a lower carbon alternative for land transport of products. However, the road transportation sector is required to make a significant effort to reduce its impact.

Assets in the trucking industry typically have long economic lifespans, sometimes exceeding 20 years. Therefore, a complete transition to a new fuel and/or engine type can raise concerns about the high replacement costs of prematurely phasing out otherwise economically valuable assets and about making the

102 International Transport Forum, "Is Low-Carbon Road Freight Possible? Link

103 International Council on Clean transportation (ICCT), Total cost of ownership of alternate technologies in long-haul trucks (pg. 28), Link
104 World Economic Forum (WEF), Demand-driven approach for decarbonisation, Link
105 The UK Logistics Confidence Index 2023 (pg. 5), Link

‘wrong’ choice. Many organisations in the sector are taking a ‘wait and see’ approach, hoping to gauge which fuels and technologies will emerge as the most cost-effective. They are trying to reduce fuel consumption and emissions while testing alternatives on a smaller scale.

However, the risks of not adopting an alternative fuels strategy are equally significant. Without the increased adoption of alternative fuels, organisations should be prepared for stranded assets and reduced profits or cash flow at a later stage.

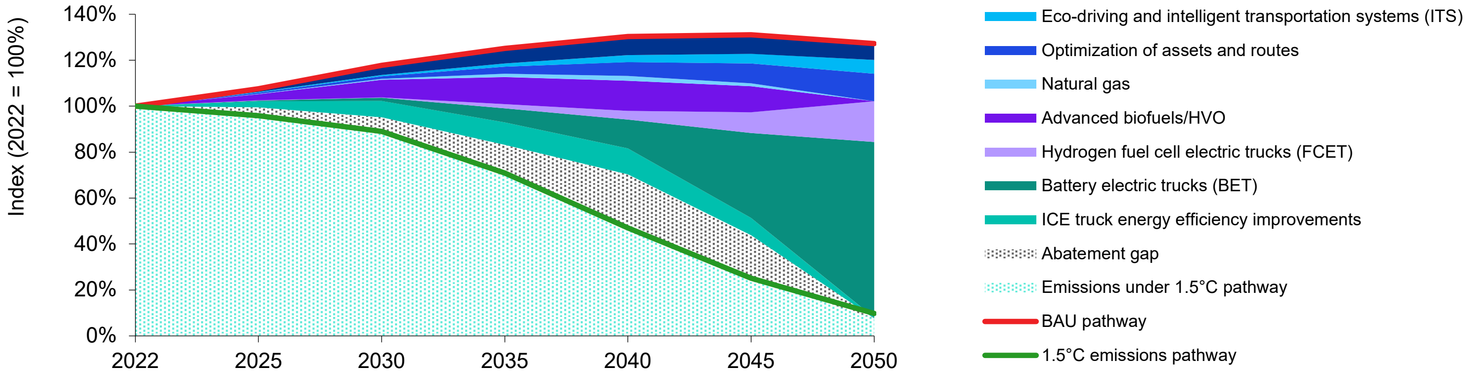
Many transitional options are available, and the industry will likely look at mosaic of solutions, including battery EVs, Internal Combustion Engine (ICE) hybrids, and hydrogen electrics alongside a range of alternative fuels. However, given coordination and infrastructure requirements, it is likely that a single alternative fuelling option will predominantly win out except in specific use cases.

Given that this is a hard-to-abate sector, the use of offsets to close the emissions gap in order to keep to 1.5°C is likely to be needed. Offset credits reliant on nature-based solutions might not be enough to respond to the world demand, and the sector may be required to add technology-based solutions such as Direct Air Carbon Capture (DACCs) to the offset mix.

There is likely to be a substantial increase in demand for road freight electrification and hence charging stations. Road freight is likely to need a different solution, due to capacity and timing needs, which could see the evolution of purpose-built electrification stations (e.g. providing pre-charged batteries). This new infrastructure would then provide new opportunities to insurers.

As hauliers transition their fleets away from fossil fuels, assets tied to traditional technologies may become stranded. This could mean the insured needing to purchase a more expensive asset and also potential costs for decommissioning. Contract terms and the propensity for these risks to emerge will therefore need to be careful considered.

Figure 7.2: Potential Road Freight decarbonisation pathway (2022-2050)



Click here for dynamic tables showing how this information may change up to 2050

Table 7.2.2: Abatement impacts on portfolio segmentation over time (illustrative)

Road freight		2050								
		Abatement activities								
Portfolio Segmentation	Assumed mix of business	Battery electric trucks	Hydrogen fuel cell electric trucks	Biofuels	Natural Gas	Output change (predominantly, mode shift to rail)	Unabated / No Change	ICE truck energy efficiency improvements	Optimisation of assets and routes	Eco-driving and intelligent transportation systems (ITS)
Abatement (% CO2)		**60%**	**14%**	**0%**	**0%**	**6%**	**6%**	**0%**	**9%**	**5%**
Small van	5%	5%	0%	0%	0%	0%	0%			
LWB and XLWB Vans	5%	5%	0%	0%	0%	0%	0%			
Articulated Lorry	40%	22%	10%	0%	0%	3%	5%			
Rigid lorry	25%	15%	6%	0%	0%	2%	2%			
Tanker lorry	25%	24%	0%	0%	0%	1%	0%			
Total	**100%**	**70%**	**16%**	**0%**	**0%**	**7%**	**7%**			

Source: KPMG analysis

Notes and limitations: This analysis is highlighting a potential sectoral decarbonisation pathway for the purposes of discussion, based on analysis of available information at this point in time. The potential abatement volumes are indicative and based on ranges and assumptions, and are subject to variation based on the evolution of multiple factors, including technology, commercial viability, policy and regulation etc. The analysis is regionally agnostic, based on multiple variables such as global averages for activity, output, grid intensity among others. Assumed mix of business is illustrative as are the impact of abatement activities on different segments albeit linked to the decarbonisation challenges mentioned in this report.

The above table provides an initial view on how the abatement activities may impact upon a typical underwriter's portfolio based upon an assumed mix of business. The table highlights battery electric trucks becoming a core part of vans, smaller lorries and articulated lorries albeit hydrogen fuel cell trucks are also important for this part of the portfolio. Given the focus on electrification, opportunities will also exist in assisting to facilitate the service station infrastructure that will be needed to support these new types of trucks.

7.3.1 Key decarbonisation levers

Energy efficiency: Various mechanical designs such as reducing the weight of trucks, reducing ICE fuel waste, optimisation of routes, intelligent transportation systems and driver training schemes on eco-driving can enhance fuel efficiency and reduce emissions significantly by 2050.

Alternative fuels: Many of the fuel options for this industry are showing a relatively good state of readiness, however scalability and costs remain a challenge.

KPMG experts believe that in assessing market outcomes between Battery Electric and Hydrogen in the HGV market, Battery Electric will likely be the winning technology. In particular, the expert view is that all short and medium range trucks will become electric, and, contingent on the development of heavy-duty charging cycle infrastructure and the development of battery capacity, long-distance could also become electric, although there remains a question mark here.

Hydrogen is likely to lose out because the cost is prohibitive and it is relatively inefficient as an energy carrying medium, with complex associated infrastructure requirements. However, it is possible that hydrogen may develop in certain sections of the market, for example long-range heavy duty trucks, and also potentially in certain regions if the cost of hydrogen is competitive.

Biofuels (first-generation Hydrotreated Vegetable Oil and renewable diesel): The use of biofuels, in particular biomethane, hydrolysed cooking oils, and biodiesel as a substitute for diesel will play a role in near-to medium-term decarbonisation for heavy duty vehicles. Biofuels are expected to account for 6% of road transport by 2030 and offer immediate GHG emission reductions for commercial and public transportation.[106] However, their production is limited by feedstock availability, higher costs, and sustainability criteria, forcing road transit organisations to consider a variety of other alternative fuel options. In 2023, US production capacity of renewable diesel surpassed US biodiesel production capacity for the first time. Rising targets for state and federal renewable fuel programs and the renewal of biomass-based diesel tax credits are driving this growth/switching of renewable diesel capacity.[107]

Biofuels (second generation Methanol, DME and e-fuels): Methanol is already widely produced and used globally, with green methanol produced with renewable energy sources attracting a growing amount of interest. With its adaptability for engine technologies and lower emissions, methanol can power trucks and public transportation fleets efficiently despite safety considerations due to its high flammability. DME is emerging as a diesel alternative for commercial vehicles, offering clean-burning properties and cost-effective production from methanol. Its similarity to LPG enables easy storage, transportation, and possible opportunities to work with existing LPG infrastructure.

[106] IEA, The Role of E-fuels in Decarbonising Transport – (pg. 17) Link
[107] State of California, Link

E-fuels: Short for electrofuels, e-fuels are a category of synthetically produced fuel using low carbon hydrogen and captured carbon dioxide. E-fuel production routes can be used to produce drop-in fuels such as e-diesel, e-HFO and e-SAF that are compatible with existing engines and fuelling infrastructure. Emerging fuels such as methanol can also be produced utilising e-fuel pathways. However, the outlook for e-fuels and their role in road freight decarbonisation remains uncertain owing to limited production, high costs, and the dependence of production technology readiness on further growth of low carbon hydrogen and carbon capture technologies.

Hydrogen fuel cell electric trucks (FCET) and decarbonisation of hydrogen: FCETs run on electricity produced in a hydrogen-powered fuel cell. The use of green hydrogen produced via electrolysis as a transport fuel is widely recognised as a medium- to long-term solution for decarbonising the sector, with existing efforts in scaling and demand building. However, while there remains significant potential in emissions saving compared to diesel vehicles and added practicality over dense, bulky batteries, hydrogen vehicles and fuel are considerably more expensive than battery alternatives, and hydrogen is relatively inefficient. Hydrogen is most suitable for long haul journeys, where batteries may not be suitable. Overall, it is believed that hydrogen will contribute to some of the overall abatement pathway for HGV's but that Battery Electric Trucks will be the technology of choice.

Battery Electric Trucks (BETs): Currently, electric trucks account for approximately 0.3% of global truck shares[108], but this is set to rise significantly in a Net Zero scenario, with Battery Electric Trucks emerging as the key decarbonisation lever for the sector. Short haul trucks can be electrified the fastest, while electric heavy-duty vehicles (HDVs) will require infrastructure investments in high-power chargers and significant grid upgrades. There are considerable innovations happening in the battery market, with battery storage deployment more than doubling year on year, and considerable cost reduction in lithium-ion batteries (90% since 2010)[109], and a focus on overnight and high-speed charging for HGVs which will unlock greater potential for BET as a decarbonisation lever.

Success in this space will be contingent on overcoming key barriers such as limited knowledge on factors such as battery degradation, the optimal ownership period, and residual value in the second-hand market is further impacting roll out. It is also important to note that the emissions reduction potential of BETs is entirely dependent on the successful decarbonisation of the power grid.

The change in risk profile to being focused on electrification of vehicles and infrastructure will need careful underwriting, as it will bring new types of risk/perils.

[108] IEA, Global EV Outlook 2022 Link

[109] Executive summary – Batteries and Secure Energy Transitions – Analysis - IEA

Demand aggregation: The GMA (Green Market Activation) Trucking Buyers Alliance is an initiative by the Centre for Green Market Activation aimed at accelerating the adoption of zero-emission heavy-duty trucks through demand aggregation.[110] This is a critical market initiative that pools demand from corporate buyers (such as PepsiCo, Meta, eBay, and Green Worldwide Shipping), to create significant market signals and investment in the development and scaling of zero-emission trucks. The GMA collaborates with the market to procure environmental attribute certificates (EACs) for zero emission trucking services through a book and claim system.

ICE truck energy efficiency: Continued improvement in **ICE truck energy efficiency** is expected to continue over time, supporting the sector efforts to close the mitigation gap.

Electric and alternative fuel trucks have different risk profiles compared to traditional diesel trucks, including battery-related hazards and technology reliability issues. Insurers will need to adjust their risk assessment models accordingly.

7.4 Other considerations

Secondary markets: The growth of thriving secondary EV resale markets are critical to ensure the uptake and continued shift of the market to electric vehicles.

Physical impacts of climate change: Global transport infrastructure assets are exposed to damages as high as US$15 billion annually, with over 60% of this additional cost being borne by low-income and middle-income countries.[111] It is estimated that close to 8% of all global road and rail infrastructure assets are vulnerable to a 100-year flood event, which has a 1% chance of occurrence in any given year. The cost of damage arising from extreme weather events could be as high as US$22 billion annually, with flooding incidents accounting for over 70% of this cost.[112] Other hazards such as wildfires, heat stress and rising sea levels would also have negative impacts on the sector, depending on the asset's exposure and vulnerability to these events.

[110] Heavy Duty Trucking – Center for Green Market Activation (gmacenter.org)

[111] United Nations Environment Programme Finance Initiative (UNEPFI), Climate risks in the transportation sector (pg. 39), Link

[112] United Nations Environment Programme Finance Initiative (UNEPFI), Climate risks in the transportation sector (pg. 42), Link

Carbon pricing: Implementing carbon prices increases the cost of operating in carbon-intensive sectors such as transportation. It is estimated that increasing the carbon price by an additional dollar could lead to emissions reductions of 0.2% in the near-term and up to 1% in the long-term. Until the sector manages to decarbonise, this will, however, lead to a rise in delivery and warehousing costs and the resulting potential for customers to look elsewhere for their products or delivery methods. Additionally, manufacturers and haulage companies failing to transition to alternative low-carbon vehicles face further regulatory and reputational risk.[113,114]

Global trade trends: Given the vast interconnectivity of the logistics sector with global trade, a majority of critical raw materials and complex goods are likely to experience rapid rises in prices, as high as 130%, which could alter operating logics within the sector itself.[115]

New market opportunities: Of the US$611 billion total investments currently directed towards the low-carbon transition, over 50% is accounted for by the energy and transportation sectors.[116] Within the transportation sector, investments are primarily focused on EVs and the development of alternative fuels. In 2021, the market share for EVs increased fourfold in two years across all vehicular categories. This is underpinned by technological advancements in battery storage capacity, encouraging higher uptake of EVs, initially in the passenger segment but increasingly in trucking as well. These advancements can lead to EVs being utilised for short and medium distance road freight as well as 'last-mile' deliveries.[117]

113 United Nations Environment Programme Finance Initiative (UNEPFI), Climate risks in the transportation sector (pg. 9), Link
114 International Journal of Production Research, Modelling the impact of climate change risk on supply chain performance (pg. 21), Link
115 International Journal of Production Research, Modelling the impact of climate change risk on supply chain performance (pg. 21), Link
116 United Nations Environment Programme Finance Initiative (UNEPFI), Climate risks in the transportation sector (pg. 19), Link
117 World resources Institute (WRI), Decarbonising freight, Link

8 Mining

8.1 Current state

The scope of this decarbonisation analysis is mining of metallic ores and non-metallic minerals excluding fuels (e.g. coal). The scope also includes quarrying and support activities for mining and quarrying. Coal mining is included in the qualitative assessment but excluded from the qualitative analysis. The mining and metals sector plays a key role in the global economy, and across value chains, providing energy security and the critical inputs and commodities to industry and society. Revenues of the top 40 mining companies in the world totalled over US$650 billion in 2020 with six of the top 10 companies being registered in China, and the remaining four in the UK.[118]

The mining and metals sector also plays a critical role in the global energy transition, providing the essential components of clean energy technologies – from electric vehicles, to solar panels and wind turbines, and electricity networks. As a result, it is projected that demand for critical minerals will increase significantly, in particular copper and aluminium to scale electricity networks; lithium, nickel, cobalt, manganese and graphite for batteries; and rare earth minerals for wind turbines and EV motors.

The volume of minerals required for clean energy technology can be significantly higher than fossil fuel alternatives, for example a typical electric vehicle requires six times more mineral inputs than a conventional alternative.[119] The International Energy Agency estimates that six times more mineral inputs will be required in 2040 compared to today[120] to meet net zero globally by 2050, while the World Bank has estimated increases in demand of up to 500% for certain minerals, in particular lithium, graphite, and cobalt[121]. Recycling could also play a role in addressing demand, and may reduce primary demand for certain minerals by 10% by 2040, but requires an enabling policy and research and development environment.[122]

The geographic concentration of minerals is a key consideration as well as the management of global supply chains. For example, China and the Democratic Republic of Congo were responsible for 60% and 70% of the global production of rare earth minerals and cobalt respectively in 2019, while Australia was responsible for over 50% of lithium production. Similarly, processing has been heavily concentrated in China.[123]

The sector is a key contributor to climate change, given the energy intensity of mining and related processes. The majority of large mining companies - Members of the International Council on Mining and Metals – had committed to a goal of net zero Scope 1 and 2 GHG emissions by 2050 or sooner[124], Therefore, it is critical that the sector pursues rapid decarbonisation, especially given the projected growth of the sector.

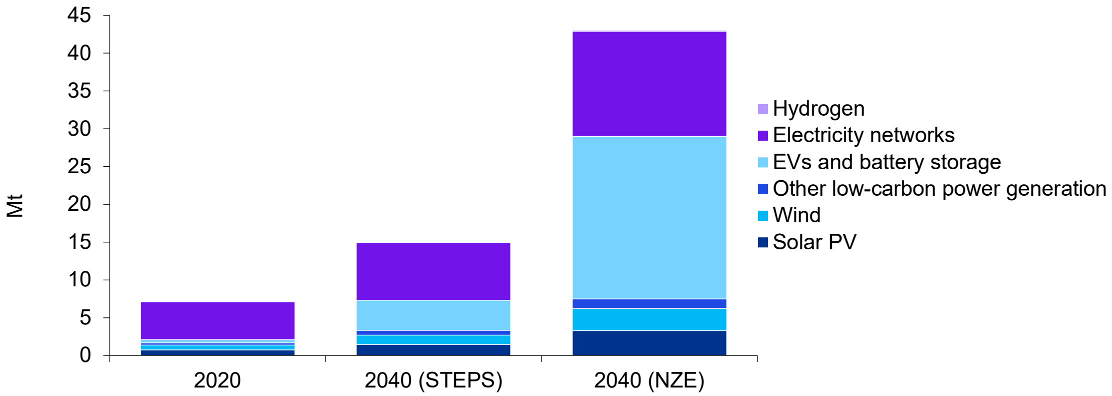
118 Company annual reports
119 Executive summary – The Role of Critical Minerals in Clean Energy Transitions – Analysis - IEA
120 Executive summary – The Role of Critical Minerals in Clean Energy Transitions – Analysis - IEA
121 Minerals-for-Climate-Action-The-Mineral-Intensity-of-the-Clean-Energy-Transition.pdf (worldbank.org)
122 Executive summary – The Role of Critical Minerals in Clean Energy Transitions – Analysis - IEA
123 Executive summary – The Role of Critical Minerals in Clean Energy Transitions – Analysis - IEA
124 International Council on Mining and Metals (ICMM), Commitment to a Goal of Net Zero by 2050, Link

In addition to climate change, there are several additional environmental and social considerations associated with the mining sector, from pollution and habitat degradation, to widespread labour exploitation and human rights abuses, while at the same time providing significant employment opportunities across emerging markets and developing economies. As such, a Just Transition is critical to the mining sector.

The industry is moving away from mining fossil fuels towards critical minerals. There is an opportunity for those insurers who can change their focus accordingly and provide insureds with the coverage they will need.

Construction may demand different types of material to be mined to meet their transition goals. Hence, there could also be opportunities for insurers who understand this change and provide insured with the coverage they will need.

Figure 8.1.1: Total mineral demand by clean energy technology across scenarios, IEA



Source: International Energy Agency (IEA), Link

Note: 1. STEPS represents IEA's Stated Policies Scenario, which is associated with a temperature rise of 2.4ºC by 2100 and provides an outlook on global energy system's progression based on current policy landscape

2. NZE is IEA's Net Zero Emissions by 2050 Scenario, which is associated with a temperature rise of 1.5ºC by 2100 and demonstrates a normative scenario of orderly transition to net zero

8.2 Key trends

Expected rise in demand for critical minerals: The transition to a greener economy is expected to amplify the demand for critical minerals. The World Bank estimates that by 2050, the demand for critical minerals could increase by 500% against 2018 levels, driven primarily by graphite, lithium and cobalt.[125]

Increased demand in green technologies is likely to continue to increase the insurable value of critical minerals.

Shifting away from mining for fossil fuels: Currently, mining activities related to thermal coal and iron ore still make up a significant portion of overall activity, accounting for approximately 25% of global mining operations. However, as the world increasingly transitions towards cleaner energy sources, this is expected to change significantly. Coal usage, for example, is projected to decline 85% by 2030 from 2018 levels, and mining will fall accordingly.[126]

This is projected to lead to a shift in the value of critical minerals relative to coal; while coal is currently the largest source of revenue for mining companies, the revenues from critical minerals are expected to surpass coal before 2040. [127]

Increasing circularity: The adoption of circular practices in the use of minerals is an evolving trend that is expected to influence the activities of large mining companies. For instance, there is a growing emphasis on utilising recycled steel in construction and vehicles. This shift towards circularity has the potential to alter the landscape of demand for critical minerals, most likely curtailing it at a top line level.[128]

As the demand for critical minerals increases, some existing insureds along with new entrants may focus at least partly on recycling, providing an opportunity for underwriters who can provide the relevant coverage.

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125 World Bank, Minerals for climate action (pg. 73), Link
126 UNC Kenan-Flagler, Decarbonising the Mining Sector (pg. 2 to 7), Link
127 Executive summary – The Role of Critical Minerals in Clean Energy Transitions – Analysis - IEA
128 International Council on Mining and Metals (ICMM), Metals and minerals are at the heart of a circular economy, Link

8.3 Decarbonisation pathway and levers

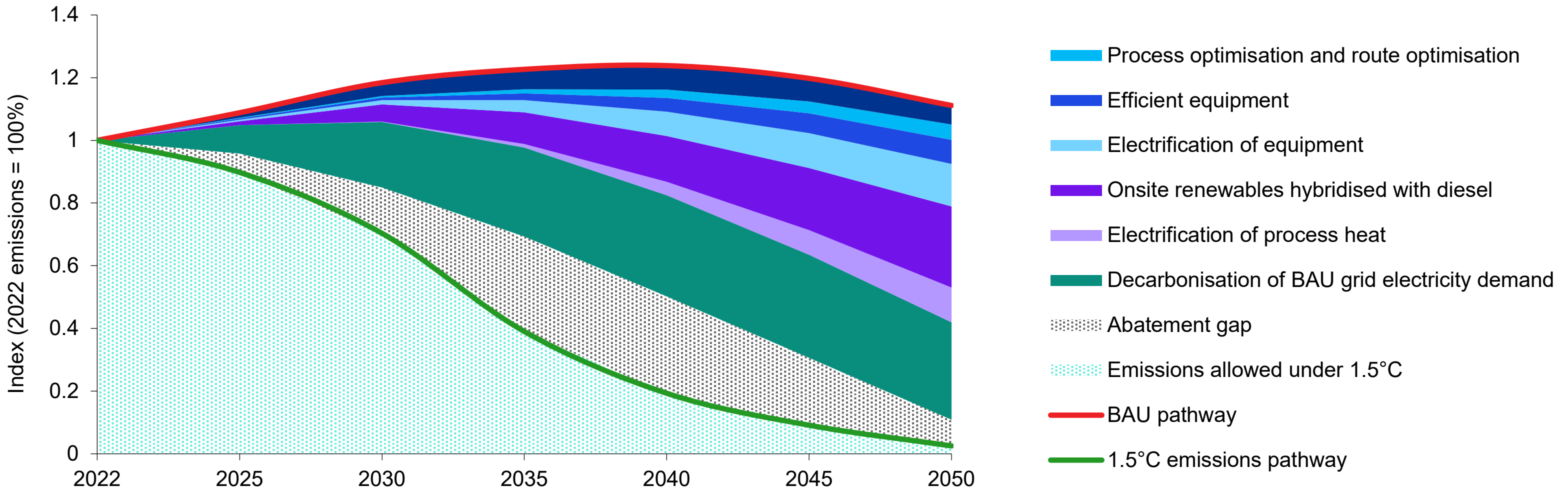
While the mining sector is considered a hard-to-abate sector, there are clear abatement pathways, including optimisation of processes, efficiency and the shifting of fossil fuelled generation to natural gas, solar photovoltaic (PV) cell and the decarbonisation of the grid.

Our analysis covers mining of metallic ores and non-metallic minerals excluding fuels, quarrying, and support activities for mining and quarrying. Coal mining, where much of the direct emissions are fugitive emissions from mine sites, is excluded. We further exclude emissions from combustion of coke in the sector to exclude metals processing at mine sites. The processes included in the analysis are:

- Extraction processes: drilling, blasting, digging, ventilation and dewatering;
- Materials handling: diesel and electric materials handling equipment;
- Beneficiation: crushing, grinding and separation;
- Ancillary operations such as living quarters and office spaces;
- On-site generation of electricity.

In this section, we offer a view on what the decarbonisation pathway for the mining sector could be in order to achieve net zero emissions by 2050.

Figure 8.2.1: Potential mining sector decarbonisation pathway (2022-2050)



Click here for dynamic tables showing how this information may change up to 2050

Table 8.2.2: Abatement impacts on portfolio segmentation over time (illustrative)

Mining		**2050**						
Portfolio segmentation		**Abatement activities**						
Segment	**Assumed mix of business**	**Decarbonisation of BAU grid electricity demand**	**Electrification**	**Onsite renewables hybridised with diesel**	**Output change**	**Unabated / No Change**	**Efficient equipment**	**Process optimisation and route optimisation**
Abatement (% CO2)		**28%**	**22%**	**23%**	**5%**	**10%**	**7%**	**4%**
Iron and Ferro-alloy metals	55%	17%	14%	14%	3%	6%		
Non-ferrous metals	25%	8%	6%	7%	2%	3%		
Precious metals	10%	3%	2%	3%	1%	1%		
Industrial Minerals	5%	2%	1%	1%	0%	1%		
Mineral Fuels	5%	2%	1%	1%	0%	1%		
Total	**100%**	**32%**	**25%**	**26%**	**6%**	**11%**		

Source: KPMG analysis

Notes and limitations: This analysis is highlighting a potential sectoral decarbonisation pathway for the purposes of discussion, based on analysis of available information at this point in time. The potential abatement volumes are indicative and based on ranges and assumptions, and are subject to variation based on the evolution of multiple factors, including technology, commercial viability, policy and regulation etc. The analysis is regionally agnostic, based on multiple variables such as global averages for activity, output, grid intensity among others. Assumed mix of business is illustrative as are the impact of abatement activities on different segments albeit linked to the decarbonisation challenges mentioned in this report.

The above table provides an initial view on how the abatement activities may impact upon a typical underwriter's portfolio based upon an assumed mix of business. The table highlights the change to electrification across the portfolio and the potential use of on-site renewables to enable off-grid electrical supply.

Abatement gap: The mining sector faces a significant abatement gap relative to a 1.5°C pathway, highlighting the potential role of CCUS or alternative fuel levers such as low carbon hydrogen and bioenergy in the sector reaching net zero. The changing mix of mining output driven by growth in demand for critical minerals and geographical mix of mining activities adds to uncertainty in estimating the abatement gap. Further, the off-grid nature of mine sites, especially in emerging markets, presents uncertainty around availability and cost of new fuels such as low carbon hydrogen.

Given that this is a hard-to-abate sector, the use of offsets to close the abatement gap in order to keep to 1.5°C will likely be needed. Offsets reliant on nature-based solutions might not be enough to respond to world demand, and the sector may be expected to add technology-based offsets such as Direct Air Carbon Capture (DACC) to the offset mix.

Emissions abatement due to change in demand between the two scenarios: Despite growth in demand for certain critical minerals, considering the sector as a whole, there is a moderate emissions abatement due to a slight reduction in sector output in a 1.5°C relative to a 4°C scenario, which may take into account reduction in primary metals and materials demand driven by material reuse and recycling, and broader socio-economic factors.

Decarbonisation of BAU electricity demand: Grid decarbonisation contributes a significant portion of the overall decarbonisation pathway for the Mining sector. This represents the decarbonisation of power systems globally and the extent of electrification on mines while highlighting decarbonisation dependencies across sectors. Given that our analysis is based on average global grid factors, we expect considerable regional variation across grid decarbonisation.

Electrification of equipment: [129] The abatement of equipment in digging, gasoline transport and diesel-fuelled materials handling is due to higher energy efficiency of this electric equipment compared to fossil fuel-powered equipment. Electric equipment also benefits from a secondary decarbonisation impact via the grid over time. The added advantages of electric equipment also include noise reduction, heat reduction and are cheaper to maintain and run than their diesel counterparts.

Efficient equipment: Abatement due to the increased efficiency of equipment over time, applicable to equipment involved in drilling, digging, dewatering, materials handling and beneficiation[130]

Process optimisation and route optimisation: Abatement due to the optimisation of processes and improving efficiencies across drilling, blasting, digging, materials handling and optimising transport routes.

129 KPMG analysis, based on 2022 electricity supply mix
130 Accelerate the mission to Net Zero (commdev.org)

Decarbonising on-site generation: On-site electricity generation at mine sites is fuelled by diesel and natural gas and is a significant portion of mine site electricity supply. On-site renewables can replace fossil-fuel fired generation, however hybridisation with diesel generators may be required in the short term to address variability in renewable energy supply.[131]

Decarbonising process heat: Fossil fuel use for process heat can be reduced by installation of industrial heat pumps. Decarbonising electricity supply from the grid and on-site generation would be the primary driver for decarbonising process heat with incremental reductions from energy efficiency gains from transitioning to heat pumps.

Enabling decarbonisation:

Power system decarbonisation is critical to the decarbonisation of the mining sector. KPMG has published a Thought Leadership highlighting the current challenges in scaling renewable energy to meet the needs of the low carbon transition.

Critical to the decarbonisation of the Mining sector is an enabling policy and regulatory environment that influences the incentives around heavy emitting activities. Through the introduction of emissions trading schemes and carbon border adjustment mechanisms, we are seeing the emerging penalisation of emissions intensive activities. Similarly, it will be critical for government to create a policy and regulatory environment that incentivises investment in decarbonisation technology.

Leveraging financing will be critical to both decarbonise the industry and scale up production of critical minerals to facilitate and enable the low carbon transition. Recent developments in sustainable finance have seen the emergence of the 'green enabling investments' category of bond issuances, which addresses both induced and avoided emissions, identifying the role that these projects play in catalysing the low carbon economy.[132]

Robust transition plans will be critical vehicles to ensure clear communication of decarbonisation strategy to the market, facilitating financing and enabling the monitoring of progress against targets. The Transition Plan Taskforce in has recently released sector guidelines for the Metals & Mining Sector.[133]

Mines are often in inaccessible areas meaning renewable energy may be increasingly produced on-site, or produced elsewhere (e.g. batteries) and brought in directly. This will change the risk profile of the business and is likely to increase exposure to breaks in energy supply leading to Business Interruption claims. Similarly, faulty new technology is likely to take longer to replace also increasing Business Interruption claims.

131 Accelerate the mission to Net Zero (commdev.org)
132 Green Enabling Projects Guidance » ICMA (icmagroup.org)
133 TPT-Metals-and-Mining-Sector-Guidance.pdf (transitiontaskforce.net)

As mining becomes more politically important, political risk insurance may become even more important for the industry.

8.4 Other considerations

Physical impacts of climate change: Flooding can have a detrimental effect on mining operations, including disruptions and damages to mining infrastructure. This, in turn, leads to higher costs for mining companies and puts a significant strain on the global supply of metals and minerals. In 2019, intensified storms and flooding were recognised as the top two factors contributing to negative financial impacts on global mining operations, accounting for 20% and 13% of this impact respectively. High temperatures also present a range of risks for the metals and mining industry. These include the escalation of hazardous working conditions, a higher likelihood of wildfires, and the increased vulnerability of mining infrastructure and transportation networks to damage.[134]

Fossil fuel asset stranding risk: To keep global warming within 1.5°C, approximately 90% of remaining coal reserves and approximately 60% of oil should remain untapped.[135] At COP28, nations agreed to accelerate efforts towards the 'phase-down' of unabated coal power, which may scale to 'phase-out' in the coming years.[136] This poses a significant risk of stranded assets for coal mining companies as a result of diminished investments and potentially early closures of existing mines. A number of initiatives and financing mechanisms have emerged to support governments and companies working towards the pledged 'phase-down' of coal, including those such as the Powering Past Coal Alliance that seek to drive a Just Transition that supports impacted communities. [137]

Redirecting investment: Investments in the climate transition are steadily rising, and metal mining companies are allocating more resources towards energy efficiency enhancements, electric vehicles, and the advancement of innovative technologies like green hydrogen. Moreover, there is a notable shift towards circularity and low-carbon alternatives on the demand side. This change in focus is particularly evident in the iron ore mining sector as companies in construction and transportation industries look to integrate recycled and scrap metal into their supply chains. Consequently, metal mining firms could see falling demand or, conversely, could have an opportunity to diversify their operations by venturing into transition metals.[138]

Supply chain and geopolitical risk: As outlined, there is a considerable geographic concentration of critical minerals, often in regions that are less developed and potentially less stable, presenting both supply chain risk and geopolitical and legal risk.

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134 United Nations Environment Programme Finance Initiative (UNEPFI), Climate risks in the metals and mining sector, Link
135 Nature, 'Unextractable fossil fuels in a 1.5 °C world', Link
136 United Nations Environment Programme Finance Initiative (UNEPFI), Climate risks in the metals and mining sector, Link

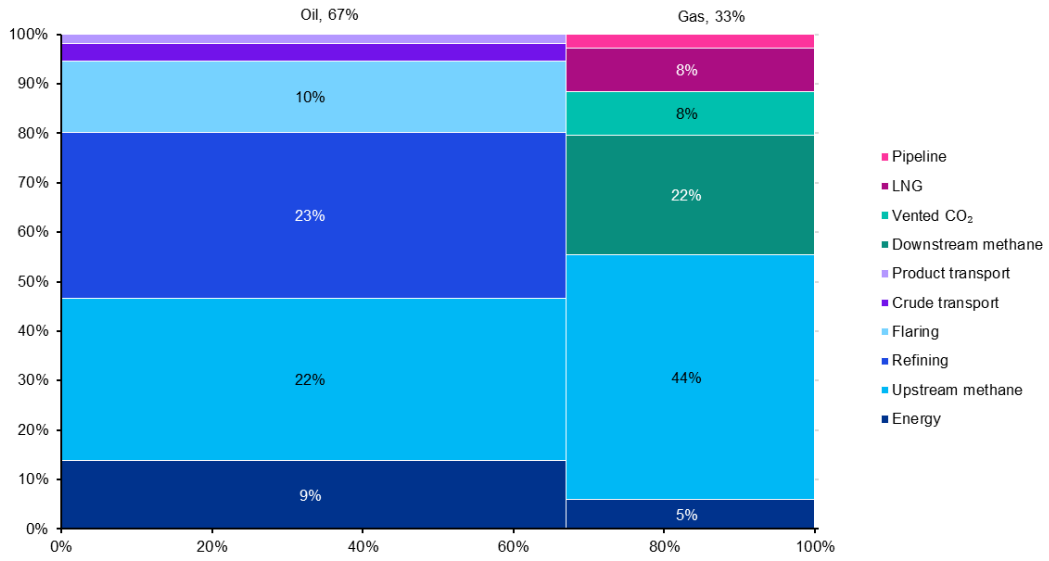
138 Institute for Energy Economics and Financial Analysis, '200 and counting: Global financial institutions are exiting coal', Link

9 Oil & Gas

9.1 Current state

The oil and gas industry is a primary contributor to climate change. The Scope 1 and 2 emissions from the sector are responsible for 15% of total energy-related GHG emissions, while the use of oil and gas resulted in an additional 40% of emissions in 2022.[139, 140] The Statistical Review of World Energy, produced by the Energy Institute in association with KPMG, shows that fossil fuels still make up roughly 84% of energy needs globally[141].

Figure 9.1.1: Breakdown of Scope 1 & 2 emissions (operational emissions) from the O&G sector (2022)



Source: International Energy Agency (IEA), Link

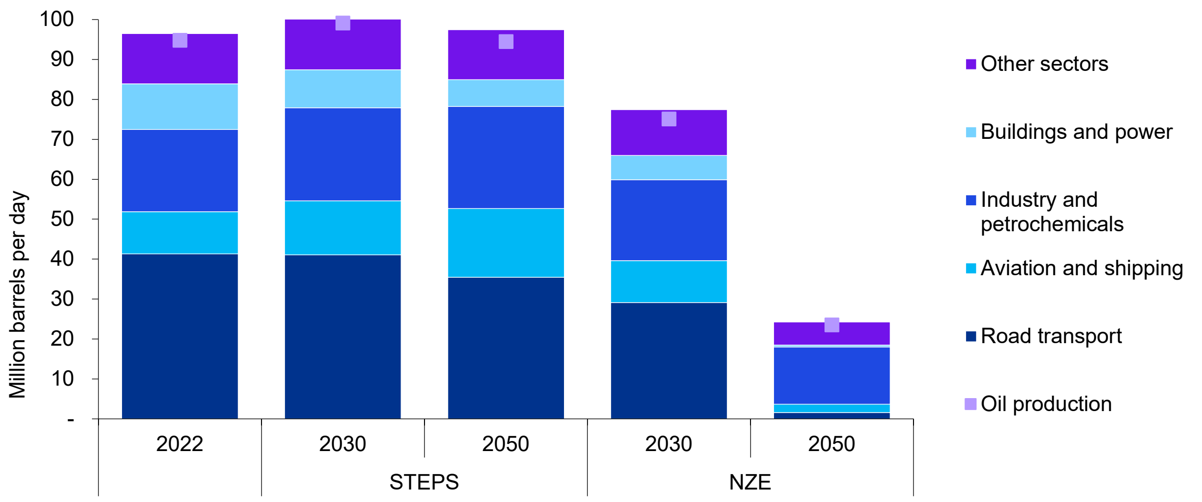
139 Note that sectors covered are not exhaustive nor mutually exclusive; emissions totals do not add up to 100%
140 International Energy Agency (IEA), Emissions from Oil and Gas Operations in Net Zero Transitions, (pg. 4 and 5), Link
141 Energy Institute, Statistical Review of World Energy, 2024, Link

For the first time, demand for fossil fuels is expected to peak by the end of the decade in all three International Energy Agency energy scenarios, however demand following the peak is projected to fall short of reductions required to align with the 1.5°C goal of the Paris Agreement.

The IEA predicts that in all scenarios, fossil fuels will increasingly lose market share to clean energy technologies across the economy, however it should be noted that this is debated by several analysts.[142]

Oil production, for example, is expected to decline across all regions in the IEA's Net Zero Emissions (NZE) scenario, from 95 million barrels per day (mb/d) in 2022 to reach 75 mb/d by 2030 and 24 mb/d in 2050. In the IEA's Stated Policies Scenario (STEPS), oil production reaches 99 mb/d in 2030 and declines slowly to 95 mb/d in 2050.[143]

Figure 9.2.2: Global oil demand and production projections by sector, scenario and year



Source: International Energy Agency (IEA), World Energy Outlook 2023 database

Note: 1. STEPS represents IEA's Stated Policies Scenario, which is associated with a temperature rise of 2.4ºC by 2100 and provides an outlook on global energy system's progression based on current policy landscape

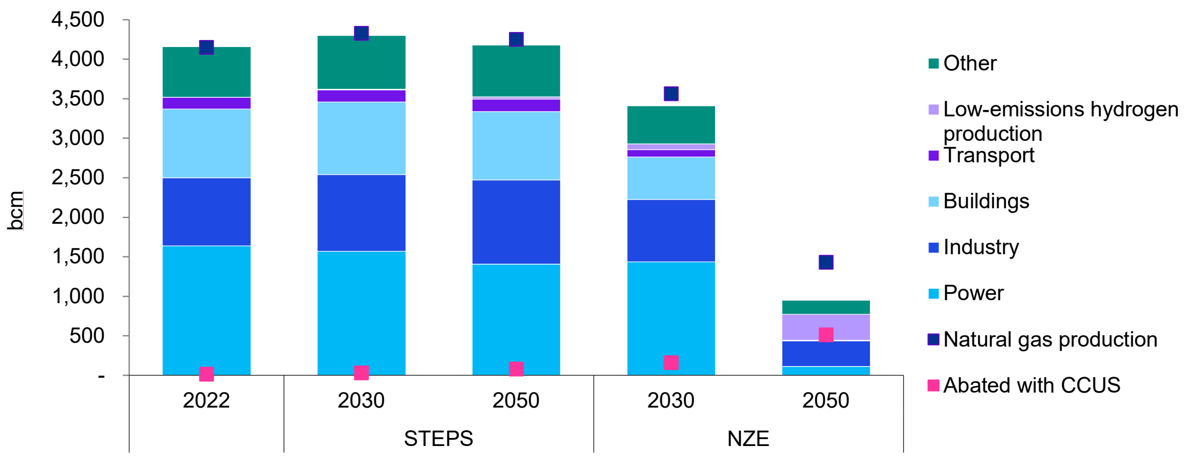
2. NZE is IEA's Net Zero Emissions by 2050 Scenario, which is associated with a temperature rise of 1.5ºC by 2100 and demonstrates a normative scenario of orderly transition to net zero

142 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 26), Link

143 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 130), Link

By 2050, global natural gas production is projected to sit at 4,173 billion cubic meters (bcm) in STEPS, with the Middle East emerging as the key source of global supply. Some of the demand for oil and gas in transport and electricity generation can be replaced by cleaner technologies available today, but it is proving more difficult to find alternatives for gas use for seasonal balancing in power systems and oil in aviation, and for sectors requiring 24/7 power, such as data centres. In the NZE scenario, it drops to 919 bcm, while demand falls even further, indicating that projects would have to shut down before the end of their technical lifetime.[144]

Figure 9.2.3: Global natural gas demand and production projections by sector, scenario and year



Source: International Energy Agency (IEA), World Energy Outlook 2023 database

Note: 1. STEPS represents IEA's Stated Policies Scenario, which is associated with a temperature rise of 2.4ºC by 2100 and provides an outlook on global energy system's progression based on current policy landscape

2. NZE is IEA's Net Zero Emissions by 2050 Scenario, which is associated with a temperature rise of 1.5ºC by 2100 and demonstrates a normative scenario of orderly transition to net zero

Oil and gas companies are facing a critical challenge as the world increasingly shifts towards clean energy systems. Policy and regulatory mechanisms are increasingly being put in place to control emissions from the oil and gas sector, and to account for emissions across the value chain. The oil and gas sector is facing increasing demands to clarify the implications of energy transitions for its operations and business model, and to develop robust transition plans. To ensure longevity in a net zero world, oil and gas companies need to align their business, decarbonisation and investment strategies with below 2°C emissions targets across the complete value chain.

Beyond Scope 3 emissions, a total 60% reduction in operational emissions from the oil sector and a 65% reduction of operational emissions from natural gas is required by 2030 to align the sectors with the IEA's Net Zero Emissions by 2050 Scenario.[145]

[144] International Energy Agency (IEA), World Energy Outlook 2023 (pg. 135 and 138), Link

[145] International Energy Agency (IEA), Emissions from Oil and Gas Operations in Net Zero Transitions, (pg. 4 and 5), Link

Oil and Gas companies are increasingly diversifying their operations into renewable energy and carbon capture, utilisation and storage (CCUS), which will continue to present opportunities for insurers to expand coverage for existing insureds and source new business.

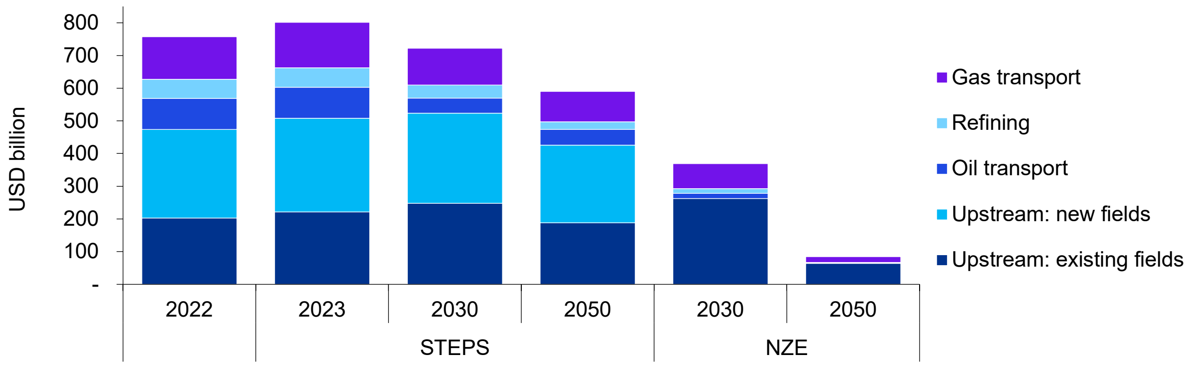
9.2 Key trends

Subsidies and incentives: In 2023, fossil fuel consumption subsidies surpassed US$1 trillion, an all-time high and double the subsidy volume from 2022.[146] Despite these volumes, there is increasing pressure on subsidies to the oil and gas sector, including a commitment in the UAE Consensus at COP28 to phasing out inefficient fossil fuel subsidies that do not address energy poverty or just transition, as soon as possible.[147] There is, similarly, an increasing focus on incentives to renewables, for example via the US Inflation Reduction Act and the EU Green Deal which contain a significant number of incentive measures to support the energy transition. While there is no sign of an immediate reduction in demand, both the IEA STEPS and NZE scenarios project reductions by 2030; and newer long-term conventional oil and gas projects are facing difficulties in attracting funding.[148]

It is important to note that an investment in exploring for and developing new oil and gas resources leads to projects with 20 to 30-year lifespans.

[146] Fossil Fuels Consumption Subsidies 2022 – Analysis - IEA
[147] COP28 Agreement Signals "Beginning of the End" of the Fossil Fuel Era | UNFCCC
[148] International Energy Agency (IEA), World Energy Outlook 2023 (pg. 134 and 135), Link

Figure 9.3: Oil and natural gas investment projections by scenario and year



Source: International Energy Agency (IEA), World Energy Outlook 2023 database

Note: 1. STEPS represents IEA's Stated Policies Scenario, which is associated with a temperature rise of 2.4ºC by 2100 and provides an outlook on global energy system's progression based on current policy landscape

2. NZE is IEA's Net Zero Emissions by 2050 Scenario, which is associated with a temperature rise of 1.5ºC by 2100 and demonstrates a normative scenario of orderly transition to net zero

Projected decrease in demand from oil and gas sector: In IEA's STEPS, the increased uptake of EVs leads to a decline in oil demand from the road transport sector. However, this decline is offset by the increased use of oil in aviation and the petrochemicals industry as demand continues to rise without low carbon alternatives. The intersection of these megatrends sees global oil demand peaking at 102 mb/d by the late 2020s and falling to 97 mb/d by 2050.[149]

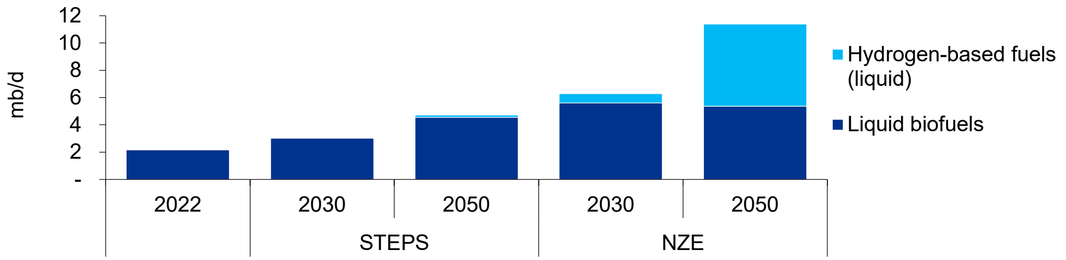
In the NZE scenario, the electrification of road transport, fuel efficiency improvements and the rising uptake of clean fuels lead to an accelerated decline in oil demand, which falls to 77 mb/d in 2030 and is met through existing projects. The demand further drops to 25 mb/d in 2050, with 70% accounted for by the petrochemical industry.[150]

The level of variation in oil demand between scenarios is different in advanced economies and emerging markets and developing economies (EMDE). In advanced economies, oil demand drops by 35% to 85%, by 2050 whereas in EMDE the range is between a 20% increase to a 70% decrease.[151]

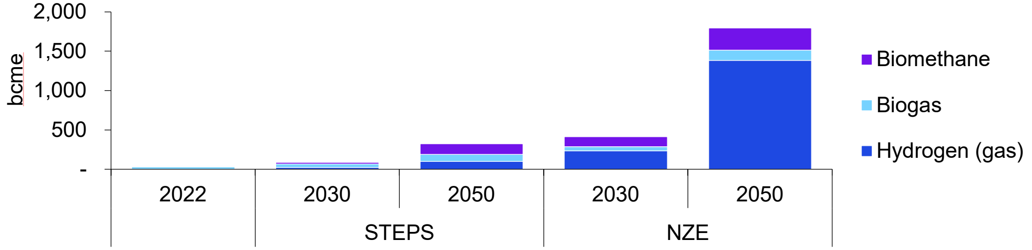
Natural gas demand in the IEA STEPS scenario peaks by 2030. However, the growth rate is expected to be much slower from 2022 to 2030, compared to the period from 2010 to 2021.[152] Additionally, global demand drops by 100 bcm by 2050. Advanced economies see a decline of 40% in demand in this period.[153]

149 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 131 and 132), Link
150 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 131 and 132), Link
151 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 131 and 132), Link
152 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 136 and 137), Link
153 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 136 and 137), Link

Figure 9.4: Low-emissions fuel demand by scenario and year



Low-emissions gases demand by scenario and year



Source: International Energy Agency (IEA), World Energy Outlook 2023 database

Note: 1. STEPS represents IEA's Stated Policies Scenario, which is associated with a temperature rise of 2.4ºC by 2100 and provides an outlook on global energy system's progression based on current policy landscape

2. NZE is IEA's Net Zero Emissions by 2050 Scenario, which is associated with a temperature rise of 1.5ºC by 2100 and demonstrates a normative scenario of orderly transition to net zero

In IEA's NZE scenario, annual demand drops by over 2% from 2022 to 2030 and by close to 8% annually from 2030 to 2040. Beyond 2040, with more CCUS deployments used for low-emissions hydrogen production using natural gas, the decline in demand is moderated. However, by 2050, global gas demand drops by 300 bcm due to rapid electrification and energy efficiency gains. Projects are closed off before their technical end of life, with a risk of significant investment losses.[154]

[154] International Energy Agency (IEA), World Energy Outlook 2023 (pg. 136 and 137), Link

9.3 Decarbonisation pathway and levers

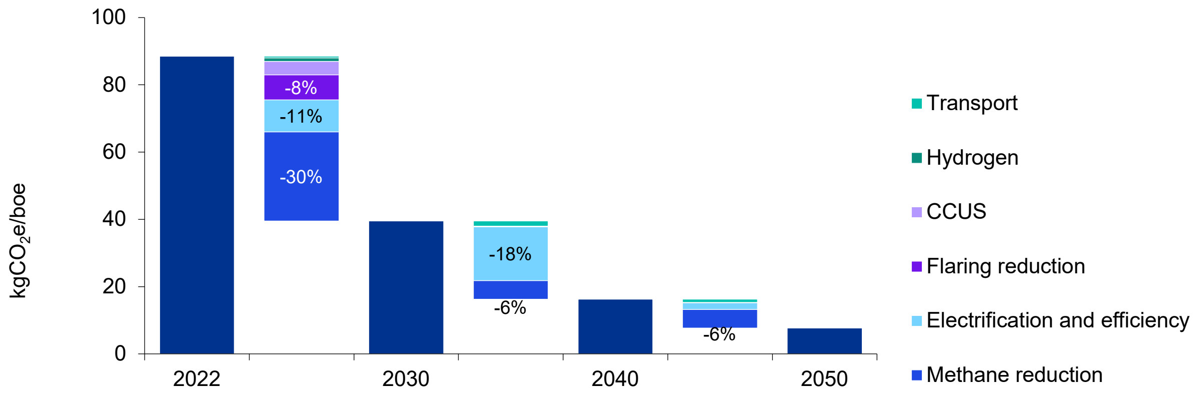
The decarbonisation of the oil and gas sector depends operational decarbonisation and on strategy and portfolio diversification, including scaling of emerging technology interventions.

Operational decarbonisation:

Decarbonisation of operational emissions and, in particular, methane emission across the oil and gas sector plays a key role and has the potential to curb global methane emissions by 23%. Approximately 40% of methane emissions from the oil and gas sector could be reduced by 2030 with the use of existing technologies and could reach to 73% reduction by 2050 at no net cost.[155].

In terms of decarbonisation of operational emissions, the Oil and Gas Climate Initiative identifies a number of key abatement levers for the sector. The abatement of methane is expected to contribute highest to emissions reduction for the sector.[156]

Figure 9.5.1: Global average Scope 1 & 2 emissions intensity for oil and gas with reduction levers (2022-2050) under a 1.5°C scenario



Source: International Energy Agency (IEA), The Oil and Gas Industry in Net Zero Transitions

Notes and limitations: CCUS is carbon capture, utilisation and storage applied to hydrogen production at refineries or to supply refineries; it also includes CCUS deployed in upstream oil and gas facilities to abate co-produced CO_2 emissions. Hydrogen represents use of low-emissions electrolysis hydrogen to replace hydrogen produced from unabated fossil fuels.

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155 Strategies to reduce emissions from oil and gas operations – Global Methane Tracker 2023 – Analysis - IEA

156 International Energy Agency (IEA), Emissions from Oil and Gas Operations in Net Zero Transitions, (pg. 4 and 5), Link

Oil and Gas Climate Initiative (OGCI) focus areas:

Methane abatement:

The energy sector, specifically coal, bioenergy, oil and gas sectors account for 40% of global methane emissions. 50% of oil and gas industry's Scope 1 and Scope 2 emissions (2.4 $GtCO_2e$) are estimated to be methane emissions. It has a higher warming potential than carbon dioxide and is estimated to be responsible for 30% of the global warming experienced currently.[157] Key abatement levers highlighted by the OGCI[158] are 1) the elimination of non-emergency flaring and venting, 2) artificial intelligence integration (to avoid emergency venting of methane), 3) methane monitoring with satellites, drones and sensors, 4) leak detection and repair.

Strategy diversification:

More broadly, oil and gas companies are under pressure to diversify their portfolio towards low carbon activities and technologies such as low emissions fuels, hydrogen production and use, and carbon capture, utilisation and storage (CCUS). This will require promoting research and development, and scaling of new technology, such as infrastructure development for CO2 transport and storage required for CCUS. The OGCI has highlighted low transport fuels as a key focus area for oil and gas diversification since transport accounts for a fifth of global emissions and oil and gas majors are able to contribute to the development of the fuel. Outlined below are a number of areas of potential diversification:

Sustainable low emissions fuels:

- With the evolving change in regulatory landscape around CO2 emissions, oil and gas companies should consider diversifying their portfolios to produce sustainable fuels;
- Sustainable fuels production and utilisation will play a key role in meeting 2030 decarbonisation targets. Sustainable fuels include biofuels such as hydrotreated vegetable oil (HVO), or bioethanol, sustainable aviation fuels, and synthetic fuels (synfuels) such as ammonia or methanol;
- Renewable gas is a space that has been long developed in Europe and the European Majors have invested in heavily;
- The OGCI has placed emphasis on the following areas:
  - Reformulating conventional fuels through operational efficiencies or blending fuels with low-emissions components to reduce a product's carbon intensity;[159]
  - Switching to alternate future fuels such as green LNG, green methanol, green hydrogen or green ammonia in maritime transportation;[160]
  - Sustainable aviation fuel (SAF) developed based on biomass or low-emissions hydrogen in aviation;[161]

157 Oil and Gas Climate Initiative (OGCI), Methane emissions, Link
158 Reducing methane emissions | OGCI
159 Oil and Gas Climate Initiative (OGCI), The role of low-carbon fuels in decarbonising transport (pg. 11), Link
160 Oil and Gas Climate Initiative (OGCI), The role of low-carbon fuels in decarbonising transport (pg. 11), Link
161 Oil and Gas Climate Initiative (OGCI), The role of low-carbon fuels in decarbonising transport (pg. 11), Link

Geothermal:

- There are many similarities and complementarities between the oil and gas and geothermal industries, where oil and gas companies and professionals are applying their transferable skills and expertise. These include technology such as subsurface exploration and advanced drilling, existing infrastructure such as drilling rigs and pipelines that can be repurposed, and workforce skills and expertise that can be transitioned. For example, the US Department for Energy has an established programme, The Geothermal Energy from Oil and Gas Demonstrated Engineering (GEODE) initiative, which aims to leverage the extensive experience, technology, knowledge and skills from the oil and gas sector toward the scaling of the geothermal sector.[162]

Green hydrogen:

- Green hydrogen refers to the production of hydrogen from electrolysis of water using renewable sources. Hydrotreating and hydrocracking are the major processes consuming over 90% of hydrogen in the refining sector. Green hydrogen currently contributes to 1% of global hydrogen production, but this share is expected to grow as the cost of renewables continues to fall.

Blue hydrogen:

- Blue hydrogen requires methane; production is energy intensive and requires carbon capture and storage (CCS). The cost of blue hydrogen is highly dependent on the cost of natural gas and the ongoing cost of CCS. Blue hydrogen and green hydrogen can be used for power-to-liquid (PtL) production.

Carbon capture, utilisation and storage (CCUS)

- To reach net zero emissions by 2050, approximately 7.6 Gt of carbon storage capacity is estimated to be required. It is projected that by 2070, 10 Gt of carbon dioxide must be captured and stored annually to limit temperature rise to below 1.5ºC by 2100. CCUS has been used for enhanced oil recovery (EOR) and natural gas processing. These activities account for the majority of the carbon dioxide captured globally every year.[163] CCUS captures CO2 from large point sources and uses it for various applications such as the production of biofuels and synthetic fuels and substitutes to input materials in the chemicals and building materials industry. While CCUS is a critical decarbonisation lever and has been acknowledged by the IEA as one of the core pillars of the global energy transition, deployment and scaling has been slow globally, with annual investment to CCUS accounting for less than 0.5% of total investment in clean energy and efficiency technologies.[164]
- Given the contribution of the oil and gas sector to global unabated emissions, their technical skills, existing infrastructure and the use of depleted oil and gas reservoirs to trap CO2 for permanent storage means the oil and gas industry is uniquely positioned to contribute to the scaling of this technology which has a key role in the decarbonisation of other hard-to-abate sectors, such as steel and cement.
- In addition to CCUS, some companies are exploring alternative uses for CO2. For example, LanzaTech has developed a carbon recycling technology to create fuels and chemicals.[165]

162 Geothermal Energy from Oil and Gas Demonstrated Engineering | Department of Energy
163 Oil and Gas Climate Initiative (OGCI), Carbon capture, utilisation and storage (CCUS), Link
164 A new era for CCUS – CCUS in Clean Energy Transitions – Analysis - IEA
165 About – LanzaTech

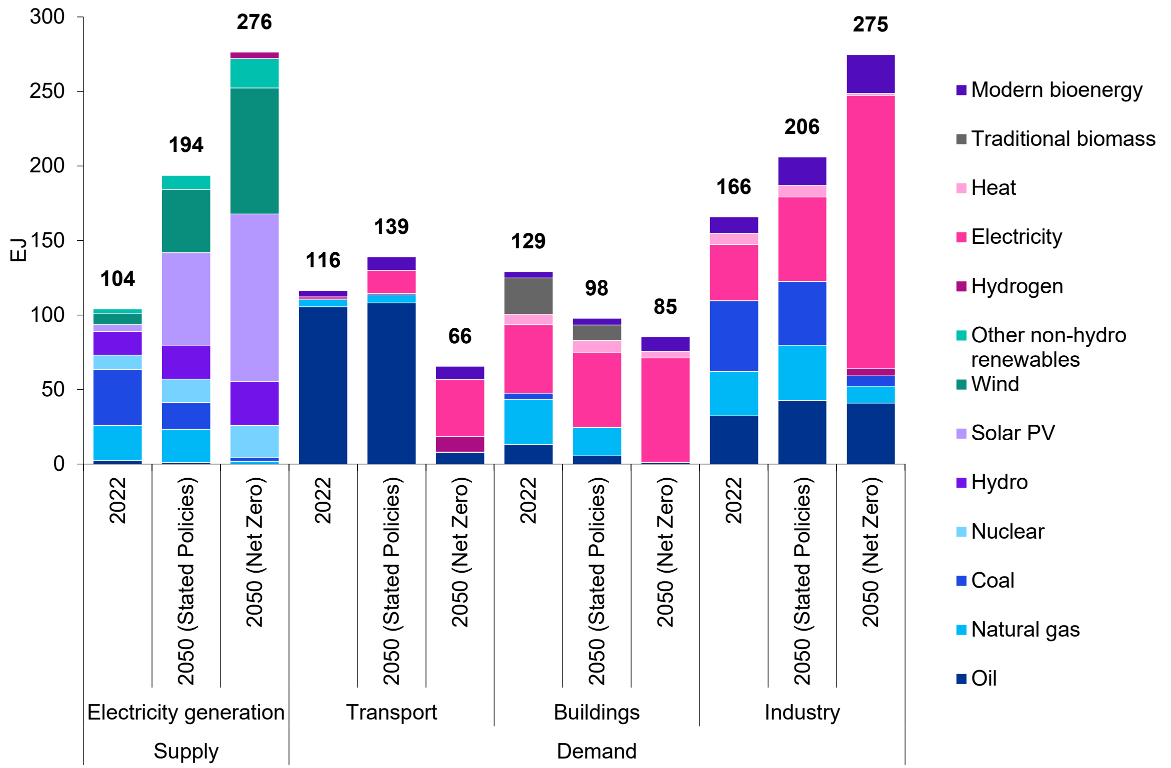
9.4 Other considerations

Physical risk exposure: The UN Environmental Programme has highlighted that physical risks pose a threat to 40% of the world's global oil and gas reserves. In particular, there is potential risk to oil and gas facilities located alongside shorelines given the potential risk posed by rising ocean levels and/or increased frequency of natural disasters. This is particularly prominent on the US Gulf Coast. Other key climate risks include intensifying storms, water scarcity, wildfires and flooding.[166]

Future product mix: The demand for oil and gas from end-use sectors is generally projected to remain stable under current policies. However, the growth in transport and industrial energy demand is projected to be served by electricity and bioenergy. Reductions in oil demand are projected from passenger cars, buildings and electricity generation, however, the demand growth in aviation, petrochemicals and road transport is projected to offset reductions in other areas. The reduction of natural gas demand in advanced economies is projected to be offset by demand growth in emerging markets.

[166] The UN Environment Programme, Climate Risks in the Oil and Gas Sector, 2023 Link

Figure 9.6.1: Fuel mix by sector, 2022 Historical vs. 2050 Projected (Stated Policies and Net Zero Scenarios)



Source: International Energy Agency (IEA), World Energy Outlook 2023 Database

Investment returns and valuations: The International Energy Agency (IEA) has identified significant risk associated with investment returns in the oil and gas industry compared to clean energy projects.

As the world moves away from fossil fuels, there's a risk that certain oil and gas reserves may become unviable or 'stranded'. This could mean that the insureds need to cover the potential costs for decommissioning. Contract terms and the propensity for these risks to emerge will therefore need to be carefully considered.

According to IEA analysis, the average return on capital employed in the oil and gas sector fluctuated from 6% to 9% between 2010 and 2022, while clean energy saw a more consistent return of 6%. While oil and gas has seen some higher returns, the volatility of prices has resulted in fluctuating revenues year-on-year, a trend that is only expected to increase, alongside lower overall returns.[167],[168] The IEA anticipates that energy transition could lower the value of private oil and gas companies by 25% if national energy and climate goals are reached in STEPS, and by 60% in a 1.5°C pathway.[169]

Expected contraction in market value: Governments, companies, and investors are making efforts to transition away from fossil fuels towards renewable energy and other sustainable alternatives. The resulting impact on the long-term value and viability of oil and gas assets is becoming a key consideration for financial markets and investors.

A 2021 Nature study[170] identified that 90% of coal and nearly 60% of remaining oil and gas reserves must remain untapped to maintain a 50% probability of alignment with a 1.5°C scenario. Studies place the global net present value of untapped fossil fuel output at US$21.5 - 30.6 trillion by 2050 under a net zero scenario. Additionally, as countries increasingly transition to cleaner energy sources, the demand for fossil fuels is expected to decline. This could lead to considerable contraction in market value of oil and gas companies, and considerable stranded asset and asset value loss.[171]

Cost of operation: The OECD estimates that to put the world on a trajectory to achieve net-zero emissions by 2050, a carbon price of US$147 per metric ton (MT) will be necessary by 2030. As a significant contributor to global emissions, the oil and gas industry will face substantial consequences due to the implementation of carbon pricing. The introduction of carbon prices will lead to higher costs for emissions, thereby affecting production processes and potentially influencing the prices of end-use products.[172]

Access to capital: Financial institutions are coming under increasing pressure from stakeholders and internal targets concerning their financing of oil and gas activities which is resulting in the increasing inclusion of oil and gas activities in exclusion policies. This could result in in a contraction in the availability of capital

167 International Energy Agency (IEA), Emissions from Oil and Gas Operations in Net Zero Transitions, Link
169 International Energy Agency, The Oil and Gas Industry in Net Zero Transitions, 2023 Link
170 Unextractable fossil fuels in a 1.5 °C world | Nature
171 Massachusetts Institute of Technology (MIT), Stranded assets could exact steep costs on fossil energy producers and –investors, Link
172 United Nations Environment Programme Finance Initiative (UNEPFI), Climate Risks in the Oil and Gas Sector, Link

and an increase in the cost of capital associated with financing oil and gas projects. This is more likely to impact smaller and independent companies since oil and gas majors and national oil companies can fund most of their projects from their balance sheets.

Transfer of skills: The low carbon transition and new energies are changing the conventional oil and gas value chain; and the oil and gas sector is well positioned to capitalise on and contribute to the low carbon transition, due to the skills, expertise and resources that exist within the sector. The IEA estimates that c.30% of the energy consumed in a decarbonised energy system in 2050 comes from technologies that could benefit from the skills and resources of the sector.[173]

Strategy diversification: Oil and gas companies can reduce their carbon impact and contribute to the low carbon transition by diversifying their core strategies, developing renewable sources of energy and related enablers, such as hydrogen, ammonia and methanol, renewable gas and biodiesel, biofuels including SAF, geothermal and lithium; and partnering to scale new energies and low carbon solutions, including hydrogen and carbon capture and storage hubs, and direct air carbon capture and storage (DACCS).

Some insureds are considering/experimenting with using old fields to store carbon, which could be used to provide carbon credits to the market. This could provide various insurance opportunities in terms of insuring the operation and the performance of the carbon credit (e.g. non-leakage).

[173] International Energy Agency, The Oil and Gas Industry in Net Zero Transitions, 2023 Link

10 Power Generation & Distribution

10.1 Current state

The power sector is at the heart of the global economy and is also the cornerstone of the low-carbon transition. Covering generation, distribution and retail energy companies, from coal power stations through to community microgrids, the sector accounted for around c.27% of total GHG emissions in 2022[174], or 14.8 $GtCO_2$[175], the highest levels in history. This was driven primarily by gas-to-coal switching in Asia-Pacific and Europe caused by high natural gas prices.[176,177,178]

Rising population, rising incomes, and the electrification of transport and heating are projected to drive the growth of global electricity demand by 80% and 150% by 2050, compared to current levels under current policies and 1.5°C scenarios respectively.[179]

As of 2022, unabated fossil fuels occupy a 60% share in total electricity generation[180], and by 2050, under a 1.5°C scenario, 90% of electricity production should be from renewable sources.

The sector ultimately supplies energy to transport, buildings (including domestic buildings) and industry, all of which are expected to experience rapid electrification. Therefore, a rapid transition from fossil fuel-fired generation to low carbon electricity sources is a key underpinning of cross-sectoral decarbonisation.

With electricity demand predicted to increase by at least 80%, grid capacity and infrastructure will need to be substantially increased. This in turn will provide insurers the opportunity to provide the appropriate coverage for the upgrade and maintenance of a much larger grid.

Given how embedded the sector is in the global economy, the pace of the transition is impacted by various exogenous factors, including geopolitical challenges, increasing an emphasis on energy security.

174 Note that sectors covered are not exhaustive nor mutually exclusive; emissions totals do not add up to 100%
175 Power – Breakthrough Agenda Report 2023 – Analysis - IEA
176 European Commissions Joint Research Centre (JRC), Emissions Database for Global Atmospheric Research (EDGAR), Link
177 International Energy Agency (IEA), Electricity – Energy System, Link
178 International Energy Agency (IEA), Coal, Link
179 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 123), Link
180 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 123), Link

The first global stocktake[181] of all climate commitments made by nations was published for the COP28 in Dubai in 2023. The stocktake outlined that i) the level of ambition is insufficient from the leaders of the nations of the world to keep global warming to 1.5C by 2050, and ii) nations need to take urgent action to implement measures to meet their current self-determined targets, which are in themselves not projected to take the world to 1.5C by 2050. There is a lack of national delivery plans, as well as critical challenges delivering major renewables projects, in particular given today's high-inflation, high-interest operating environment.

10.2 Key trends

10.2.1 Demand side:

Electricity demand: Electrification is a key enabler for cross-sectoral decarbonisation. The simultaneous decarbonisation and growth of demand-side sectors will lead to a growth in electricity demand.[182] In 2023, electricity demand grew 25% faster than total primary energy consumption.[183]

Renewable electricity: Renewable generation is set to increase with an annualised growth of over 9% from 2023, making up over one-third of the global generation mix by 2025.[184] The upward trend is set to continue until 2050, even under current policies with solar photovoltaic (PV) cell and wind contributing most of the growth.[185] At COP28, the UAE Consensus outlined a commitment to trebling renewable energy capacity globally by 2030 in order to align with the Paris Agreement, however, there are a number of market and operational barriers which much be addressed to enable this scaling. See KPMG report 'Turning the Tide on Scaling Renewables' for further detail [link]. [186].

AI and Data Centres: The unexpected growth in demand for energy from AI, data centres and cryptocurrencies is projected to put considerable strain on the power generation and distribution system, as well as the associated emissions targets of technology companies. The IEA estimates that electricity consumption from these services could double by 2026.[187] As a result, technology companies are considering a variety of options to build power capacity, for example, Microsoft is exploring use of small nuclear reactors.

10.2.2 Supply Side:

Energy efficiency: At COP28, the global community pledged to double annual global average rates of energy efficiency improvements from around 2% to over 4% by 2030. Energy efficiency can reduce CO2 emissions by 50% by 2030, which is why it is often considered to be the 'first fuel' at the core of policymaking, planning and major investment decisions.[188]

181 UNFCCC, Technical dialogue of the first global stocktake, synthesis report, 2023, Link
182 International Renewable Energy Agency (IRENA), World Energy Transitions Outlook 2023 (pg. 74), Link
183 Energy Institute, Statistical Review of World Energy, 2024, Link
184 International Energy Agency (IEA), Electricity Market Report 2023 (pg. 21), Link
185 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 123), Link
186 KPMG, Turning The Tide on Scaling Renewables, 2023 Link
187 International Energy Agency (IEA), Electricity 2024, Link
188 International Energy Agency (IEA), Energy Efficiency 2023 Link

Storage and flexibility: As the share of variable renewables rises, battery storage capacity additions are required to provide operational reserves. Battery storage projects are attracting increasing investment, to ensure grid stability and hourly flexibility.[189] In 2022, battery capacity additions rose by over 80% in the US and 100% in China relative to 2021.[190]

Grid and transmission infrastructure: To support the projected increase in demand for electricity, the physical infrastructure of grids must be upgraded and expanded, and the permit and licensing process streamlined for efficiency. By 2030, grid line length is projected to increase by around 18% under a current policies scenario and by 20% under a 1.5°C scenario.[191]

Offshore generation: With the growth of offshore wind power generation, there will be more construction offshore, and a greater role for ports in the maintenance and construction of wind turbines.

De-centralisation: With increasing scrutiny being placed on energy security and affordability, the physical landscape of generation and distribution could be restructured and decentralised as virtual power plants (VPPs), consisting of onsite generation and local battery networks, emerge with the capability to feed energy back into the grid. This may bring additional considerations around ownership and responsibility for the maintenance of this infrastructure.

Additional barriers: Skills shortages, and supply chain bottlenecks due to lump roll-out of renewables and emerging low carbon technologies.

10.2.3 Existing and Emerging Technology

Emerging fuels: Low carbon hydrogen and ammonia are emerging as clean fuels and energy to address intermittency of renewable energy. The cost of producing green hydrogen could reduce by 30% by 2030 driven by lower renewable electricity costs and global scale up of hydrogen production.[192]

Carbon capture: Emissions reductions in the near and medium term from hard-to-abate industrial assets and fossil fuel power plants can be achieved through deployment of carbon capture, utilisation and storage (CCUS). However, the current pace of deployments of CCUS is estimated to be inadequate to meet national net zero commitments and the 1.5°C temperature goal.[193]

10.2.4 Policy:

Short-term policy implications: Following recent geopolitical events, there is an increased focus on energy security and affordability. This has led in some places to a growth in renewable energy, but in others to restarting coal-fired power stations, and, in almost all, to shoring up a supply of natural gas to meet

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[189] International Energy Agency (IEA), World Energy Outlook 2023 (pg. 129), Link
[190] International Energy Agency (IEA), Electricity Market Report 2023 (pg. 27), Link
[191] International Energy Agency (IEA), World Energy Outlook 2023 (pg. 176), Link
[192] International Energy Agency (IEA), The Future of Hydrogen (pg.14), Link
[193] International Renewable Energy Agency (IRENA), Reaching Zero with Renewables – Capturing Carbon (pg. 8), Link

seasonal demand swings given the immaturity of the energy storage market. As a result, in contrast with a 1.5°C scenario, under current policies, electricity generation from natural gas is anticipated to remain stable up to 2050.[194]

Carbon pricing and future direction: There are over 75 carbon pricing schemes in operation globally, such as via emissions trading schemes and carbon border adjustment mechanisms.[195] The price and incidence of these schemes is likely to grow as companies look to meet their Nationally Determined Contributions.

10.2.5 Investment and subsidies:

Investment projections: Under a 1.5°C scenario, approximately US$1.2 trillion is projected to be invested in renewable generation by 2030. Within the same period, an additional US$150 billion and US$680 billion are required to be invested towards battery storage and transmission networks, respectively.[196]

Power generation is predicted to substantially increase its reliance on renewables, which will therefore continue to be an opportunity for insurers.

Subsidies and incentives: In 2023, fossil fuel consumption subsidies surpassed US$1 trillion, an all-time high and double the subsidy volume from 2022.[197] Despite these volumes, there is increasing pressure on subsidies to the oil and gas sector, including a commitment in the UAE Consensus at COP28 to phasing out inefficient fossil fuel subsidies that do not address energy poverty or Just Transition, as soon as possible.[198] There is similarly an increasing focus on incentives to renewables, for example via the US Inflation Reduction Act and the EU Green Deal which contains a significant number of incentive measures to support the energy transition. While there is no sign of an immediate reduction in demand, both the IEA STEPS and NZE scenarios project reductions by 2030, and newer long-term conventional oil and gas projects are facing difficulties in attracting funding.[199]

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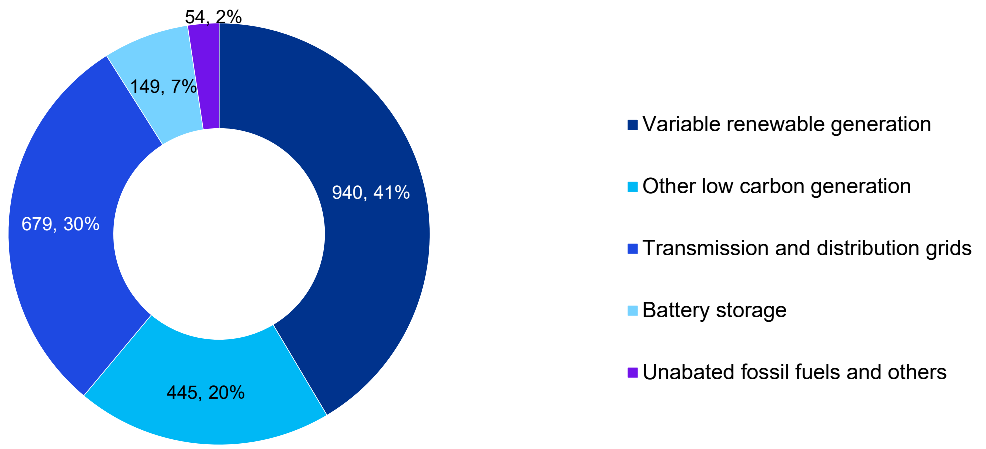
194 International Energy Agency (IEA), World Energy Outlook 2023, Database
195 State and Trends of Carbon Pricing 2024 (worldbank.org)
196 International Energy Agency (IEA), World Energy Outlook 2023, Database
197 Fossil Fuels Consumption Subsidies 2022 – Analysis - IEA
198 COP28 Agreement Signals "Beginning of the End" of the Fossil Fuel Era | UNFCCC
199 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 134 and 135), Link

Figure 10.2.1: Projected annual average power sector investment under a 1.5°C scenario in 2030 (USD billion)



Sources: International Energy Agency (IEA), World Energy Outlook 2023, Database

10.3 Decarbonisation pathway & levers

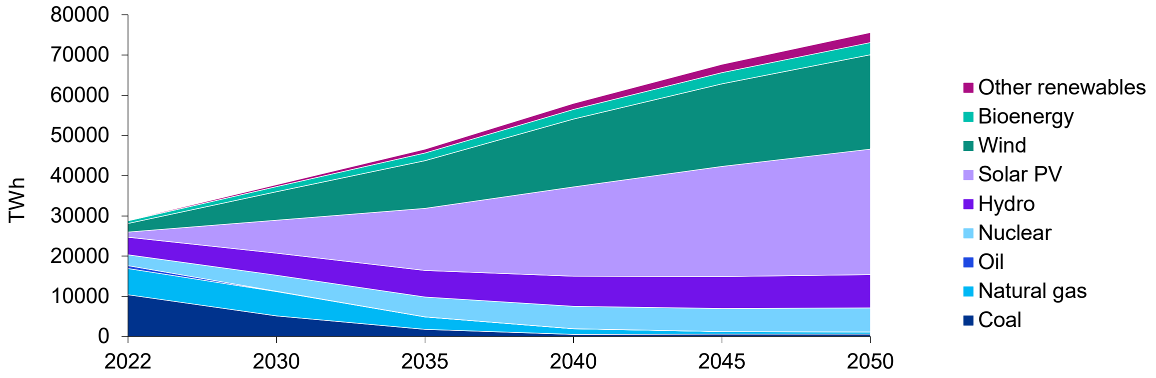
Global power sector emissions are projected to peak in the near-term (before 2030) and decline under all scenarios. Under a 1.5°C scenario, the sector is projected to reach net zero by 2035 in advanced economies and by 2040 in China, reaching net zero globally by 2045.[200]

In 2022, renewables constituted 30% of the total electricity generated. This is projected to rise to 70% by 2050 in a current policies scenario and close to 90% in a 1.5°C scenario. This growth is projected to be driven primarily by solar PV and wind energy technologies.[201]

200 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 128), Link

201 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 126), Link

Figure 10.3.1: Projected electricity generation by source under Net Zero Emissions (1.5°C) scenario



Source: International Energy Agency (IEA), World Energy Outlook 2023, Database

Note: NZE is IEA's Net Zero Emissions by 2050 Scenario, which is associated with a temperature rise of 1.5ºC by 2100 and demonstrates a normative scenario of orderly transition to net zero

Global installed capacity mix under current policies and a 1.5°C scenario

Electrification of demand-side sectors including heating in buildings and industry, and road transport is expected to drive the growth of total installed capacity across all regions.[202]

According to the International Energy Agency (IEA)[203] and the International Renewable Energy Agency (IRENA)[204], variable renewable energy (VRE) i.e., solar and wind, is expected to occupy over 80% of installed capacity under a 1.5°C scenario. Even under a current policies scenario, the share of VRE capacity is projected to reach 65-70%. Under current policies, the IEA's outlook for renewable energy by 2050 is more favourable than IRENA's assessment.

VRE generation is currently curtailed in all countries due to inadequate grid capacity. Investment in growing the grid capacity and increasing flexibility through storage and connectivity is required to maximise the utilisation of solar and wind power plants.

Sources:
1. International Energy Agency (IEA), World Energy Outlook 2023, Database
2. International Renewable Energy Agency (IRENA), World Energy Transitions Outlook 2023

Note:
1. STEPS represents IEA's Stated Policies Scenario, which is associated with a temperature rise of 2.4ºC by 2100 and provides an outlook on global energy system's progression based on current policy landscape
2. Planed Energy Scenario represents IRENA's scenario based on national energy plans, targets and policies with a focus on G20 countries
3. NZE is IEA's Net Zero Emissions by 2050 Scenario, which is associated with a temperature rise of 1.5ºC by 2100 and demonstrates a normative scenario of orderly transition to net zero
4. IRENA's 1.5°C Scenario prioritises readily available technology solutions which can be scaled up to meet the global goal of limiting temperature rise to 1.5°C by 2100 compared to pre-industrial levels

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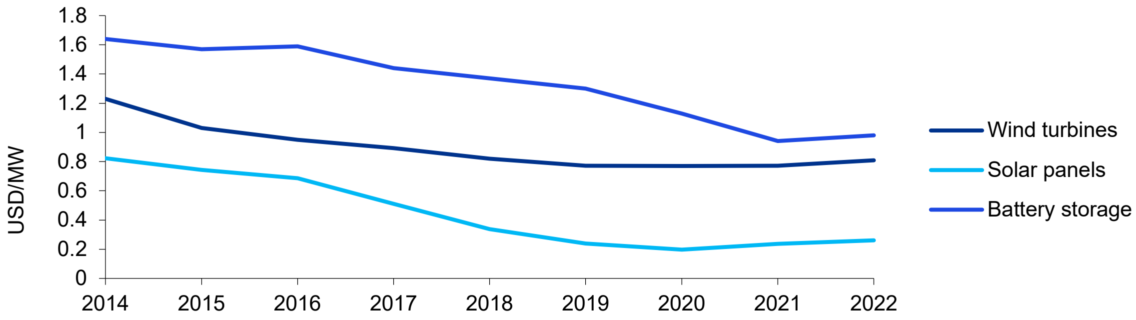
202 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 59), Link
203 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 279), Link
204 International Renewable Energy Agency (IRENA), World Energy Transitions Outlook (WETO) Power Generation and Capacity, Link

Figure 10.1.2: Average prices for selected clean energy technologies



Sources: International Energy Agency (IEA), World Energy Outlook 2023 (pg. 99), Link

Over the long term, the price of solar and wind technologies has been declining, with increases during 2021-2022 reflecting the higher prices of critical minerals and semiconductors. As of 2024, apart from China, solar and wind prices are yet to normalise to pre-pandemic levels. However, the IEA anticipates further improvements in technology and efficiency, and a decline in prices in the long-term with solar and wind remaining competitive vis-à-vis fossil fuel alternatives.[205],[206]

In 2022, 49% of global renewable capacity additions were in China, and were primarily distributed solar PV systems. China aims to promote both large-scale mega projects for demand centres and distributed solar for public institutions, state-owned enterprises and residences. Based on national commitments (IEA's Announced Pledges Scenario), by 2050, 38% of the global installed capacity for solar and wind would be based in China.[207]

Role of dispatchable low carbon power

Nuclear power experienced a decade of slow deployment following the Fukushima Daiichi accident in Japan, however, the outlook is now more positive and installed capacity is anticipated to increase by 49% during 2022-2050 under current policies.[208] In 2022, a third of global nuclear capacity additions were in China.[209] Capacity additions are planned primarily in China and emerging markets, while advanced economies are primarily carrying out asset lifetime extensions and new projects to offset capacity retirements. [210]

205 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 99), Link
206 International Energy Agency (IEA), Renewable Energy Market Update: Outlook for 2023 and 2024 (pg. 57), Link
207 International Energy Agency (IEA), World Energy Outlook 2023, Dataset
208 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 126), Link
209 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 237), Link
210 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 126), Link

Advanced nuclear designs such as small modular reactors (SMRs) are receiving research and development (R&D) funding from the public and private sectors. While there is uncertainty around the scaling potential of commercial deployment of SMRs, the momentum in deployment is growing and the technology is anticipated to become an increasing part of nuclear capacity additions after 2030. SMRs are suitable for industrial applications, distributed generation, and flexibility. SMR capacity additions can reduce the need for transmission grid reinforcements.[211]

Dispatchable renewables including bioenergy, geothermal and tidal power are also projected to occupy 2-3% of installed capacity under current policies and 1.5°C scenarios. [212,213]

Outlook for conventional fossil fuel generation

Under current policies, the use of unabated coal is anticipated to peak during 2025-2030 with a decline following 2030 as the largest users of coal – China, India and Indonesia – develop alternatives. COP28 saw commitments around “Transitioning away from fossil fuels in energy systems, in a just, orderly and equitable manner, accelerating action in this critical decade, so as to achieve net zero by 2050 in keeping with the science”. Discussions around ‘phase down’ versus ‘phase out’ of fossil fuels are expected to continue in successive COP conferences in line with the requirement to ensure that approximately 90% of remaining coal reserves, and approximately 60% of oil reserves untapped in order to ensure the attainment of a 1.5°C scenario, with a 50% probability.[214]

The outlook for natural gas remains stable under current policies with a modest growth in capacity; however, advanced economies are expected to utilise natural gas power plants for flexibility rather than bulk energy output.[215]

Phase out of unabated coal

The phase out of unabated coal is critical to enable a 1.5°C transition. At COP28, a commitment was made to “transition away from fossil fuels in energy systems” including the specific call for parties to begin “accelerating efforts towards the phase-down of unabated coal power”.[216] In 2023 however, global coal production reached its highest level, where the Asia Pacific region accounted for nearly 80% of global output[217], and coal currently accounts for over one-third of global power supply and 40% of all energy sector CO2 emissions. Urgent focus on this area is critical due to the ‘lock in’ effect of current coal plants (‘lock-ins’ refer to the long lifespans of assets that effectively ‘lock in’ their associated greenhouse gas emissions for years or decades to come) and the long life span of new assets, and countries that have set net zero emissions pledges currently cover 85% of global energy sector emissions, which necessitates action on this agenda.[218]

211 International Energy Agency (IEA), Nuclear Power and Secure Transitions (pg. 79 – 81), Link
212 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 279), Link
213 International Renewable Energy Agency (IRENA), World Energy Transitions Outlook (WETO) Power Generation and Capacity, Link
214 Nature, ‘Unextractable fossil fuels in a 1.5 °C world’, Link
215 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 127), Link
216 Executive summary – Accelerating Just Transitions for the Coal Sector – Analysis - IEA
217 Energy Institute, Statistical Review of World Energy, 2024
218 Executive summary – Accelerating Just Transitions for the Coal Sector – Analysis - IEA

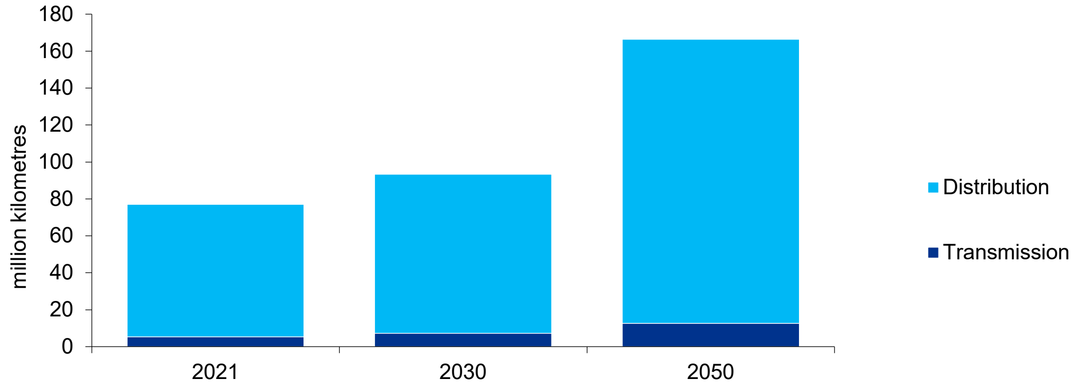
Hydrogen and ammonia in the power system

Low carbon hydrogen and ammonia are emerging as clean fuels and inter-seasonal storage media for renewable energy. Under a 1.5°C scenario, the IEA projects that hydrogen and ammonia-based electricity generation will account for 1% of the installed capacity mix by 2050. Both IEA and IRENA anticipate that hydrogen production would contribute to over 22% of total electricity demand by 2050 under a high-transition scenario. However, due to differences in the total energy demand projections by IEA and IRENA, the total volume of hydrogen production varies significantly across the two.[219] In the long-term, IRENA has a more favourable outlook for green hydrogen compared to blue hydrogen. Green hydrogen is produced from the electrolysis of water using renewable electricity while blue hydrogen is produced from natural gas through steam methane reforming with CO2 from the process captured using carbon capture technologies.[220]

Outlook for grid development

The rapid growth of the transmission and distribution grid is essential to accommodate growing demand and the changing energy mix. Grid development integrates capacity expansion and digitalisation. Expansion includes line extension, substation installation, stability and load control devices, energy storage devices and digitalisation technologies.[221]

Figure 10.3.3: Projected installed network length under national commitments

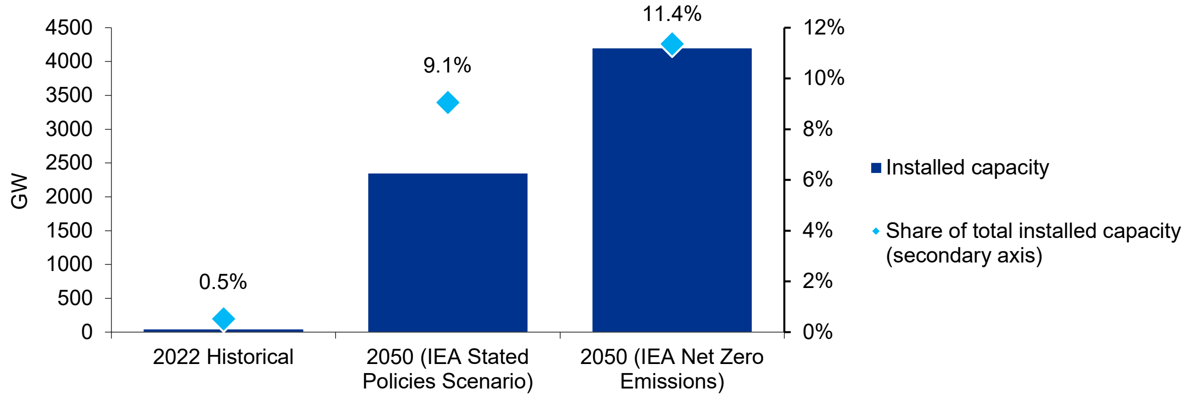


Source: 1. International Energy Agency (IEA), Electricity Grids and Secure Energy Transitions (page 88), Link

Note: Based on IEA's Announced Pledges Scenario (APS), which is associated with a temperature rise of 1.7ºC by 2100 and assumes that governments will meet all climate-related commitments in full and on time.

219 International Energy Agency (IEA), World Energy Outlook 2023 (pg. 124), Link
220 International Renewable Energy Agency (IRENA), Global Hydrogen Trade to Meet the 1.5°C Climate Goal: Part 1 – Trade Outlook for 2050 and Way Forward, Link
221 International Energy Agency (IEA), Electricity Grids and Secure Energy Transitions (page 76), Link

Figure 10.3.4: Projected installed capacity of battery storage under Stated Policies and Net Zero



Source: 1. International Energy Agency (IEA), World Energy Outlook 2023, Database

Note: 1. IEA's Stated Policies Scenario (STEPS), which is associated with a temperature rise of 2.4ºC by 2100 and provides an outlook on global energy system's progression based on current policy landscape

2. NZE is IEA's Net Zero Emissions by 2050 Scenario, which is associated with a temperature rise of 1.5ºC by 2100 and demonstrates a normative scenario of orderly transition to net zero

Drivers of grid development

Economic growth: Increasing electricity demand due to economic growth and electrification is the primary driver for grid expansion and reinforcement across all regions. [222]

Capacity for variable renewable energy (VRE): Enabling adequate capacity for VRE integration requires growth of network capacity to ease congestion. In addition to the installation of lines, battery storage improves the availability of renewables by reducing curtailment at power plants and helps improve network stability and reliability. [223]

Distributed generation and the electrification of heat: Increasing proliferation of electrified building heat and distributed generation requires investment into smart meters, remote control, and communication and automation across low- and medium-voltage grids. [224]

[222] International Energy Agency (IEA), Electricity Grids and Secure Energy Transitions (page 76), Link
[223] International Energy Agency (IEA), Electricity Grids and Secure Energy Transitions (page 42), Link
[224] International Energy Agency (IEA), Electricity Grids and Secure Energy Transitions (page 79), Link

Management of Distributed Energy Resources (DER): DER, especially solar PV, could be owned by small commercial operators which might require infrastructure upgrades by distribution network operators to enable the prediction and management of energy flows.[225]

Electric vehicle (EV) charging: EVs are typically charged in the evening or overnight at residences and, if left unmanaged, will increase peak demand. Measures such as time-of-use tariffs and vehicle-to-grid transfer would be key to manage the load and accelerate EV adoption.[226]

Connecting remote generation sites: Solar and wind power plant sites can be geographically separated from grid connections and points of demand, which is driving the need for high-voltage direct connection (HVDC) transmission links. Power sector regulators are enabling private transmission links to generation sites which is key for corporate power purchase agreements. [227]

Emerging digitalisation technologies: Virtual power plants (VPPs), demand-side response (DSR), internet of things (IoT), and smart home implementations can unlock significant demand-side energy savings while improving the integration of small-scale DER.[228]

10.4 Other considerations

Acute reliability risks due to extreme weather events: Extreme weather events, such as storms, can impact the reliability and security of supply; through impacting the quality of fuel (coal, oil and gas), reducing the input of energy (e.g., water, wind and sun), damaging key infrastructure such as electricity generation and the grid and reducing output. [229]

Chronic reliability risks due to long-term weather patterns: Changes in precipitation patterns and surface water discharges as well as increased frequency of droughts or floods may adversely impact hydropower generation and affect water availability for cooling purposes to thermal and nuclear power plants. [230]

Siting constraints: Sea level rise can affect electric power sector infrastructure and limit the choice of location of power plants and grids, which are often in low-lying areas.[231]

Power plant efficiency: Increases in water temperature are likely to reduce electric power generation efficiency, especially where water availability is affected. Similarly, rises in air temperature will also reduce power generation efficiency and output.[232]

225 International Energy Agency (IEA), Electricity Grids and Secure Energy Transitions (page 30), Link
226 International Energy Agency (IEA), Electricity Grids and Secure Energy Transitions (page 79), Link
227 International Energy Agency (IEA), Electricity Grids and Secure Energy Transitions (page 18), Link
228 International Renewable Energy Agency (IRENA), Innovation Landscape for a Renewable-powered Future: Solutions to Integrate Variable Renewables (pages 64 & 65), Link
229 Asian Development Bank (ADB), Climate Risk and Adaptation in the Electric Power Sector (pg. 4), Link
230 Asian Development Bank (ADB), Climate Risk and Adaptation in the Electric Power Sector (pg. 4), Link
231 Asian Development Bank (ADB), Climate Risk and Adaptation in the Electric Power Sector (pg. 4), Link
232 Asian Development Bank (ADB), Climate Risk and Adaptation in the Electric Power Sector (pg. 3), Link

Impact on renewable sites: Climate change and related physical hazards could impact the production, transmission, and consumption of electricity globally. Hydroelectric power plants are sensitive to stream inflow volume and timing. Drastic variations in wind speed and patterns, increased occurrences of hailstorms and cloud cover variations with changing precipitation patterns could damage wind and solar power assets.[233]

Increase in construction activity and associated risks: The considerable increase in construction activity and the changing profile of that construction activity will lead to a number of potential risks including:

- Major interventions in transmission and distribution networks;
- Deployment of new infrastructure;
- Movement of networks to deal with a much more complex load;
- Potential market volatility;
- The development of offshore wind networks and the associated offshore wind transmission network;
- Hydrogen infrastructure to act as a storage and transport mechanism.

Renewable energy sources can be intermittent, leading to reliability challenges for power generation and distribution. This could provide opportunities for insurers (e.g. business interruption coverage) to assist those that could be potentially impacted.

Global supply chain issues and concentration of production: Between 2020-2023 there was a global semiconductor shortage which curtailed the pace of growth in low carbon technologies. While this was caused by a unique combination of high pandemic-induced demand outstripping supply, the geographically constrained nature of many renewable supply chains presents a risk of similar future shortages. For example, 60% of the world's semiconductors and 90% of the most advanced are produced in Taiwan, while China's share in manufacturing the components of solar energy is 80%.[234,235]

With the increased reliance on renewables, the grid will need to continue to find viable and scalable solutions to store energy, which should also be an opportunity for insurers who can provide the right coverage.

Legal risks: The changing of market rules may result in increased legal activity to defend existing positions.

233 US Environmental Protection Agency (EPA), Climate Impact on Energy, Link
234 The Economist, 'Taiwan's dominance of the chip industry makes it more important'. Link
235 IEA, 'Solar PV Global Supply Chains'. Link

Cyber threat: The new energy system creates a new cyber threat landscape; the energy system will have technology embedded within it that increases the surface area of cyber threat.

Localised networks: There will be opportunities and risks arising from the shift from centralised large-scale networks to localised networks which are linked to generation assets such as Community Choice Aggregation.

Electricity growth and associate infrastructure: The power and utilities sectors will be a primary beneficiary of the energy transition due to the growth in electricity and associated infrastructure due to the low carbon transition.

Retail energy companies: Opportunity to expand service portfolio in many directions from in-home efficiency and retro-fitting existing services to more bespoke plans.

Fixed and variable price of electricity: As more renewables are built into the power system, the variable price of electricity will untether from gas and the variable cost will trend downwards along with the cost of renewables. However, fixed costs will trend upwards to account for investments in transport and distribution networks.

Some regulation may inadvertently stifle new developments (e.g. new, less carbon-intensive gas stations to displace older thermal generators, or re-purposing of old coal powered stations to link up to the grid). This is an area where the insurance industry could potentially influence the debate.

11 Construction

11.1 Current state

For the purpose of analysis, the scope of this sector is restricted to the construction of buildings (residential, commercial), and excludes the construction of infrastructure (e.g. roads, bridges etc.).

The building and construction sector accounts for 37% of total global emissions[236], with the building construction sector alone accounting for approximately 7% of the total[237], [238], [239], with the equivalent of a Paris-sized city being built every week across the world.[240] The sector is expected to see US$4.2 trillion growth over the next 15 years, driven by opportunities in the global green economy and rapidly rising demand in markets such as the Philippines, Vietnam, Malaysia and Indonesia.[241]

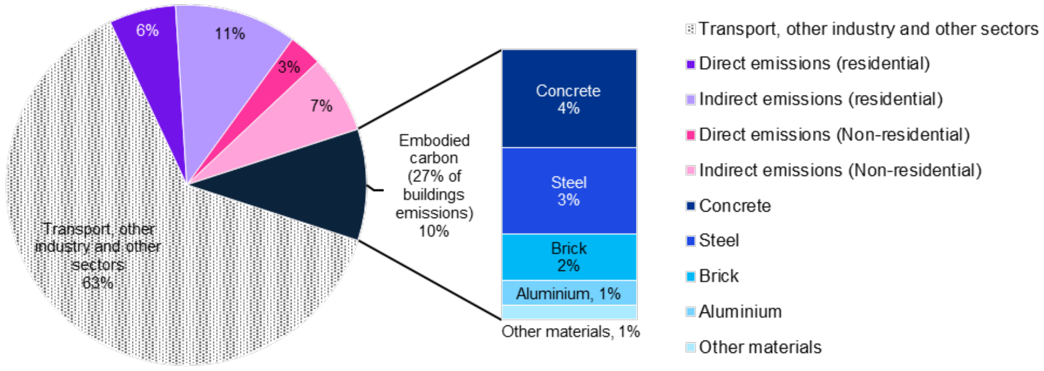
While the energy used in building operations is the biggest contributor to emissions from the built environment, it can mask the significant volumes emitted in construction, termed the 'embodied carbon' of a building. This embodied carbon is estimated to account for approximately a quarter of total building emissions, and includes the emissions associated with the production, manufacturing, and transportation, of the materials used in buildings, as well as those produced during the construction process itself.[242] As building operations become more efficient, embodied carbon could rise to 50% of total building-sector emissions by 2050.[243]

Breakdown of embodied carbon emissions as a proportion of total building lifecycle emissions

Figure 11.1.1: Global emissions by sector and estimated share of embodied carbon from buildings (2022)

236 UNEP, Building Materials And The Climate: Constructing A New Future, 2023, Link
237 Note that sectors covered are not exhaustive nor mutually exclusive; emissions totals do not add up to 100%
238 UNEP, Global Status Report for Buildings and Construction, 2024, Link
239 This emissions figure relates to building construction only and excludes other forms of construction, e.g. infrastructure
240 WBCSD, 'Net-zero buildings, Where do we stand?', Link
241 Aon, 'Future Demand in Construction', Link
242 RMI, Reducing embodied emissions in buildings (pg. 7), Link
243 RMI, Reducing embodied emissions in buildings (pg. 7), Link

Global emissions by sector and estimated share of embodied carbon from buildings (2022)



Source: Global Alliance for Buildings and Construction (Global ABC), Global Status Report for Buildings and Construction 2023, 2023, Link; Zhong et al., Global greenhouse gas emissions from residential and commercial building materials and mitigation strategies to 2060, 2021, Link; KPMG analysis

Notes: Embodied carbon refers to materials used in construction. Energy use in the construction sector is not shown in the chart. Other materials include copper, glass and wood.

Concrete, steel, and aluminium are the some of the primary sources of emissions in construction projects, typically accounting for over two-thirds of the total. Notably, cement, the major component of concrete and the second-most used substance in the world, is responsible for approximately 8% of global carbon emissions.[244, 245]

It is estimated that spending in the global construction industry will exceed US$30 trillion annually within the next three decades, a significant increase from the current spending of around US$11 trillion. Every billion dollars spent on infrastructure development contributes to around one million tons of embodied carbon, primarily due to the prevailing use of high carbon-intensive materials and processes.[246]

The construction sector is slowly starting to respond to this challenge, driven by governmental regulations, investor pressure, and changing consumer preferences. As a result, the sector is beginning to adopt new solutions such as low-carbon materials, energy-efficient design, and renewable energy sources to reduce its environmental impact. [247] It should be noted however, that adoption is slow and only in certain markets; there is little focus on this in emerging markets currently, and many of these low carbon materials are not currently available at scale.

244 Note that sectors covered are not exhaustive nor mutually exclusive; emissions totals do not add up to 100%
245 KPMG Thought Leadership, Embodied carbon management for global infrastructure (pg. 18), Link
246 Future of Construction- A global forecast for construction to 2030 by Marsh & Guy Carpenter, September 2021
247 KPMG Thought Leadership, Tackling embodied carbon within Australia's infrastructure sector, Link

Circularity will also play a key role in this sector. The Science Based Targets Initiative (SBTi) Building Criteria published in August 2024[248] has highlighted the role of adopting circularity principles in the way buildings are designed and the potential to reduce global carbon emissions from building materials by 38% by 2050[249], and has set out the key recommendation that companies must set a target to reduce upfront embodied emissions, for which circularity will be critical.

11.2 Key Trends

Sectoral growth: Global building floorspace is estimated to double by 2060.[250]

Focus on embodied carbon emissions reduction: As operational carbon is expected to reduce in the future, embodied carbon will continue to grow in importance as a proportion of total emissions. The World Green Building Council has called for all new buildings to reduce their embodied carbon by 40%, including a significant reduction in material production and construction, by 2030.[251]

Circularity: Material and substitution along the supply chain can reduce raw material demand along the entire construction value chain. The planning and design phases of the building cycle are critical in designing in circularity, including modular design and 'design for assembly', enabling greater reuse of building materials and keeping existing materials at their highest value for as long as possible. Digitisation, digital twins and computer-aided design optimisation are key levers for enhancing circularity.[252] However, it must be flagged that structure and cladding of buildings are likely to be in place for at least 50 years, and interior fit outs for at least 20 years, which may limit impact on carbon emissions in the short term.

Alternative materials: The use of recycled, and alternative, renewable and bio-based materials, for example timber and bamboo, has the potential to reduce emissions use in the building cycle as well as sequester carbon. Increased focus is needed on integrating these materials into building codes, upskilling and incentivisation of use.[253] It must be noted however, that in many cases, there are limited alternatives to concrete and steel and so the development of low carbon concrete and steel at scale will be critical. Similarly, there is a finite supply of timber and there have been risks raised around excessive deforestation in Europe to fuel the construction industry. The concept of 'do not significant harm' to ecology and biodiversity needs to be addressed and balanced alongside the demand for alternative construction materials.

Underwriters will need to be vigilant to ensure that new low carbon materials are used in line with appropriate building regulations and industry guidelines.

248 Buildings - Science Based Targets Initiative
249 Built environment and the circular economy (ellenmacarthurfoundation.org)
250 World Economic Forum, How to Build Zero Carbon Buildings, 2021, Link
251 World Green Building Council (WGBC), Bringing embodied carbon upfront, Link
252 UNEP, Building Materials And The Climate: Constructing A New Future, 2023, Link
253 UNEP, Building Materials And The Climate: Constructing A New Future, 2023, Link

Market valuation and incentives: The construction industry is projected to receive significant incentives for adopting low-carbon technologies[254], as the market for green building materials is anticipated to be valued at US$459 billion by 2027 (a compound annual growth rate (CAGR) of 10.6% during the period between 2019 and 2027).[255]

With the economy relying on construction to transition, there should be plenty of opportunities in this sector. Western markets are likely to be become more focused on retrofitting with new construction more likely to be in the South East Asian markets.

11.3 Decarbonisation pathway & levers

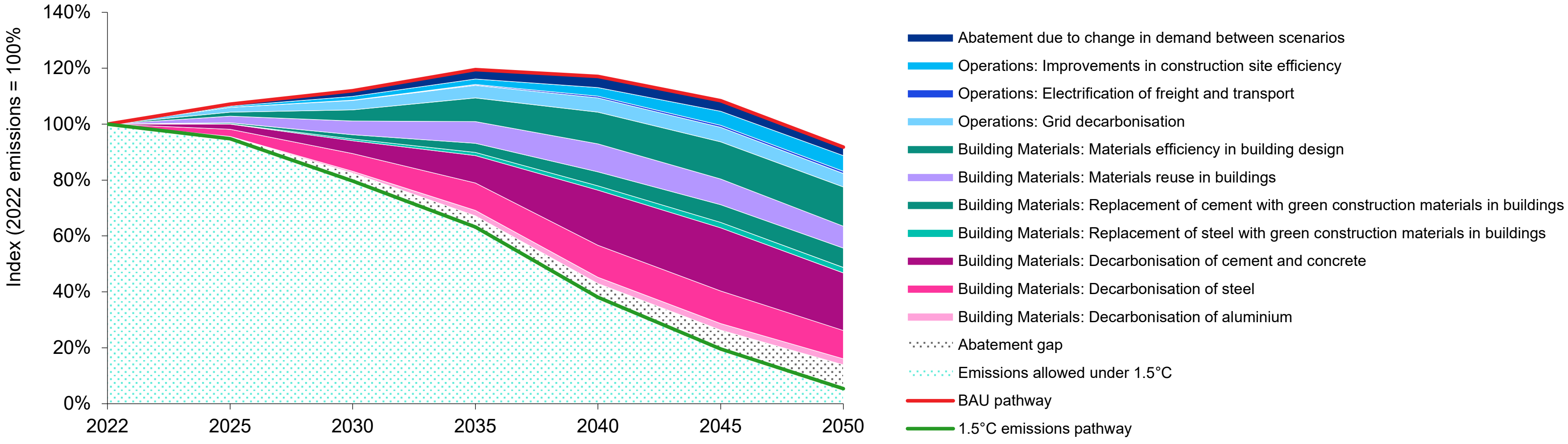
Construction is considered a hard-to-abate sector that is not on track to meet net zero but has a key role to play in the decarbonisation of the economy. Given the significance of embodied materials, and, in particular, the role of cement and steel in the sector, they have been the focus of significant industry attention in determining a commercially viable decarbonisation pathway.

For the purpose of this analysis, we have assessed the decarbonisation of construction operations, taking into consideration onsite activity and logistics, as well as key building materials which form the majority of embodied carbon (emissions along the value chain). In particular, we have assessed the contribution of steel, cement and aluminium.

Steel is one of the most important engineering and construction materials, and the steel industry is among the three biggest producers of carbon dioxide, responsible for c.7% of GHG emissions in 2020[256][257]. Global demand for steel is projected to grow considerably between now and 2050. Similarly, cement and concrete is essential to the construction sector today and emits c. 7-8% of the world's CO2e, with the majority of emissions coming from the clinker making phase. Projected global demand for cement is expected to grow by 14% from 2020-2030 and another 22% by 2050 in line with GDP and population growth.[258] Decarbonisation of these critical inputs is essential to achieving a 1.5°C aligned pathway for construction.

254 Major clients commit to low-carbon construction 'incentives' | Construction News
255 From a base year of 2019; GMI Research, Green buildings materials market, Link
256 Note that sectors covered are not exhaustive nor mutually exclusive; emissions totals do not add up to 100%
257 Steel Net Zero Explorer (plotly.host)
258 Making Net-Zero Concrete and Cement Possible (missionpossiblepartnership.org)

Figure 11.3.1: Potential Construction sector decarbonisation pathway (2022-2050)



Click here for dynamic tables showing how this information may change up to 2050

Table 11.3.2: Abatement impacts on portfolio segmentation over time (illustrative)

Construction		Year	2050							
Portfolio segmentation		Abatement activities								
Segment	Assumed mix of business	Decarbonisation of aluminium	Decarbonisation of steel	Decarbonisation of cement and concrete	Replacement of steel with green construction materials in buildings	Replacement of cement with green construction materials in buildings	Materials reuse in buildings	Materials efficiency in building design	Operations	Unabated / No Change
Abatement (% projected CO2)		2%	11%	23%	2%	8%	9%	16%	13%	16%
Retail	35%	1%	4%	8%	1%	3%	3%	6%	4%	5%
Office	25%	1%	3%	6%	1%	2%	2%	4%	3%	4%
Industrial	15%	0%	2%	3%	0%	1%	1%	2%	2%	2%
Mixed Use	15%	0%	2%	3%	0%	1%	1%	2%	2%	2%
Hospitality/ Services	10%	0%	1%	2%	0%	1%	1%	2%	1%	2%

Source: KPMG analysis

Notes and limitations: This analysis is highlighting a potential sectoral decarbonisation pathway for the purposes of discussion, based on analysis of available information at this point in time. The potential abatement volumes are indicative and based on ranges and assumptions, and are subject to variation based on the evolution of multiple factors, including technology, commercial viability, policy and regulation etc. The analysis is regionally agnostic, based on multiple variables such as global averages for activity, output, grid intensity among others. Assumed mix of business is illustrative as are the impact of abatement activities on different segments albeit linked to the decarbonisation challenges mentioned in this report.

The above table provides an initial view on how the abatement activities may impact upon a typical underwriter's portfolio based upon an assumed mix of business. Unlike transportation, the table highlights the myriad of different abatement activities that are likely to affect construction from the introduction of low carbon materials to changes in the design and use of buildings, as well as builders' own operations towards electrification.

Abatement gap: There is an abatement gap relative to a 1.5°C carbon budget prior to 2050 due to residual fuel use in construction equipment and fossil fuel use in electricity generation. The abatement gap in construction site emissions could be closed by electrification of construction equipment and adopting biofuels.[259],[260] The embodied carbon gap could be closed by reductions from glass, brick and block industries.[261],[262] The brick industry is small to medium scale and decentralised[263] in several markets making it difficult to coordinate technology transitions. The use of removal offsets to close the abatement gap in order to keep to 1.5°C will likely be needed. Offsets reliant on nature-based solutions might not be enough to respond to the world demand, and the sector may need to add technology-based offsets such as Direct Air Carbon Capture (DACCS) to the offset mix.

11.3.1 Key decarbonisation levers specific to site operation

Improvements in construction site efficiency: Emissions abatement due to process efficiency across operations and new practices, such as Modern Methods of Construction, offsite, modular construction, digitalisation of the whole construction process etc.

Decarbonisation of people/crew transport and freight on construction sites: Use of electric vehicles for freight and transport across construction sites.

Decarbonisation of the grid: Abatement due to reduction in emissions intensity of the grid through the addition of more low carbon and renewable sources to the power grid. This reduces the emissions intensity of electrified activities on construction sites. However, given the variation of grid decarbonisation globally, the rate of decarbonisation due to grid decarbonisation in specific regions may vary.

Emissions reduction due to activity change in 1.5°C scenario relative to 4°C: Reduction due to the impact of reduced demand in a 1.5°C scenario relative to 4°C (note both scenarios project growth); the United Nations Environment Programme has outlined three urgent pathways to decarbonise the built environment – 'Avoid, Shift and Improve'. The first strategy focuses on reusing buildings and recycled materials wherever feasible.[264]

New building materials will require different on-site health & safety considerations and will bring new risks that will need to be managed by the construction firms and insurers.

[259] Karlsson et al., Achieving net-zero carbon emissions in construction supply chains – A multidimensional analysis of residential building systems, Developments in the Built Environment, 2021, Link
[260] Karlsson et al, Reaching net-zero carbon emissions in construction supply chains – Analysis of a Swedish road construction project, Renewables and Sustainable Energy Reviews, 2019, Link
[261] British Glass, Glass sector Net zero strategy 2050, Link
[262] UK Green Building Council (UK GBC), Net Zero Whole Life Carbon Roadmap A Pathway to Net Zero for the UK Built Environment, Link
[263] Bureau of Energy Efficiency (BEE) India, Roadmap of Sustainable and Holistic Approach to National Energy Efficiency, 2019, Link
[264] UNEP, Building Materials And The Climate: Constructing A New Future, 2023, Link

11.3.2 Key decarbonisation levers specific to building materials

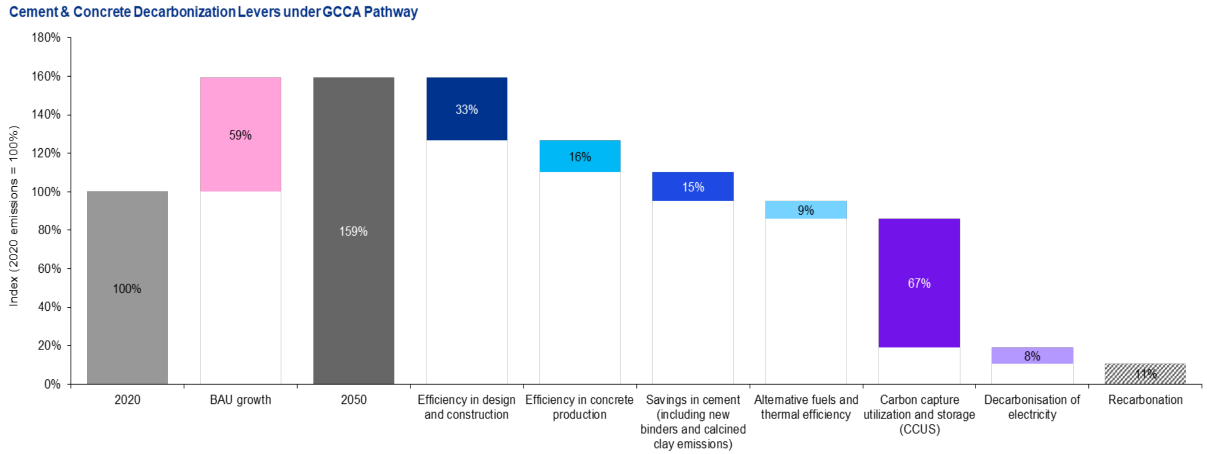
Materials efficiency in building design: Greater efficiency with materials through optimising design and delivery at each stage of the building cycle. This includes prefabrication and modular building, where quantities can be controlled and optimised.[265]

Materials reuse in buildings: Circularity of key building materials including cement, steel, and aluminium, through the use of scrap (used materials) and recycling, resulting in lower primary demand for inputs and, correspondingly, lower Scope 3 or embodied emissions in construction. There can be additional gains that come from circularity in other building materials such as plastics, glass etc. [266]

Concrete and cement decarbonisation: Because of the long lifespan of concrete and cement assets, decisions made over the next 10 years will be critical to ensure the potential decarbonisation of this sector. The Mission Possible Partnership and the GCCA[267] have developed a sectoral decarbonisation pathway. They have highlighted a number of specific challenges to the decarbonisation of this sector which must be considered, in particular, the considerable process emissions from clinker production, the required high temperatures for kilns (which are currently predominantly served by fossil fuels), the significant projected growth in demand, and the highly localised nature of the market as cement and concrete are typically produced close to their use, necessitating region-specific decarbonisation pathways. [268]

[265] UK Green Business Council, Net Zero Whole Life Carbon Roadmap, 2021, Link
[266] UK Green Business Council, Net Zero Whole Life Carbon Roadmap, 2021, Link
[267] Making Net-Zero Concrete and Cement Possible (missionpossiblepartnership.org)
[268] Mission Possible Partnership, Concrete and Cement Transition Strategy, 2023, Link

Figure 11..2.1: Building Material: Decarbonisation of Cement and Concrete



Source: Mission Possible Partnership / Global Cement and Concrete Association, Sector Transition Pathway, Cement & Concrete

Key levers:

- **Efficiency in concrete production:** Reducing clinker content of concrete by reducing the binder intensity of cement through using less cement per unit of concrete results in significant CO2 savings. Moving from bagged to bulk cement usage is a key lever.
- **Decarbonisation of clinker production:** Switching to the use of alternative fuels, such as biofuels and green electricity in the production of clinker, and energy efficiency improvements.
- **Clinker substitution:** Replacement of clinker with supplementary cementitious materials, naturally occurring or industrial byproduct materials such as coal fly ash and blast furnace slag However, it must be noted that availability of these materials is limited and will decrease as coal fired power stations are phased out, so should be considered an interim and not a long-term option. Clinker can also be blended with a range of alternative materials.[269]
- **Decarbonisation of electricity:** Decarbonisation of electricity via the grid, or addition of onsite renewables (e.g. solar etc) or power purchase agreements (PPAs).
- **Carbon Capture Utilisation and Storage:** Installing carbon capture infrastructure to clinker production plants. Direct air carbon capture technology is particularly impactful for this sector.

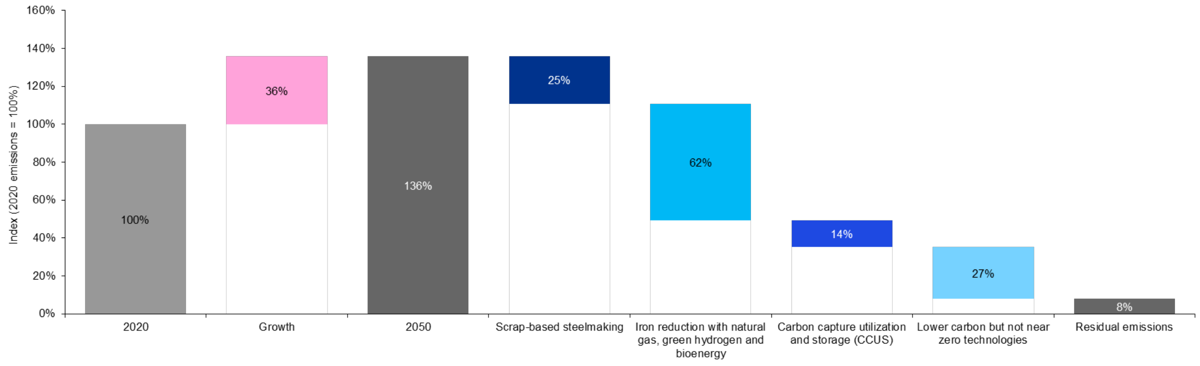
[269] Global Cement and Concrete Association, Clinker Substitutes Link

- **Replacement of cement with green construction material:** e.g. adobe blocks, compressed earth blocks to substitute for high-carbon cement based blocks.[270]

Steel decarbonisation[271]: Steel decarbonisation requires a switch from carbon intensive production routes to net zero production routes depending on biomass, renewable energy, hydrogen, energy efficiency, and captured carbon dioxide. Steel plants typically have a 40 year life spa which means that decisions made this decade are critical for future pathways .

Building Material: Decarbonisation of Steel

Figure 11.3.2: Steel Decarbonisation Levers



Source: Mission Possible Partnership, Sector Transition Pathway, Steel Net Zero

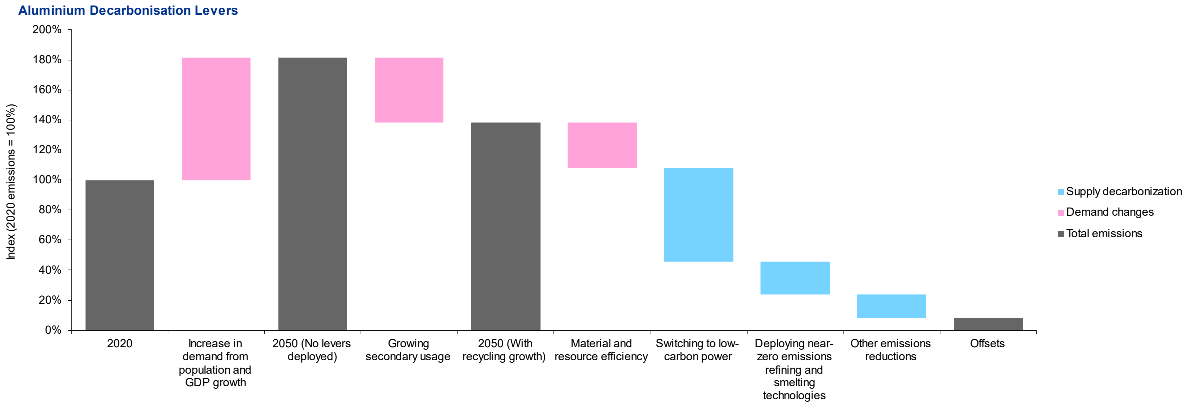
Key levers:

- **Iron reduction with natural gas or green hydrogen:** Decarbonisation of the iron reduction process through switching from fossil fuel-based processes to natural gas or green hydrogen, with the decision based on both the availability and cost of hydrogen relative to natural gas.
- **Carbon Capture Utilisation and Storage**
- **Incremental improvements in existing steel making technologies and grid decarbonisation**
- **Replacement of steel with green construction material, for example with timber**

270 UNEP, Building Materials And The Climate: Constructing A New Future, 2023, Link
271 Mission Possible Partnership, Steel Transition Strategy, September 2022, Link

Aluminium decarbonisation[272]: While aluminium is a smaller component of overall construction than steel or cement or concrete, its decarbonisation is also critical to the decarbonisation pathway for the construction sector, as well as the wider economy, as it accounts for 2% of total global emissions with a projected growth in demand of 80% by 2050.[273]

Figure 11.3.3: Aluminium Decarbonisation Levers



Source: Mission Possible Partnership, Sector Transition Pathway, Aluminium

- **Material and resource efficiency:** as addressed above
- **Switching to low carbon power:**
  - Switching to low-carbon electricity is the primary decarbonisation lever for aluminium given it is such an electricity intensive industry;
  - Switching from fossil fuel based heat to low carbon heat, including through fuel switching, concentrated solar thermal or emerging technology such as heat recovery.
- **Deploying near-zero emissions refining and smelting technologies:**
  - Inert anodes and CCS: New technology to capture carbon emissions or re-engineer anodes to make them inert.
  - Downstream fuel switching: The use of hydrogen, or electrification of processes currently driven by fossil fuels in casting, recycling and semi-production process.

272 Mission Possible Partnership, Making 1.5 Aligned Aluminium Possible, 2022, Link
273 Aluminium (missionpossiblepartnership.org)

11.4 Other Considerations

Lack of affordable low-carbon resources: While there is increasing demand for low-carbon projects, key inputs such as steel and cement still lack low-carbon alternatives at competitive prices, and are considered among the hardest to abate sectors. A number of global initiatives have emerged to support the accelerated decarbonisation of these key input sectors, but technology availability, viability and cost mean prices have not sufficiently fallen, and the construction industry is not always sufficiently integrated into these efforts to be able to drive change. If these issues are not addressed, the sector's reliance on conventional, higher-carbon alternatives risks undermining climate change mitigation efforts, thereby exposing the industry to long-term transition climate risks.[274]

Policy risk: Climate change and its impacts are likely to lead regulators to implement more onerous controls into either the mitigation of climate related risks through more stringent construction design, limitations around development, or by imposing a carbon tax related measure impacting the costs of construction, for example, a carbon border adjustment mechanism (CBAM). The shadow cost of carbon must be considered in evaluating and comparing alternatives (see KPMG Thought Leadership for further details).

Improving climate-adaptation: As the impacts of climate change become increasingly apparent, adaptation is rising up the global agenda. The construction industry has a significant role to play in these efforts, and thus has a major market opportunity to roll out projects such as flood-resistant design, nature-based solutions, and self-sufficient energy supplies.

Physical impacts of climate change: Adverse weather events due to climate change are responsible for 45% of delays in construction projects globally and have cost implications such as additional expenses and lost revenue.[275]

If some constructors are reluctant to use new transition materials (e.g. concerns that green steel is not as strong), this could be an opportunity for insurers to offer (multi-year) product guarantee type products.

274 KPMG Thought Leadership, Tackling embodied carbon within Australia's infrastructure sector, Link
275 Schuldt, S. J., Nicholson, M. R., Adams II, Y. A., & Delorit, J. D. (2021). Weather-related construction delays in a changing climate: A systematic state-of-the-art review. Sustainability (Switzerland), 13(5), 2861. https://doi.org/10.3390/su13052861

12 Commercial Real Estate

12.1 Current state

Globally, approximately 26% of global emissions are attributable to building operations.[276, 277] This includes the emissions produced through heating, cooling, and the provision of electricity for operations within the building. According to the IEA, the building sector is not on track to achieve Net Zero by 2050, with emissions growing on average 1% a year.[278]

Across the sector, legislation is driving increased action on embedding sustainability principles into design, increasing energy efficiency and mandating retrofits. However, while legislation is the minimum bar, market demands for more sustainable products is a critical driver that will continue to grow in line with customer emissions reduction targets and an increasing awareness of potential financial value at risk associated with climate transition risk in the sector (presenting a stranded asset risk). These market dynamics and a more rigorous focus on this sector will continue to drive action.

Within this, the building operations account for 30% of global final energy consumption and 26% of global energy-related emissions (8% being direct emissions in buildings and 18% indirect emissions from the production of electricity and heat used in buildings).[279] Currently, buildings emit 3Gt CO2e in direct emissions, 9.8 Gt CO2e from electricity and heat consumption and 3.5Gt CO2e from materials[280], highlighting the criticality of engaging partners throughout the value chain to account for both embodied and operational emissions.

To align with the IEA's Net Zero Emissions Scenario (NZE), operational emissions from buildings should decrease by approximately 50% from their 2022 level by 2030.[281] In order to support the sector's efforts to reach net zero, the IEA has set a target of retrofitting 20% of the existing building stock to be zero-carbon-ready by 2030, which requires an annual deep renovation rate of over 2%. These targets underscore the urgent need to prioritise extensive retrofitting efforts for existing buildings.[282]

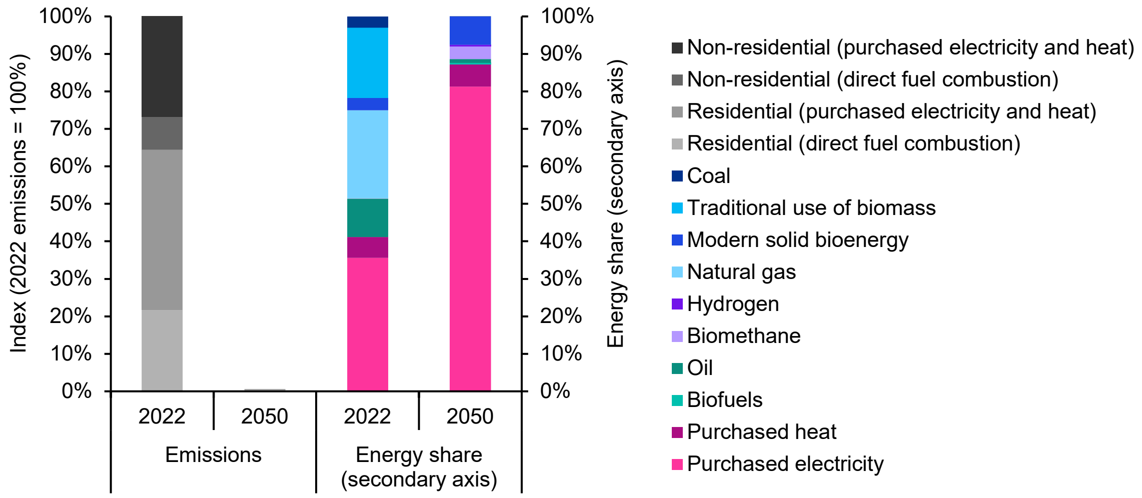
Energy consumption in commercial buildings is high, accounting for approximately one-third of typical operating budgets (though will vary significantly in different building types, where energy can have higher or lower costs depending on the building use e.g. office, retail, logistics etc.). As a result, there is a growing demand to prioritise energy efficiency, often considered the 'first fuel', in the commercial real estate sector and widely recognised as a highly cost-effective solution for

276 Note that sectors covered are not exhaustive nor mutually exclusive; emissions totals do not add up to 100%
277 Architecture 2030, Why the Built Environment, Link
278 International Energy Agency (IEA), Buildings – Breakthrough Agenda Report 2023, Link
279 IEA | Energy Systems | Buildings;
280 Buildings Sector SBTi Guidance
281 International Energy Agency (IEA), Buildings – Breakthrough Agenda Report 2023, Link
282 International Energy Agency (IEA), Renovation of near 20% of existing building stock to zero-carbon-ready by 2030 is ambitious but necessary, Link

emissions reduction.[283] If we consider the whole life cycle of a building (approximately 50 years), there are different phases on which companies from the building sector (construction and real estate) must have an influence: design, construction, usage, renovation and demolition.[284]

The commercial real estate sector is also expected to experience substantial growth. Projections indicate that the floor area of commercial buildings will expand from approximately 820 million square meters in 2020 to over 1.3 billion square meters by 2050. This highlights the urgent need for sustainable and energy-efficient solutions to mitigate the environmental impact associated with this growth, particularly to align with a 1.5ºC scenario.[285]

Figure 12.1: Required emissions reduction and energy mix transformation for buildings under Net Zero Emissions Scenario (2022-2050)



Source: IEA World Energy Outlook 2023 data

Note: Within this sector, only the carbon emissions associated with the operational phase of a building are taken into consideration. However, the decarbonisation potential concerning other components of the building's value chain, such as planning, land acquisition, development, and end-of-life considerations, falls under the purview of the construction sector.

283 Energy Star, Commercial Real Estate: An Overview of Energy Use and Energy Efficiency Opportunities, Link

284

285 KPMG Thought Leadership, Tackling embodied carbon within Australia's construction and infrastructure sector (pg. 10), Link

12.2 Key trends

Growing awareness and commitment: The weight behind the transition is highlighted by the commitment of over 450 firms, collectively pledging US$130 trillion, as part of the Glasgow Financial Alliance for Net Zero (GFANZ), to achieve global net-zero emissions.[286] Commercial real estate has emerged as one of the nine high priority sectors identified by GFANZ, which emphasises the crucial role that the sector plays in achieving global emissions reduction targets.

Asset managers committing to net zero investment: Asset managers are increasingly integrating environmental, social, and governance (ESG) factors into their investment decision-making processes. The focus on net zero emissions within portfolios is likely to drive a shift towards more environmentally friendly investments, including sustainable building development and retrofitting projects.

The Net Zero Asset Managers initiative has over 325 signatories representing more than US$57 trillion in assets under management (AUM); these signatories have committed to Net Zero GHG emissions by 2050. Given that real estate is the largest investment asset class globally, this significant commitment from asset managers adds momentum to the push for decarbonisation.

Increasing demand for sustainable commercial real estate: In recent years, there has been a significant increase in the demand for sustainable commercial real estate, driven by the growing commitment of major corporations towards net zero. About 60% of Fortune 500 companies have announced sustainability plans, which creates a demand for low carbon buildings.[287] There is a growing expectation that commercial real estate projects will meet green building standards and possess certifications such as LEED (Leadership in Energy and Environmental Design) or BREEAM (Building Research Establishment Environmental Assessment Method). There is increasingly a green premium for sustainable buildings, and, increasingly, a need to apply green design real estate to preserve value of buildings.

Challenges in retrofitting existing buildings: The retrofit of existing building stock is a critical decarbonisation lever, but presents challenges. The findings from the Carbon Risk Real Estate Monitor (CRREM) and the Global Real Estate Sustainability Benchmark (GRESB) indicate that only 15% of global assets currently align with the 1.5°C target set by the Paris Agreement, which means the decarbonisation of 37% of global buildings by 2030 is necessary.[288] In addition, at least 40% of building floor space in developed economies was built before 1980, when thermal regulations were introduced.[289]

To achieve the IEA target of retrofit of 20% of existing building stock by 2030, an annual deep renovation rate of 2% is needed, compared to the current level of approximately 1% of mostly shallow renovations. While retrofitting presents considerable OPEX benefits, the initial investment can be high with long payback periods, along with the complexity associated with working with older and varying buildings.[290]

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286 World Economic Forum (WEF), What's a 'carbon bubble' and how can markets avoid it?, Link
287 Fortune 500 companies are acting on the climate crisis—but is it enough? | Stories | WWF (worldwildlife.org)
288 Decarbonising Commercial Real Estate | CBRE
289 Renovation of near 20% of existing building stock to zero-carbon-ready by 2030 is ambitious but necessary – Analysis - IEA
290 Renovation of near 20% of existing building stock to zero-carbon-ready by 2030 is ambitious but necessary – Analysis - IEA

CRREM (Carbon Risk Real Estate Monitor Global Pathways): CRREM is the leading global standard and initiative for operational decarbonisation (of real estate assets)[291], addressing carbon risk assessment and decarbonisation targets and pathways for the real estate industry. CRREM has driven an increased market awareness around potential financial value at risk and stranded asset risk, and has driven an increased focus on decarbonisation for the real estate sector.

Insurers need to consider the risks in retrofitting existing buildings (e.g. older structures will typically have been built to different building standards).

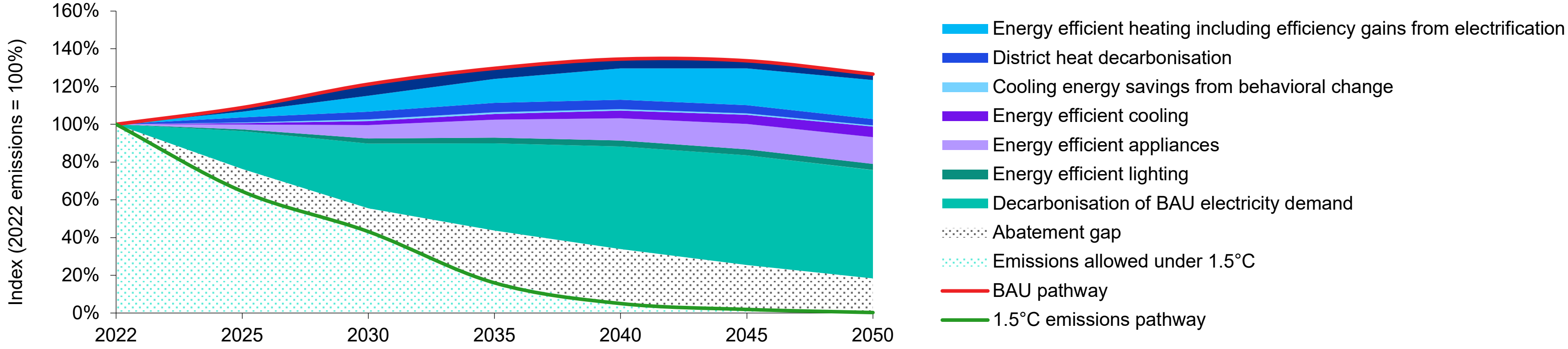
12.3 Decarbonisation pathway & levers

The Real Estate sector will play a significant role in the effort to achieve net zero emissions, as buildings are responsible for a significant portion of global greenhouse gas (GHG) emissions. As of 2024, more than 40% of countries globally either have mandatory energy codes for all buildings or have these codes for part of their building stock.[292] Given the energy consumption of the sector, the decarbonisation of the Power Sector is a critical lever, along with the energy efficiency of heating and transition from fossil fuel fired heating to district heat or heat pumps. Energy efficiency and behavioural change play a key role throughout. Many of the sectoral decarbonisation levers present opportunities for cost and operational efficiencies.

In this section, we offer a view on what the decarbonisation pathway for the Real Estate sector could be in order to achieve net zero emissions by 2050.[293] This analysis looks at operational carbon only, not embodied, and for the purposes of this analysis we have excluded a detailed assessment on data centre decarbonisation.

291 CRREM Phase II – CRREM Global
292 1. Global Status Report For Buildings And Construction

Figure 12.2.1: Potential decarbonisation pathway for Commercial Real Estate (2022-2050)



Click here for dynamic tables showing how this information may change up to 2050

Table 12.3.2: Abatement impacts on portfolio segmentation over time (illustrative)

Commercial Real Estate			2050							
Portfolio segmentation		Abatement activities								
Segment	Assumed mix of business	Decarbonisation of BAU electricity demand	Energy efficient lighting	Energy efficient appliances	Energy efficient cooling	Cooling energy savings from behavioral change	District heat decarbonisation	Energy efficient heating including efficiency gains from electrification	Heating energy savings from behavioral change	Unabated / No Change
Abatement (% projected CO2)		47%	3%	12%	5%	1%	3%	17%	0%	15%
Retail	30%	14%	1%	3%	1%	0%	1%	5%	0%	4%
Office	25%	12%	1%	3%	1%	0%	1%	4%	0%	4%
Industrial	20%	9%	1%	2%	1%	0%	1%	3%	0%	3%
Mixed Use	15%	7%	0%	2%	1%	0%	0%	3%	0%	2%
Hospitality/Services	10%	5%	0%	1%	0%	0%	0%	2%	0%	1%

Source: KPMG analysis

Notes and limitations: This analysis is highlighting a potential sectoral decarbonisation pathway for the purposes of discussion, based on analysis of available information at this point in time. The potential abatement volumes are indicative and based on ranges and assumptions, and are subject to variation based on the evolution of multiple factors, including technology, commercial viability, policy and regulation etc. The analysis is regionally agnostic, based on multiple variables such as global averages for activity, output, grid intensity among others. Assumed mix of business is illustrative as are the impact of abatement activities on different segments albeit linked to the decarbonisation challenges mentioned in this report.

The above table provides an initial view on how the abatement activities may impact upon a typical underwriter's portfolio based upon an assumed mix of business. The table highlights the change to electrification across the portfolio primarily in relation to heating and cooling, but also the continued move to energy efficient fittings and appliances.

12.3.1 Key decarbonisation levers

Abatement gap: Given that this is a hard to abate sector, the use of offsets to close the abatement gap in order to keep to 1.5°C will likely be needed. Offsets reliant on nature-based solutions might not be enough to respond to the world demand, and the sector is expected to add technology-based offsets such as Direct Air Carbon Capture (DACCS) to the offset mix.

Implications of change in demand between scenarios: There is some abatement between a 1.5°C and 4°C scenario due to projected reduced activity, in line with reduced construction figures, and avoided demand (including better use of existing buildings).

Decarbonisation of the grid: The decarbonisation of real estate is critically dependent on the decarbonisation of the Power Sector. While this analysis takes a regionally agnostic view, there will be considerable regional variation in the decarbonisation of the grid in terms of timeframe and extent of decarbonisation that will have a significant impact on the sector. Where grid decarbonisation is projected to move more slowly, on-site renewables and power purchase agreements (PPAs) could play a key role along with onsite energy efficiency which removes demand pressure on the grid while having a decarbonisation impact. This lever addresses decarbonisation of electrified heat, cooling, appliances and lighting.

Heating energy efficiency including gains from phase out of fossil fuel-fired heating: The IEA projects a 30% increase in heated floor area by 2050, but a reduction in energy consumption associated with space heating by almost 70% due to efficient equipment and zero-carbon-ready buildings energy codes.[294] This lever considers the installation of heat pumps, which are projected to meet up to 55% of service demand by 2050, and a shift to district heating from fossil fuel fired heating. While the majority of heat pumps are projected to be installed in advanced economies, the share grows considerably in emerging markets and developing economies.

Decarbonisation of district heat: Fossil fuels dominate energy supply for district heating networks in 2022. Under a net zero scenario, the IEA anticipates 15% reduction in energy consumption by 2030 due to energy efficiency gains in district heat and a doubling in share of renewable energy used by heat networks. Transitioning to lower-temperature networks and integration of newer renewable energy sources such as solar thermal and geothermal also contribute towards district heat decarbonisation.[295]

[294] Space heating – Analysis - IEA
[295] District Heating - Energy System - IEA

Energy efficiency gains in space cooling:[296] The IEA projects that cooled floor area will more than double by 2050, with new additions primarily based in emerging markets and developing markets. The energy intensity of space cooling is projected to decrease considerably, more so in advanced economies than emerging markets and developing economies, via more efficient equipment and improvements in minimum performance standards.[297]

Energy efficiency gains in lighting and appliances: Similarly, energy efficiency gains are assumed in lighting and appliances.

Heating savings from behavioural change: Energy consumption savings are assumed from behavioural change such as turning off or down the heating.

Space cooling savings from behavioural change: Energy consumption savings are assumed from behavioural change and the optimisation of existing equipment, such as turning off or down the air-conditioning.

Given the potential impact of new construction materials and processes on underwriting, insurers will need to monitor progress closely and potentially try to proactively assist the industry in coming up with new guidelines and regulations that will also assist in the underwriting process.

New building materials will have a different risk profile (e.g. green steel) and possible peril risks (e.g. timber) that underwriters will need to take account of when pricing.

12.4 Other considerations

Policy risk: In order to drive the transition, it is likely that regulators will employ strategies such as energy efficiency standards and emissions reduction targets on new build projects and renovations. Rising carbon prices driven by both market and regulatory forces will also have an impact on the real estate sector.[298]

Investment risk: A recent global survey reveals that 83% of real estate occupiers and 78% of investors think that climate risk poses a financial risk. As a result, 80% of leading investors incorporate climate risk and resilience as an essential aspect of their due diligence process while acquiring new real estate.[299] High-carbon assets, or those with poor resilience to the impacts of climate change, are therefore likely to struggle to attract investment.

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296 Space cooling – Analysis - IEA
297 Space cooling – Analysis - IEA
298 United Nations Environment Programme Finance Initiative (UNEPFI), Managing transition risk in real estate (pg. 33), Link
299 JLL, Decarbonising the Built Environment, 2021 (pg. 16 and 21), Link

Cost of retrofitting: With current retrofit rates for existing buildings around 1%, with the typical retrofit achieving less than a 15% reduction in energy intensity, there is a requirement to rapidly scale up retrofitting and retrofit efficacy. This poses a potentially significant cost to asset owners as building codes may become more stringent mandating retrofits.[300]

Green premium: Green certifications in sustainable real estate can potentially generate a rent premium of 6.0% and a sales premium of 7.6%. In commercial real estate in particular, the concept of a 'brown discount' is gaining prominence, and the scale of brown discounts is expected to rise, demonstrating the reduced value of buildings that don't meet higher environmental standards.[301]

Physical risk: Global real estate assets worth around US$35 trillion are expected to be at risk of exposure to physical damages from climate change over the next 50 years.[302]

300 United Nations Environment Programme Finance Initiative (UNEPFI), Global status report buildings construction 2023 (pg. 45), Link
301 World Economic Forum (WEF), How the conversation around green real estate is changing, Link
302 CSA Group, Climate Adaptation and Resilience in Commercial Real Estate (pg. 9), Link

13 Methodology

13.1 Analysis and Data

13.1.1 Scope of analysis

The Sectoral Decarbonisation pathway analysis has been conducted to give an illustrative view of a potential pathway to meet a 1.5°C scenario, in line with the Paris Agreement, relative to a business-as-usual (BAU) counterfactual that aligns to a roughly 4°C pathway by 2100.

13.1.2 Scenarios

The 1.5°C scenario is aligned with the emissions pathway aligned to the International Energy Agency forward look scenarios, predominantly the Net Zero Emissions by 2050 (NZE) scenario, which outlines a pathway for the global energy sector to achieve net zero emissions by 2050 and limit the global temperature rise to 1.5°C above pre-industrial levels in 2100 (with at least a 50% probability) with limited overshoot. This also aligns to the UN Sustainable Development Goals (SDGs) such as universal access to reliable modern energy services and major improvements in air quality.

The BAU emissions pathway projects no change in policies and aligns with the growth of the sector. The BAU scenario is derived from a KPMG proprietary integrated assessment model. Current policies are taken into account in lever modelling; BAU is a do-nothing scenario where current policies do not deliver intended results.

The pathways have been modelled in line with the Shared Socio-Economic Pathway 2 (SSP2) scenario, representing a 'middle of the road' scenario with medium challenges to mitigation and adaptation, where the world does not shift markedly from historical patterns. It is assumed to be an orderly transition.

Pathway and lever analysis to move from a BAU scenario to a 1.5°C scenario are normative, outlining what should or could happen to meet a 1.5°C pathway, as opposed to what is the most likely outcome.

13.1.3 Decarbonisation lever analysis and data

Overview

This analysis has been conducted to provide a potential view of the transition for each sector in line with a 1.5°C scenario, and associated levers, for the purposes of assessing the associated insurance implications.

This work leveraged KPMG models and analysis, including KPMG in-house climate models, contributions from the industry and sector experts, and published industry pathways and data where relevant, including the International Energy Agency World Energy Outlook 2023 in particular. Pathways do not take into account current capacity, investment requirements, or the policy or regulatory environment required to meet the 1.5°C pathway. However, where possible, we have built in the likely outcome based on current views on direction of travel, which may take into consideration some or all of these factors.

Across certain decarbonisation glidepaths, there is an abatement gap based on the necessary 1.5°C pathway and degree of abatement achieved. Any abatement gap must be met through high quality offsets or removals.

This review was conducted based on the currently available information. Where public pathways have been leveraged, these have been referenced. The potential abatement volumes are indicative and based on ranges and assumptions, and are subject to variation based on the evolution of multiple factors, including technology, commercial viability, policy and regulation etc.

The analysis has been conducted at a global level, using global averages, based on multiple variables such as global averages for activity, output, grid intensity among others, and so regional divergences must be taken into account when applying our findings.

Decarbonisation Pathway sectoral scope and exclusions

Sector	Inclusions	Exclusions	Other considerations
Aviation	• In-flight operations	• Airports (ground handling etc.) • Contrails • Fuel related upstream emissions	• Landing and take-off cycle
Marine	• Shipping operations	• Ports	• Overall pathway does not consider fuel related upstream emissions, but net emissions changes due to fuel changes are inclusive of upstream emissions
Road Freight	• Heavy-Goods Vehicles (Medium, heavy)	• Vans etc	
Mining	• Metals and minerals mining • Support activities for mining (e.g. lodgings, mine site operations)	• Coal mining • Metals processing on site	• Pathway is an aggregate of mining activity across different metals and minerals; pathways for specific types of mining may vary
Construction	• Construction operations • Construction support activities • Embodied carbon inputs for buildings	• Embodied carbon inputs for infrastructure • Transport of materials to construction sites	• Pathway did not consider decarbonisation levers for glass, brick, plastics
Real Estate	• Commercial real estate and public services • Small scale industrial assets (e.g. small manufacturing units)	• Residential buildings	• Pathway includes support buildings for transport sector

Data sources

Sector	Data point	Sources
Aviation	Analysis	KPMG analysis
Marine	1.5°C pathway	IEA, World Energy Outlook, 2023
	Fuel shares	IRENA 'A Pathway to Decarbonise Shipping by 2050', 2021
	Non-fuel levers	Maersk-McKinney-Moller Centre for Zero Carbon Shipping (MMMCZCS) KPMG analysis
Road Freight	1.5°C pathway	• IEA, World Energy Outlook, 2023
	Fuel shares	• BNEF, Long-term EV Outlook, 2024 • IEA, World Energy Outlook, 2023
	Non-fuel levers	• Organisation for Economic Cooperation and Development (OECD), Towards Road Freight Decarbonisation: Trends, Measures and Policies, 2018 • IEA, The Future of Trucks, Implications for Energy and the Environment, 2017 • International Council on Clean Transportation (ICCT), Fuel cell electric tractor-trailers: Technology overview and fuel economy, 2023 • KPMG analysis
Mining	1.5°C pathway	• IEA, World Energy Outlook, 2023 • KPMG analysis
	Levers	• IFC, Net Zero Roadmap for Copper and Nickle Value Chains, Technical Report, 2023 • National Renewable Energy Laboratory, Integrating Clean Energy in Mining Operation, 2020 • KPMG analysis
Oil and Gas	1.5°C pathway (Scope 1 & 2)	• IEA, The Oil and Gas Industry in Net Zero Transitions, 2023
	Levers (Scope 1 & 2)	
Power Generation & Distribution	1.5°C pathway	• IEA, World Energy Outlook, 2023
	Levers	

Sector	Data point	Sources
Construction	1.5°C pathway	• IEA, World Energy Outlook, 2023 • Mission Possible Partnership: Sector Transition Strategies (Steel, Aluminium, Cement and Concrete) • Science Based Targets Initiative (SBTi), A 1.5°C Pathway for the Building Sector's Embodied Emissions Pathway Development Description, Draft, 2023 • KPMG analysis
	Levers	• Mission Possible Partnership: Sector Transition Strategies (Steel, Aluminium, Cement and Concrete) • UK Green Building Council, Net Zero Whole Life Carbon Roadmap: A Pathway to Net Zero for the UK Built Environment, 2021 • UNEP, Building Materials and The Climate: Constructing A New Future, 2023 • KPMG analysis
Real Estate	1.5°C pathway	• IEA, World Energy Outlook, 2023 • KPMG analysis
	Levers	• IEA, World Energy Outlook, 2023 • IEA, Net Zero Roadmap: A Global Pathway to Keep the 1.5°C Goal in Reach, 2023 • KPMG analysis

Note: Primary data sources highlighted, however this list is non-exhaustive; additional data sources, and expertise were leveraged in the analysis

13.2 Decarbonisation Pathway Uncertainties

13.2.1 Political challenges

The low carbon transition is extremely complex, requiring significant coordination, commitment and investment from all groups of stakeholders globally. This results in a complex interplay of political, economic and social factors that could impact the trajectory of the low carbon transition. These factors include ideological opposition and the politicisation of climate and ESG factors; changes in government leading to shifts in climate policy priorities and long term strategies, including row-backs on existing stated or announced commitments; changing financial incentives, such as shifts in subsidies, investment plans and commitments; public resistance to potential costs associated with the transition, such as carbon taxation, or job and sectoral displacement, as was seen in France through the 'yellow vest' protests; lobbying and entrenched economic interests that can influence policy and political outcomes; international coordination considerations, including trade and competition, and national security; and policy design and implementation.

In particular, support for green technology deployment policies may vary due to both community concerns about environmental pressure (e.g. natural disasters), costs and availability of green technology (e.g. declining renewable costs, a sense of technical progress), perceptions of trade and economic risks (e.g. environment related trade measures, communities wanting to secure their future) and exogenous shocks particularly involving energy costs or poor economic conditions (e.g. war induced high fossil fuel prices, sustained cost of living crisis, migration – increased populism).

These factors may influence the trajectory, speed and ultimately the success of the low carbon transition, and whether the pathway is orderly or disorderly. Strong international cooperation, rigorous and effective governance mechanisms, at international and national level, and strategic policy and incentive design, and a focus on a 'Just Transition', considering broader social factors will be critical enablers.

13.2.2 The Role of Innovation and Artificial Intelligence

Innovation plays a critical, and potentially, transformative role in the global transition to a low-carbon economy. By driving technological advancements, creating new business models, and fostering cross-sector collaboration, innovation helps overcome barriers to the adoption of sustainable practices and technologies. This can not only reduce costs and improve efficiency but also engages consumers and supports the development of conducive policy frameworks. Innovation can lead to breakthroughs in areas like advanced materials, quantum computing and biotechnology, which can revolutionise energy storage, carbon capture and renewable energy generation, reducing costs and making new technologies more economically viable and displacing traditional approaches. For example, continuous technological innovation in solar power has reduced the cost profile by over 80% since 2010[303], with the same exponential process currently underway for battery storage, transforming the energy system. The most transformative innovations may come from areas we have not yet considered, highlighting the importance of supporting a wide range of research and development efforts.

Artificial Intelligence has the potential to significantly accelerate the global transition to a low-carbon economy. AI has shown considerable promise in optimising energy use, enhancing efficiency, and enabling innovative solutions, and it is expected will contribute to continued advancements in energy storage, carbon capture and renewable energy technology, enhanced climate modelling and enabling adaptation amongst other areas. However while AI can make a significant impact in terms of accelerating decarbonisation pathways, it also presents several challenges and potential negative impacts on the climate, including energy-intensive nature of AI technologies, in particular the substantial amounts of energy required for large-scale machine learning models and data centres, and the environmental impact of hardware production. Data centre consumption is expected to double by 2026[304], and the technology companies have reported significant increases in their emissions due to the expansion of data centres needed to support AI, which has put existing emission reduction targets under pressure. Scaling renewable energy and grid capacity, while not displacing existing energy demand will be critical to mitigate the potential negative impacts of AI on the transition.

13.2.3 Climate Policies and Incentives

Governments worldwide are implementing a variety of climate policies and incentives to drive the low carbon transition. These measures include regulatory mandates, carbon pricing, tax credits, and subsidies for renewable energy. For instance, the Carbon Border Adjustment Mechanism (CBAM) aims to prevent carbon leakage by imposing tariffs on carbon-intensive imports. Similarly, the EU Deforestation Regulation (EUDR) seeks to ensure that products imported into the EU do not contribute to deforestation, while the Corporate Sustainability Due Diligence Directive (CSDDD) mandates companies to identify and mitigate adverse environmental impacts in their supply chains. Such policies create a complex regulatory landscape for global companies, requiring them to navigate diverse regulations, ensure compliance, and leverage available incentives to support their transition strategies.

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[303] How much has the cost of renewable energy fallen by since 2010? | World Economic Forum (weforum.org)
[304] Electricity 2024 – Analysis - IEA

The evolution of climate policies is accelerating as countries strive to meet net zero targets, with 90% of global GDP now covered by such commitments. Governments are using tools like green taxes, investment credits, and renewable fuel mandates to influence corporate and consumer behaviour towards sustainability. This rapid policy development underscores the need for businesses to adopt sustainable practices and capitalize on fiscal incentives and grants to drive environmentally friendly behaviour.

Climate policies are increasingly affecting international trade and investment flows, as countries compete in the clean energy economy. Policies and incentives in certain jurisdictions can have significant cross-border impacts, influencing regulatory approaches and economic strategies in other regions. For example, the CBAM not only affects exporters to the EU but also encourages other countries to adopt similar mechanisms to remain competitive. The EUDR and CSDDD also have far-reaching implications, pushing companies globally to adhere to stricter environmental standards. The uncoordinated and uneven pace of policy changes across markets poses strategic and compliance risks for businesses. Organisations must stay informed about emerging legislation and regulations, manage these risks, and utilize available incentives to support their low carbon transition. The current emissions trajectory highlights the urgency for additional policy measures to achieve the Paris Agreement goals and secure a sustainable future.

13.2.4 Nature & Biodiversity

Nature is declining globally at unprecedented rates. The data are telling us that we have already lost the use of half of our ecosystems in terms of natural resources.

Climate and nature are inextricably linked. The Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) underscore the importance of biodiversity for climate. Approximately 30% of the emissions reductions needed to meet the Paris Agreement targets by 2030 can be achieved through nature-based solutions (NBS), such as reforestation, wetland restoration, and sustainable land management. These solutions provide not only carbon sequestration but also resilience against the impacts of climate change, such as flooding, droughts, and extreme weather events – all of which carry significant financial risks for insurance companies.

In the aviation sector, nature-based solutions can mitigate climate risks (such as extreme heat and floods) and enhance resilience (i.e. business continuity) on sites. For renewables, site selection provides the greatest opportunity to avoid negative biodiversity impacts. Environmental Impact Assessments are required by law in some jurisdictions, but these take place when the majority of decision-making on the site selection is already completed. Integrating biodiversity very early on into siting decision making-process, reduces permitting time and mitigation costs, with up to 14% savings.

In the mining, oil and gas, and power generation and distribution sectors, sustainable practices in operations and restoration of the ecosystem can reduce ecological footprints and improve compliance with increasingly stringent environmental regulations. Real estate and infrastructure development, meanwhile, can benefit from nature-based solutions that integrate green building practices and urban biodiversity to mitigate environmental risks and enhance property value over time – but may also increasingly become exposed to regulations around compensations for the loss of nature (e.g. UK’s Biodiversity Net Gain scheme).

14 Appendix A: Carbon Markets

According to the latest edition of UNEP's Emissions Gap Report, the world is significantly off the mark to achieve its interim 2030 targets with a 14 to 22 GtCO2e remaining gap between the current policies scenario (including planned unconditional Nationally Determined Contribution targets) and the median estimate of emissions level consistent with a 2°C or 1.5°C scenario respectively.

This gap is precisely where carbon markets, and carbon pricing instruments more broadly, can play a critical role. Directly embedded in the Paris Agreement are considerations from Article 6 (A6) mechanisms, which address arrangements for voluntary coordination mainly Article 6.2 and Article 6.4. A6.2 (cooperative approaches) refers to the bilateral cooperation between Parties leading to the transfer of finance and Internationally Transferred Mitigation Outcomes (ITMOs), the carbon credit equivalent of such transactions which can be counted towards national achievement of emissions reduction targets. A6.4, the successor to the Clean Development Mechanism (CDM), is a global carbon crediting mechanism developed and managed under the supervision of the United Nations Framework Convention on Climate Change (UNFCCC), providing a comprehensive framework (governance system, methodologies, registry etc.) for carbon transactions not only involving countries, but also the private sector.

Compliance markets, either geographical or sectoral, are gaining momentum and adding to the relevance of carbon markets in curbing the effect of climate change. According to the World Bank's State and Trends of Carbon Pricing 2024, there are already 36 Emissions Trading Systems (ETS) and 39 Carbon Taxes implemented, 40% of which are allowing a portion of international carbon credits to offset liabilities. Separately, according to S&P's Commodity Insights, CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation) is expected to represent almost 1.5 billion MtCO2e of demand for international carbon credits during its mandatory phase (2027-2035) after accounting for sustainable aviation fuel (SAF) reductions.

The Voluntary Carbon Market (VCM) is also expected to play a part by enabling corporates to contribute substantially, above and beyond their own decarbonisation pathways. The Science-Based Targets initiative (SBTi) is the leading framework for corporate decarbonisation and net-zero target setting in line with climate science, and covers nearly 40% of the global economy by market capitalisation according to their latest Monitoring Report. As per their current guidance, corporates engaged in net zero trajectories, are allowed to use carbon removals (those leading to the permanent sequestration of GHG emissions) in order to counterbalance their residual emissions from net-zero target year and beyond (10% of baseline emissions). In terms of scale, and recognising that all the demand will not come from corporates, scientists estimate that up to 10 GtCO2e will need to be removed annually from the atmosphere by 2050. In addition to the compensation of residual emissions, corporates are also encouraged to participate in so-called 'Beyond Value Chain Mitigation' (BVCM), contributing to actions or investments falling outside their value chains and beyond their own net zero targets, which often leverages carbon projects or carbon crediting frameworks. Finally, other concepts to engage the private sector are being tested such as the compensation of non-state actors' (NSAs) unabated emissions in their transition to net zero (VCM initiative Claims Code of Practice), or the feasibility and eligibility requirements for a Scope 3 Claim that would see a role for a high-integrity VCM in helping companies accelerate their climate ambition and action, as a complement to delivering Scope 3 decarbonisation goals.

Up until recently, participants in carbon markets had to operate in total absence of insurance systems, adding risks and, therefore, limiting carbon transactions and the financial flows towards emissions reduction and sequestration activities. This is particularly challenging in unregulated (or less regulated) markets such as the VCM. This is changing, and insurance companies, either historical players or dedicated start-ups, have started noticing the opportunity and the role they could play.

The types of risks carbon insurance can (or could) cover include: (1) counterparty risks such as fraud or negligence of the project developer (PD), insolvency of the PD, abandonment of the project by the PD, or actions of other entities, for instance local communities or contractors, (2) unavoidable risks such as natural catastrophe (e.g., wildfire, flood, or drought beyond modelled expectations), machinery breakdown or supply chain disruption, (3) carbon risks such methodology revisions causing under-delivery or invalidation of the methodology, delayed verification leading to delayed delivery, additionality changes leading to lower issuance, insolvency of the carbon standard, (3) political risks such as revocation of land rights or license to operate, war and civil disturbance, breach of contract by government or non-enforcement of bilateral investment treaty (both growing concerns as carbon credits will increasingly require Corresponding Adjustments sanctioned by Host Countries governments). Finally, other risk areas may be covered as the depletion of buffer pools in the case of Nature-Based Solutions (NBS) activities, protection against market fluctuations, non-payment of loan or even cyber-attacks against trading platforms.

Emerging insurance products are both available on an indemnity or parametric basis depending on the risk appetite and relevant risks/triggers that are of particular concern for insureds. Some of the carbon insurance pure players include Oka (Carbon Protect, Corresponding Adjustments Protect), Kita (Carbon Purchase Protection Cover, Abandonment & Insolvency, Buffer Depletion Protection Cover, Carbon Political Risk Cover), Arbol (parametric insurance solutions), CarbonPool (Carbon Shortfall Insurance, Carbon Reversal Insurance, Unintended Emissions Insurance). A recent report by Kita & Oxbow Partners estimates that the Gross Written Premium (GWP) related to carbon insurance services could reach US$ 1 billion annually by 2030 and between US$ 10-30 billion annually by 2050, underwritten across the industry (both for existing general insurance products and new carbon insurance coverages). It is therefore unsurprising to see insurance leaders such as AON, AXA, Fidelis, Howden, Marsh, or Mitsui Sumitomo Insurance, all designing their own carbon service lines at the moment. Finally, it is worth noting that even the Multilateral Investment Guarantee Agency (MIGA), part of the World Bank Group, is developing a type of risk insurance to protect investors or project developers against Corresponding Adjustments rollback and other forms of political risks.

The VCM has been challenged for the past couple of years, and risks are impacting buy-side and sell-side, as well as investors and other stakeholders involved. Insurance is not only critical in restoring buyer confidence (particularly when it comes to NBS activities) but also needed to attract the scale of institutional investor capital required for the VCM to meaningfully contribute to the global net zero goal.

15 Appendix B: Sector regulation, policy and incentives

15.1 Aviation

15.1.1 Current regulatory and policy landscape

SAF incentives have been integrated into the **US Inflation Reduction Act**. The regulation provides a tax credit for the sale or use of SAF that achieves a lifecycle greenhouse gas emissions reduction of at least 50% as compared with petroleum-based aviation turbine fuel.[305] Section 40007 Grant Program provides approximately US$250 million for projects relating to the production, transportation, blending or storage of SAF and close to US$47 million for projects to develop, demonstrate or apply low-emission aviation technologies.[306]

Under the **EU's ReFuelEU** aviation regulation, fuel suppliers are mandated to blend a minimum volume of 2% SAF with kerosene.[307] This regulation also mandates airports to ensure the necessary fuelling infrastructure fit for SAF distribution is available.[308]

The **UK's Jet Zero Strategy** for net zero aviation by 2050 has a proposal to mandate SAF with a target of at least 10% SAF in the UK aviation fuel mix by 2030. Approximately £9 million of funding was provided between 2020 and 2023 to support airspace modernisation such as developing efficient flight routes and performance-based navigation.[309] The strategy also has the ambition to ensure all airport operations in the country are zero emissions by 2040. An additional £3 million is invested in the Zero Emission Flight Infrastructure (ZEFI) programme which supports fundamental infrastructure changes that are required for the transition.[310]

The **UAE's General Policy for Sustainable Aviation Fuel (SAF)** has the target to establish and develop domestic SAF capacity of 700 million litres annually by year 2030. Additionally, the aim is to supply the national airlines with locally produced SAF, accounting for 1% of the total fuel volume at UAE airports by 2031.[311]

The **Singapore Sustainable Air Hub Blueprint** mandates the use of sustainable aviation fuel from 2026. All flights departing Singapore will be required to use 1% SAF by 2026 and increase it to between 3% and 5% by 2030.[312]

The **EU Circular Economy Action Plan (CEAP)** is a comprehensive body of legislative and non-legislative actions aimed to transition the European economy from a linear to a circular model across the entire lifecycle of products, in order to achieve its climate-neutrality target by 2050. Circular economy principles apply

305 Government of USA, Building a clean energy economy (pg. 64), Link
306 US Government, Building a clean energy economy: Inflation Reduction Act of 2022 (pg. 65 and 66), Link
307 European Commission, ReFuelEU Aviation, Link
308 European Commission, ReFuelEU Aviation Regulation, Link
309 Government of UK, Jet Zero Strategy, Link
310 Government of UK, Department for transport, Jet Zero Strategy (pg. 26), Link
311 United Arab Emirates, General policy for sustainable aviation fuel, Link
312 S&P Global, Singapore mandates SAF, Link

across the aviation value chain. Cabin waste and airport waste including waste from airport offices, flight catering centres, air cargo terminals, and aircraft and ground service equipment maintenance facilities are covered under the regulation.[313]

The **Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)** is a global market mechanism that aims to stabilise aviation emissions at 2020 levels by requiring airlines to offset and reduce additional emissions growth. The scheme mandates that CO2 emissions that cannot be reduced through technology or operational improvements are credibly offset. Operators are entitled to claim emissions reductions only from eligible fuels listed under CORSIA such as SAF and low-carbon fossil-based fuels. The mechanism is intended to incentivise companies to invest in new technologies.[314] From 2021-2035, it is estimated that the scheme will offset around 80% of the emissions above 2020 levels.[315]

EU Emissions Trading System (EU ETS) is a cap-and-trade system that puts a market-based price on emissions and entails limiting the overall volume of greenhouse gases that can be emitted by a covered entity. The EU ETS covers intra-European Economic Area (EEA) flights based on historical emissions. The airlines are given individual emission allowances and any extra emissions need to be offset.[316]

15.1.2 Regulations and policies specific to air transport support services

Airport Carbon Accreditation is a global carbon management certification programme that follows seven levels of certification, namely mapping, reduction, optimisation, neutrality, transformation, transition, and level 5. These certification levels acknowledge that airports are at their respective stages of carbon management. This programme is applicable for airports of all sizes ranging from hubs to regional airports to freight focused airports.[317]

15.1.3 Potential future policies, regulations and incentives

Climate regulation and policy is advancing globally, but at different speeds around the world. A three-tier system emerges, where the EU and international standard setters pave the way for new regulation and policy, some players in the international space follow the lead adopting similar initiatives later on, and the US for example moves at a slower pace with most developing economies.

Domestic aviation increasingly covered by decarbonisation policies: Decarbonisation policies such as carbon pricing and regulation around activity or the uptake of SAF fuel will increasingly be applied to domestic aviation, with implications on international aviation due to the potential for extraterritorial application of domestic measures (e.g. Singapore SAF mandate on all departing flights), and additional incentives and policies under consideration for global associations (e.g. IATA).[318] Additionally, as more awareness emerges on contrails, the non-CO2 warming effects in aviation industry will start to be reflected in climate policy with contrails management regulation also playing a role in national policies.

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313 European Commission, Circular economy action plan, Link
314 International Air Transport Association (IATA), Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), Link
315 European Commission, Reducing emissions from aviation, Link
316 European Commission, Reducing emissions from aviation, Link
317 Airport Carbon Accreditation, Link
318 CAPA, 'UK to include aviation in carbon emissions targets'. Link

CORSIA expansion and formalisation: From 2027, almost all international flights will be subject to mandatory offsetting requirements, representing more than 90% of all international aviation activity. [319] Under the EU Emissions Trading Scheme, airlines are given tradable allowances for flights within the European Economic Area (EEA), which should broaden to flights from and to the EEA beyond 2024. Together, these emissions pricing mechanisms should incentivise decarbonisation.

Market for Sustainable Aviation Fuel

- **Further development of SAF market:** Initiatives such as the EU's 'Fit for 55' package encourage the development and use of SAF. Under the ReFuelEU strategy, at least 63% of all aviation fuel used for flights departing from EU airports should be SAF by 2050, up from 2% in 2025 and 5% in 2030.[320] Similarly, all flights departing Singapore from 2026 must use at least 1% SAF.[321] In both instances, this will encourage extraterritorial emissions reductions.
- **Potential push-back on SAF:** The development of the SAF industry will, as a side-effect, place increasing pressure on land, in competition with biofuels for road transport and shipping, and with potential challenges on food security and implications around nature and biodiversity, and rewilding. Bio-SAF may therefore face political pushback, resulting in increased focus on synthetic SAF.

[319] KPMG, 'Aviation Sector – Transition Plan'. Link
[320] EASA, 'Fit for 55 and ReFuelEU Aviation'. Link
[321] Reuters, 'Singapore to require departing flights to use sustainable fuel from 2026'. Link

15.2 Marine

15.2.1 Current regulatory and policy landscape

The International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI adopted under the IMO sets limits on the emissions of sulphur oxide, nitrogen oxide and ozone depleting substances. Vessels are also required to adopt technical and operational energy efficiency measures. All ships are mandated to develop Ship Energy Efficiency Management Plan (SEEMP), calculate their Energy Efficiency Existing Ship Index (EEXI) and initiate data collection for annual operational carbon intensity indicator (CII) rating calculations. New ships are mandated to comply with Energy Efficiency Design Index (EEDI).[322,323]

2023 IMO Strategy on Reduction of GHG Emissions from Ships set the following targets for the sector:

- Emissions reduction by at least 20%, striving for 30%, by 2030 and by at least 70%, striving for 80%, by 2040, compared to 2008 levels;
- Reach net-zero GHG emissions by 2050; and
- Uptake of low emission technologies and alternative fuels by at least 5%, striving for 10%, of the total energy consumption by international shipping by 2030.[324]

Clean Shipping Act of 2023 has been introduced in the US congress to set progressively tighter carbon intensity standards for fuels used by vessels. Vessels are required to reduce carbon intensity of the fuels used, including lifecycle carbon dioxide-equivalent reductions of 20% from January 1, 2027, 45% from January 1, 2030, 80% from January 1, 2035, and 100% from January 1, 2040.[325]

EU Emissions Trading System (ETS) is a cap-and-trade system that puts a market-based price on emissions and entails limiting the overall volume of greenhouse gases that can be emitted by a covered entity. It currently applies to ships above 5,000 gross tonnage entering EU ports regardless of their flags. The scheme covers carbon dioxide, methane and nitrous oxide emissions and will be extended to vessels above 400 gross tonnages from 1 January 2025, significantly limiting GHG emissions from the sector.[326] The UK has proposed a similar ETS.

Fuel EU Maritime Regulation imposes a limit on the GHG emissions intensity of energy consumed onboard any vessel entering, departing, or staying within EU ports urging the use of low-carbon fuels.[327]

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322 International Maritime Organisation (IMO), International Convention for the Prevention of Pollution from Ships (MARPOL), Link
323 International Maritime Organisation (IMO), EEXI and CII - ship carbon intensity and rating system, Link
324 International Maritime Organisation (IMO), 2023 IMO Strategy on Reduction of GHG Emissions from Ships, Link
325 US Government, Clean Shipping Act of 2023, Link
326 EUR-Lex, Regulation (EU) 2015/757 monitoring, reporting and verification of greenhouse gas emissions from maritime transport, Link
327 EUR-Lex, Regulation (EU) 2023/1805 on the use of renewable and low-carbon fuels in maritime transport, Link

The Green Ship Programme under the **Maritime Singapore Green Initiative** provides initial registration fee reduction and tax rebates for Singapore-flagged ships voluntarily adopting LNG as their primary fuel.[328] Additionally, through the **Maritime Singapore Decarbonisation Blueprint**, investments up to USD 300 million will be utilized to reduce emissions from the maritime industry over the next 10 years.[329]

Insurance Implications: Electric and alternative fuel trucks have different risk profiles compared to traditional diesel trucks, including battery-related hazards and technology reliability issues. Insurers must adjust their risk assessment models accordingly.

15.2.2 Climate regulations and policies specific to on-land and terminals operations

Financial incentives for implementing low carbon technology at ports include the **US Inflation Reduction Act of 2022** with US$3 billion allocated for the purpose of funding zero-emission port equipment, and the **Green Tariff Scheme** in the Port of London to incentivise and support vessels using cleaner and more environmentally friendly technologies.[330,331]

Many countries and regions have set specific climate policies and targets to reduce emissions that also impact port such as **Fit for 55,** an EU package designed to reduce greenhouse gas emissions by 55% by 2030. For ports, it includes regulations for alternative fuels infrastructure (AFIR) and promotes incentives for zero emission technology while at berth, with a technology-neutral approach.[332]

Countries have also been adopting guidelines and initiatives that enable the decarbonisation of ports, such as the **Maritime Singapore Green Initiative** which aims to reduce charges for other goods vehicles (OGVs) operating on low emissions fuel.[333] Similarly, India’s **'Harit Sagar' Green Port Guidelines 2023** incentivise the environmental performance of ports. By promoting green hydrogen facilities, LNG bunkering, and offshore wind energy, this initiative aims to reduce carbon emissions and foster sustainable practices in India's ports.[334]

Major ports including Los Angeles and Montreal have signed up to a **Shore Power Declaration** which allows ships to shut off their diesel-powered engines when berthed and connect to the electricity grid to reduce greenhouse gas emissions.[335]

The **Clydebank Declaration**, introduced during the Conference of the Parties 26 (COP26), emphasizes the creation of green shipping corridors connecting multiple ports with an aim to provide bunkering options for vessels that operate on low or zero carbon fuels, while also enabling the testing and implementation of various solutions. Considering this initiative, 21 green shipping corridor initiatives have been established, and over 110 stakeholders throughout the value chain have been involved.[336]

[328] Maritime and Port Authority (MPA) of Singapore, Maritime Singapore Green Initiative, Link
[329] Maritime and Port Authority (MPA) of Singapore, Maritime Singapore Decarbonisation Blueprint, Link
[330] US Environmental Protection Agency (EPA), Clean ports program, Link
[331] Port of London Authority (PLA), Green tariff scheme, Link
[332] European Council, Fit for 55: Alternative fuels infrastructure, Link
[333] Maritime and Port Authority (MPA) of Singapore, Maritime Singapore Green Initiative, Link
[334] Government of India – Ministry of ports, shipping and waterways, Harit Sagar - green port guidelines, Link
[335] Seatrade Maritime News, Ports and ministers commit to 2028 shore power deadline, Link
[336] Government of UK, Clydebank Declaration for green shipping corridors, Link

Green Port Initiatives are a collection of policy measures and management approaches aimed at reducing the environmental impact of ports and have been implemented at a number of ports across the world in recent years, including in the Netherlands, the United Kingdom, Germany, Singapore, and the United States. The Port of Rotterdam, Port of Southampton, Port of Hamburg, Port of Singapore and Port of Los Angeles have implemented initiatives such as energy efficiency programs, the use of clean energy sources, modern waste treatment, and reducing the use of sulphur-based fuels. [337]

15.2.3 Future looking policies, regulations and incentives

The key consideration in the transition for the Maritime sector is its cost and who will pay, solutions exist but customers typically do not want to pay. As such, global regulations (for example via the International Maritime Organisation) have a key role to play to bridge the cost of conventional versus green fuel, and this will be much easier to customers to buy green logistics.

Updated IMO net-zero strategy: In 2023, the International Maritime Organisation brought forward its target net-zero date from 2060 to 2050 and is currently debating the package of measures that it will employ to enable the sector to reach this target.[338] Levers under discussion include a goal-based marine fuel standard regulating the phased reduction of the marine fuel's GHG intensity, and an economic mechanism(s) to incentivise the transition.

Incorporation of shipping into general decarbonisation strategy: As the viability of alternative fuels improves alongside the potential for efficiency gains, it is likely that maritime emissions will more regularly be subsumed into broader strategic interventions such as carbon pricing at both the national and multilateral levels and included more comprehensively in target setting. This will mean more scrutiny is placed on the sector and more accountability is required from its companies in terms of detailed transition plans rooted in proven technology.

Coordination to scale low-carbon fuels: There remains uncertainty around the pathway to maturity for alternative fuels, with implications on scale up of associated infrastructure and marine orderbooks. As a result, increased cross-industry and public-private collaboration will be required to align on investment priorities and overcome barriers to commercial viability. The Poseidon Principles were an early example of successful collaboration, achieving widespread disclosure amongst financial institutions which has led to real world investment in shipping decarbonisation.[339] Looking ahead, governments are considering the introduction of '**green shipping corridors'** which, in a comparable manner to special economic zones, will bring together public and private actors along the value chain to collaborate around fuels, ports, ship types and voyage optimisation to enable the scaling of low-carbon fuels and decarbonisation across the sector.[340] The UK government amongst others is considering the development of zero emission shipping routes between key collaborating ports, as part of its Clean Maritime Demonstration Competition (CMDC5). [341]

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[337] Identec Solutions, Green port initiative, Link
[338] Argus, 'IMO sets 2050 net zero target in revised GHG strategy', Link
[339] RMI, 'A Year at Sea'. Link
[340] Admiralty, 'Discovering the benefits of green shipping corridors'. Link.
[341] Gov UK, 'New green international shipping routes backed by government funding'. Link

Updated IMO net-zero strategy: In 2023, the International Maritime Organisation brought forward its target net-zero date from 2060 to 2050 and is currently debating the package of measures that it will employ to enable the sector to reach this target.[342] Levers under discussion include a goal-based marine fuel standard regulating the phased reduction of the marine fuel's GHG intensity, and an economic mechanism(s) to incentivise the transition.

Direct alternative fuel mandates: Direct mandates have been successfully used in road transport and aviation, requiring a quota of low emissions fuels/technologies to be deployed.[343] As alternative maritime fuels develop, equivalent mandates could be used, driving multi-territorial emissions reduction.

Incorporation of shipping into general decarbonisation strategy: As the viability of alternative fuels improves alongside the potential for efficiency gains, it is likely that maritime emissions will more regularly be subsumed into broader strategic interventions such as carbon pricing at both the national and multilateral levels and included more comprehensively in target setting. This will mean more scrutiny is placed on the sector and more accountability is required from its companies in terms of detailed transition plans rooted in proven technology.

[343] IEA, 'International Shipping'. Link

15.3 Road Freight

15.3.1 Current regulatory and policy landscape

The **Sustainable and Smart mobility strategy** of the European Union provides a framework for activating financial capital and developing regulatory mechanisms that reduce the dependence of transport, including road freight, on fossil fuels. Measures include the replacement of vehicles with electric alternatives, encouraging modal shifts by optimising existing connections and networks across different transport modes, and introducing mechanisms for internalising the cost of carbon based on a 'polluter-pays' mechanism.[344]

With the adoption of **low-carbon fuel standards** across numerous jurisdictions, new build vehicles that are either diesel-based or hybrid-electric are manufactured to a specific configuration of mechanical design and efficiency. Additionally, the market for retrofitting (the mechanical addition of new aerodynamic resistance reduction components and improvements on internal combustion engines) continues to grow substantially as a result of changing standards. This process also includes the availability of low-interest capital and tax subsidies for transitioning to low-carbon fuel vehicles.

The EU launched the **CO2 emissions standard** for heavy duty vehicles as a supportive legislation to define standards around zero emission heavy duty vehicles and define targets on sufficient emissions reduction, specifically, a 15% and 30% emission reduction for heavy duty vehicle manufacturers by 2025 and 2030 respectively.

In the UK, a **complete phase out of vehicles with internal combustion engines** by 2035 is in place with a 22% target for zero emission vehicle sales in 2024, slowly increasing to 100% by 2035. These targets impact both freight and commercial use vehicles and are being replicated around the world.

15.3.2 Future looking policies, regulations and incentives

Regulatory uncertainty: Most alternative fuels have some regulatory support, but there are gaps in regulations, especially for less mature fuels. Given current infrastructure and economic challenges, regulatory incentives are required to support organisations to invest in and adopt these fuels. This has proven successful, for example where subsidies in the passenger car market have incentivised consumers to switch from internal ICEs to EVs in some markets. Technical operating parameters and methods also need to be standardised and adopted by countries and OEMs to enable manufacture at scale and its deployment. With uncertainty around which technologies and pathways will be supported and to what degree, the regulatory environment is an area that should be carefully considered before investing.

Regulatory scale-up: With plans for bans on the sale of ICE passenger vehicles proposed across the world, governments are extending these to cover HGVs. In the absence of full bans, emissions standards are also being employed.

[344] European Energy Agency (EEA), Transport and environment report 2021 (pg. 30 to 45), Link

Scaling low carbon infrastructure: A key determinant of the success of low carbon trucks is the rollout of supporting infrastructure. While alternative fuels such as hydrogen may be able to utilise the existing refuelling network, major investment is needed to produce sufficient charging points, with potential requirements to upgrade distribution and transmission grids to meet demand. Doing so in the passenger vehicle space has proved challenging and is held back by, amongst other things, a lack of common standards and supporting grid infrastructure. Future incentives to encourage "off-shift" slow charging will improve the economics and operating cost of electric trucks in long-distance applications, along with securing bulk contracts for faster charging.[345]

Shift to rail: Given the difficulties in electrification in trucking, alongside the slow adoption of hydrogen and alternative fuels, there is much discussion about the potential role of rail in the decarbonisation of land freight. It is estimated that each tonne of freight transported by rail produces 76% fewer carbon emissions than equivalent road transportation.[346] The UK government, for example, has pledged a 75% rail freight growth target by 2050, underpinned by the Mode Shift Revenue Support (MSRS) scheme which offers grants for transitioning to rail and water-based transport.[347],[348]

Decarbonisation challenges due to long asset life: The average lifespan of an ICE truck is well over 10 years. After initial use in a developed economy, there is a risk that assets find their way to less developed regions, particularly Sub-Saharan Africa, without the same restrictions on emissions. This risks undermining the emissions reduction potential of any proposed bans.[349]

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345 IEA, "Global EV Outlook 2023, Trends in Charging Infrastructure". Link
346 Hawsons, 'Could there be a modal shift from road to rail to decarbonise freight'. Link
347 Gov UK, 'Rail freight growth target'. Link
348 Gov UK, 'Mode Shift Revenue Support and Waterborne Freight Grant applications: overview'. Link
349 The Economic Times, 'Used cars keep Africans moving, but dumping concerns remain'. Link

15.4 Mining

15.4.1 Current regulatory and policy landscape

Net Zero: Members of International Council on Mining and Metals committing to a goal of net zero Scope 1 and 2 GHG emissions by 2050 or sooner

The **International Council on Mining and Metals** has spearheaded the introduction of ESG within leading mining firms through a voluntary framework that aims to allow firms to disclose within regulatory regimes and track their decarbonisation progress, with members committing to Net Zero Scope 1 and 2 emissions by 2050.[350]

Similarly, the **Intergovernmental Forum of Mining, Minerals, Metals, and Sustainable Development** has produced a ‘Mining Policy Framework’ that helps member governments to develop mining laws and regulations that can enhance emission reduction and biodiversity protection.[351]

European Critical Raw Materials Act (CRMA): The general objective of CRMA, which entered into force on 23 May 2024, is to ensure the EU’s access to a secure and sustainable supply of 34 critical raw materials (raw materials that are both important economically and present a high supply risk, of which 17 are strategic raw materials) by pursuing four specific objectives: To strengthen the EU’s capacities along the different stages of the value chain; to diversify the EU’s imports of raw materials; to improve monitoring and risk mitigation capacities and; to ensure a well-functioning single market while improving the sustainability and circularity of critical raw materials.

Emissions Trading Schemes and Carbon Border Adjustment Mechanisms (CBAMs) such as the EU’s proposed regulation which is due to come fully into force in 2027, impact certain carbon intensive raw materials and electricity which may impact the demand and price of minerals extracted through carbon intensive processes.

The **EU Green Deal** includes a wide variety of measures including on waste, battery recycling, and the circular economy, which will impact demand and sustainability measures in the mining sector.

In the UK, the **Environmental Permitting Regulation** requires mining firms to obtain a series of life cycle assessments and environmental impact assessments around the mining activities carried out (crushing/grinding materials, excavation, pollutant discharge). This places a significant emphasis on appropriate due diligence in the mining value chain as well.[352]

350 International Council on Mining and Metals (ICMM), Link
351 IGF Mining Policy Framework - Intergovernmental Forum
352 Government of UK, The Environmental Permitting (England and Wales) Regulations 2016, Link

15.4.2 Future looking policies, regulations and incentives

Cross-jurisdictional impact of carbon border adjustments: Countries such as the UK and the US are considering following the EU's lead and introducing carbon border adjustment mechanisms (CBAMs).[353],[354] This will have implications for global supply chains, with mining particularly impacted as a high emitting industry that is often located outside of the direct jurisdictional control of regimes with strict emissions targets. Mining companies across the world will be incentivised to decarbonise their operations in order to avoid being subject to tariffs that will reduce their competitiveness.

Social-related policy measures: As ESG issues receive increasing attention, the mining sector attracts particular scrutiny due to its historically poor record on equality and human rights, and the policy landscape develops accordingly. The EU's Corporate Sustainability Due Diligence Directive (CSDDD), for example, will place demands on accounting for environmental and human rights impacts in the value chain, while the emerging Taskforce on Inequality and Social-related Financial Disclosures (TISFD) will require comprehensive disclosures on social related risks akin to similar climate and nature related regulation.[355,356] This disclosure is intended to drive action to reduce negative social impacts through increased investment and safeguards, as companies look to attract funding.

Circularity mandates will influence demand: The future growth of the mining sector, already shaped by the changing energy mix and growing demand for renewable energy components, will be heavily influenced by the requirement for and/or development of circular technologies within the renewable energy sector, particularly in terms of lithium-ion batteries. If circular technology becomes commonplace, the demand for mined materials will fall.

Taskforce on Nature-Related Financial Disclosures: Market led disclosures that will drive progress across nature and biodiversity issues which may impact mining operations and location choices.

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353 Gov UK, 'Introduction of a UK carbon border adjustment mechanism from January 2027'. Link
354 Joint Economic Committee. Link
355 European Council of the European Union, 'Corporate sustainability due diligence: Council gives its final approval'. Link
356 TISFD. Link

15.5 Oil & Gas

15.5.1 Current regulatory and policy landscape

The regulatory and policy landscape is rapidly evolving to control carbon emissions in line with the requirements of the Paris Agreement, impacting the oil and gas sector.

COP28 saw commitments around “Transitioning away from fossil fuels in energy systems, in a just, orderly and equitable manner, accelerating action in this critical decade, so as to achieve net zero by 2050 in keeping with the science”. Discussions around ‘phase down’ versus ‘phase out’ of fossil fuels are expected to continue in successive COP conferences in line with the requirement to ensure that approximately 90% of remaining coal reserves, and approximately 60% of oil reserves untapped in order to ensure the attainment of a 1.5°C scenario, with a 50% probability.[357]

Reporting:

- Disclosure regimes such as the Taskforce for Climate Related Financial Disclosures, the EU Corporate Sustainability Reporting Directive and the International Sustainability Standards Board mandate reporting on emissions, intensities and targets that impact oil and gas companies.
  - The United Nations Environment Programme’s flagship oil and gas reporting and mitigation programme **The Oil & Gas Methane Partnership 2.0 (OGMP),** which has been joined over by 130 companies across the world is a comprehensive, measurement-based reporting framework for the oil and gas industry that improves the accuracy and transparency of methane emissions reporting.[358]
  - The US Government, under its Methane emissions reduction action plan launched the **Protecting the Infrastructure of Pipelines and Enhancing Safety Act (PIPES Act) of 2020**, which aims to establish advanced leak detection programs for detecting and repairing all gas leaks by adopting the latest technology to minimize the gas released into the atmosphere.[359]

Carbon Pricing & Emissions Trading Schemes:

- The European Union Emissions Trading Scheme (ETS) is a cap-and-trade system that puts a market prices on the GHG emissions from certain industries and puts a cap on the GHG emissions that companies within that sector may emit; this incentivises decarbonisation away from energy intensive inputs, and requires operators of installations that are subject to the scheme, which include combustion installations with a rated thermal input exceeding 20 MW and mineral oil refineries which emit CO2 (offshore oil and gas facilities that produce their own power are included within these categories if they are sufficiently large, as well as processing plants both onshore and offshore that are below this threshold) to reduce their emissions.
- The EU Carbon Border Adjustment Mechanism CBAM imposes a charge on the embedded carbon content of certain imports that is equal to the charge imposed on domestic goods under the ETS, encouraging cross-border decarbonisation of processes and activities, potentially impacting the demand for oil and gas products.

[357] Nature, ‘Unextractable fossil fuels in a 1.5 °C world’, Link
[358] Oil & Gas Methane Partnership 2.0 (OGMP 2.0), Link
[359] AGA Summary of 2020 PIPES Act, Link

- The Government of Canada has released the proposed **Regulatory Framework of a National cap-and-trade system** to help reduce greenhouse gas (GHG) emissions in the oil and gas sector by establishing an emissions cap with specified limits between 2026-2030 and imposing an upper legal bound on GHG emissions to achieve the goal of net-zero emissions by 2050.[360]

Incentives:

- The US Inflation Reduction Act (IRA) of 2022 allocated USD 370 bn for clean energy and transition to a low carbon economy. It will incentivise the US oil majors to adopt electrification, carbon capture, low carbon fuels, and advanced technologies for emissions reductions. IRA also provides hydrogen and hydrogen-related provisions, such as support for carbon storage

Operational decarbonisation and flaring:

- The **Oil and Gas Climate Initiative (OGCI)** is an initiative led by CEOs of member companies to bring down emissions to net zero in alignment with the Paris Agreement and accelerate energy transition using climate investment funds. It aims at reducing upstream methane emissions intensity to well below 0.20% by 2025 and bringing routine flaring to zero by 2030.[361]
- During COP 28, the **Oil and Gas Decarbonisation Charter (OGDC)** was introduced as a global industry initiative aimed at accelerating climate action in the oil and gas sectors. Currently, the OGDC has been signed by 50 companies including a number of major players, collectively representing more than 40% of global oil production. Companies that have signed up to the Charter have committed to the following:
  - Achieving near zero upstream methane emissions by 2030
  - Ending routing flaring by 2030
  - Achieving full Scope 1 and 2 decarbonisation by 2050
  - Increasing transparency including enhancing measurement, monitoring, reporting and independent verification of GHG emissions.[362]
- **The Global Methane Pledge**[363] was launched at COP26, and as of 2024 has 158 participants. The pledge targets a global reduction of at least 30% from 2020 levels by 2030. The initiative is focusing on the Energy Pathway, the Waste Pathway, the Food and Agriculture Pathway, Methane Plans and Policies, Data for Methane Action, and Finance for Methane Abatement
- **Global Gas Flaring Reduction Partnership (GGFR)** led by IPIECA and World Bank, is a public-private initiative which supports the efforts of oil producing countries and companies to reduce flaring and venting by making use of gas produced as a by-product.[364]
- The **China Oil and Methane Gas Alliance** has been established to control methane emissions across the entire industry chain and take practical measures to push for the low-carbon transformation of energy.[365]

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[360] Economic Impacts of a Greenhouse Gas Emissions Cap on the Oil and Gas Sector, Link
[361] Oil and Gas Climate Initiative (OGCI), Link
[362] Conference of the Parties 28 (COP28), Oil & Gas Decarbonisation Charter launched to accelerate climate action, Link
[363] Global Methane Pledge, Pledge document Link
[364] Global Flaring and Methane Reduction Partnership (GFMR), Link
[365] China National Petroleum Corporation (CNPC), China Oil and Gas Methane Alliance, Link

15.5.2 Future looking policies, regulations and incentives

NDCs impacting the phase-down of Oil and Gas: Successive Conference of the Parties (COPs) have been dominated by debates surrounding the ambition of Nationally Determined Contributions (NDCs) to emissions reduction, and the associated degree of phase-down or phase-out of fossil fuels. Commitments made at COP28 to “transition away from fossil fuels in energy systems” are likely to be the focus of continued debate, and as the impacts of climate change become increasingly tangible, it is likely that language around phasing down or out fossil fuels, in line with what the UN terms ‘the beginning of the end’ of the fossil fuel era, will be translated to country NDCs with implications for domestic decarbonisation strategies.[366]

Coordination and policy responses to accelerate the retirement of oil and gas, and coal power plants: There are currently initiatives in place to finance the early retirement of coal power plants[367]. Growing pressure to decarbonise and phase out coal and oil could see a scale up of these initiatives aiming to address the financial incentives to keep fossil fuel plants in operation (e.g. public-private funding agreements), in particular in emerging markets and developing economies.

Potential exogenous political shocks shaping demand: Political events such as the Russian invasion of Ukraine or the cost-of-living crisis can impact demand for oil and gas. As countries aim to increase their energy security, as well as find cheap alternative sources of energy, they are turning to renewables on the one hand and re-opening coal fields on the other. With geopolitical relations becoming increasingly strained, and the prospect of climate-change-induced pressure on resources, such shifts could become increasingly common.

Social-related policy measures: Heavy industries with significant social impacts such as mining and oil and gas will come under increasing scrutiny with the introduction of disclosure regimes such as the EU Corporate Sustainability Due Diligence Directive (CSDDD), The Taskforce on Inequality and Social-related Financial Disclosures (TISFD), and associated policy measures to uphold equality and human rights.

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[366] UNFCCC, COP28 ‘Agreement Signals the Beginning of the End of the Fossil Fuel Era’ Link

[367] See Asian Development Bank Energy Transition Mechanism, Link

15.6 Power Generation and Distribution

15.6.1 Current regulatory and policy landscape

During COP28, G20 leaders announced a target to triple the global capacity of renewable generation by 2030. The target also addresses other zero and low emissions technologies for abatement and removals. Targets were also set for doubling the global average rate of energy efficiency improvements to over 4% annually until 2030.[368]

Since power is a major source of global emissions, there are a number of targeted climate and energy policies and regulatory regimes to address power sector emissions, that are adopted across countries:

- **Nationally Determined Contributions (NDCs)**: As of November 2021, 182 countries had included renewable energy components in their NDCs under the Paris Agreement. 144 countries had a quantified target, of which 109 focus on power. [369] The targets outline either an installed capacity ambition or renewables share ambition. Renewable energy targets are typically followed by sub-national targets for states and provinces, and trigger key electricity market reforms to enable the growth of renewable capacity.
- **Coal phase out**: Coal is the most carbon intensive fossil fuel utilised in the power system and phasing it out is a key step to achieving grid decarbonisation and the economy-wide emissions reductions needed to limit global warming to 1.5°C. During COP26, over 190 countries agreed to phase out coal power and end support for new coal power plants.[370] Since coal power plants in Asia cease operations before the end of their useful life, innovative transition finance models are being explored through the Just Energy Transition Partnership (JETP) and Energy Transition Mechanism (ETM).[371,372]
- **Emissions Trading Schemes (ETS)**: The EU ETS is a cornerstone of the EU's climate policy and is the world's first major carbon market.[373] UK ETS replaced UK's participation in the EU ETS in 2021 and now includes the power generation sector.[374] The China ETS covers coal- and gas-fired power plants. Set to expand to seven other sectors, it will be the world's largest by far, covering a seventh of global CO_2 emissions from fossil fuel combustion.[375] Several jurisdictions already have experience with covering fossil fuel-fired power generators under a carbon pricing scheme. Applying ETS for the sector incentivizes investment in low carbon generation, the reduction of demand and the de-prioritisation of emissions intensive technologies in dispatch.[376]

368 United Nations Framework Convention on Climate Change (UNFCCC), Global Renewables and Energy Efficiency Pledge, Link
369 International Renewable Energy Agency (IRENA), Targets and NDCs, Link
370 United Nations Framework Convention on Climate Change (UNFCCC), End of Coal in Sight at COP26, Link
371 International Institute of Sustainable Development (IISD), Just Energy Transition Partnerships: An opportunity to leapfrog from coal to clean energy, Link
372 Asian Development Bank (ADB), Energy Transition Mechanism (ETM), Link
373 European Commission, EU Emissions Trading System (EU ETS), Link
374 Department for Business, Energy and Industrial Strategy (BEIS) and Department for Energy Security and Net Zero (DESNZ), Participating in the UK ETS, Link
375 International Energy Agency (IEA), China's Emissions Trading: Designing efficient allowance allocation, Link
376 International Energy Agency (IEA), Implementing Effective Emissions Trading Systems: ETS in power sector, Link

- **EU Green Deal:** The European Green Deal aims to drive the clean energy transition in Europe focusing on ensuring a secure and affordable EU energy supply, energy efficiency and developing a power sector based largely on renewable sources. To do this, it has set out regulation, policy and incentives to achieve a number of key power sector objectives including build interconnected energy systems and better integrated grids to support renewable energy sources, promote innovation, boost energy efficiency, decarbonise the gas sector and promote smart integration across sectors, and develop offshore wind energy.[377]
- **The US Inflation Reduction Act (IRA), 2022:** The act expands support for renewable energy generation and energy storage technologies through tax credits and other measures, and is expected to provide a significant boost to investments over the next 10 years.[378]
- **The EU Taxonomy** is a classification system for economic activities and the degree to which they can be considered environmentally sustainable, thus enabling investment towards such activities. Amidst some controversy, gas is included as a transition fuel towards a low carbon economy as it emits half the amount of CO2 of coal. Similarly, the expansion of nuclear power has faced opposition, but it is also included as a low carbon source of power under the taxonomy[379,380]
- **European Commission Electricity Grid Action Plan**: Proposed in November 2023, the Plan identifies actions to address challenges in expanding, digitalising and optimising EU transmission and distribution grids. The proposed actions include long-term planning, accelerating project implementation, regulatory incentives, improving access to finance, and faster permitting.[381]

15.6.2 Future looking policies, regulations and incentives

National renewable energy targets and strategies: The deployment of low-carbon power will be heavily influenced by regulation including carbon taxes, specific deployment targets or incentives assisting the scaling of renewables. The scaling of CBAM, emissions trading schemes and similar measures will reinforce the push to decarbonise energy supply and Scope 2 emissions in traded goods across jurisdictions.

The global influence of the US IRA: The USA Inflation Reduction Act has driven hundreds of billion dollars of investment in clean technologies across the USA and its success, built around tax breaks and other incentives, could influence the development of similar packages in Europe and other regions.[382] The European Green Deal, for example, aimed to mobilise €1 trillion in sustainable investment, which may be further scaled.[383]

The impact of planning regimes: The rollout of renewable energy systems is heavily governed by the planning, approval and connection process. This is currently slowing the take up of renewables, for example in the UK and the US where there has been particular friction around the planning process for onshore wind development. Challenges with the planning and approval processes could significantly curtail to the speed of development of renewable infrastructure, that may result in increased intervention from governments in the allocation across the development cycle, e.g. governments identifying sites for developers to bid into.[384]

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377 European Commission, Energy and the Green Deal, Link
378 US Department of Treasury, Fact Sheet: How the Inflation Reduction Act's Tax Incentives Are Ensuring All Americans Benefit from the Growth of the Clean Energy Economy, Link
379 Economist Intelligence Unit (EIU), Energy regulations to look out for, Link
380 European Parliament, Taxonomy: MEPs do not object to inclusion of gas and nuclear activities, Link
381 European Commission, Press release: Commission sets out actions to accelerate the roll-out of electricity grids, Link
382 TIME, 'How the Inflation Reduction Act Has Reshaped the US – and The World'. Link
383 Euro News, 'What does the future hold for the European Green Deal'. Link
384 House of Commons Library, 'Planning for onshore wind'. Link

Nature and biodiversity: National governments will develop policies to protect nature and biodiversity to meet the goals and targets of the global Kunming-Montreal Global Biodiversity Framework (GBF), There's an already existing increasing conflict between scaling renewable infrastructure and the goal of protecting land to meet biodiversity targets (in particular, GBF's Target 3 of protecting 30% of land, waters and seas by 2030). At the same time, recent research shows that while conflicts occur, these do not have to be too severe if renewables are deployed with appropriate regulatory controls[385]. Spatial analysis across multiple regions drives more optimal decisions. In particular to meet the goal of protecting 30% of land by 2030, governments will need to put in place clear regulations around where, and how, to consider new developments. Site selection provides the greatest opportunity to avoid negative biodiversity impacts. Developing projects on existing sites or in areas of low-biodiversity-value such as brownfields, degraded lands and redevelopment areas can result in minimised impacts and better outcomes for biodiversity with less or the same amount of remediation and offsetting efforts. This is likely to be an ongoing focus of regulatory harmonisation.

Uncertain profitability: A number of factors are converging to leave some renewable energy projects struggling to turn a profit, as seen with Orsted's retraction from two New Jersey based offshore wind developments.[386] An often lengthy and costly planning process, hindered by the variety of stakeholders involved in each part of the power grid, contrasts with the low prices of renewable energy, while a lack of storage infrastructure or grid interconnection means that energy produced is often curtailed, an issue for both the viability of the grid to manage demand cycles but also for producers looking to make a profit. Finally, protectionist tariff increases could impact the security of current and predicted revenue streams, as has been seen with the EU on EVs and the US on solar, both targeting Chinese imports and risking potential retaliation.[387,388]

Sectoral convergence: As transport and energy are increasingly electrified, alongside broader industry developments including data and AI, focus will be placed on greening a growing electricity demand, and thus on improving demand side efficiency and coordination. This will also help to ensure the stability of rapidly growing power grids.

385 Does renewable energy threaten efforts to conserve biodiversity on land? - resilience
386 n a setback for wind industry, 2 large offshore projects are canceled in N.J. : NPR
387 The New York Times, 'European Union Hits EVs From China With Extra Tariffs Up to 38%'. Link
388 The New York Times, 'US Adds Tariffs to Shield Struggling Solar Industry'. Link

15.7 Construction

15.7.1 Current regulatory and policy landscape

There is a wide variety in construction policy frameworks and incentives globally. A key common area to promote and incentivise consistency among development projects is the presence of a national Green Building Council, with rating tools that address embodied carbon and life cycle assessment. As of 2023, 70 countries had Green Building Councils, with frameworks that include embodied carbon and lifecycle assessment, while eight countries had embodied carbon emissions limits in construction.[389]

- There are a number of global initiatives such as the **Leadership in Energy and Environmental Design (LEED)** certification, a globally recognised green building certification system developed by the US Green Building Council which addresses elements of climate-related construction regulation, such as energy efficiency, embodied carbon and broader sustainability practices; and the **Building Research Establishment Environmental Assessment Method (BREEAM)**, a green building certification scheme widely used in the EU and UK that addresses a range of sustainability factors.
- The European Union **Emissions Trading Scheme** affects construction by increasing the cost of carbon-intensive materials within the EU, and the **EU Carbon Border Adjustment Mechanism** (CBAM) imposes tariffs on imported iron and steel, cement and aluminium, driving decarbonisation of materials within the EU and across importing regions.[390]
- In the European Union, the **Construction Products Regulation** (CPR) will require manufacturers to declare the environmental performance of their products using Environmental Product Declarations (EPDs). This will help promote transparency and encourage the use of more sustainable materials for construction. The EU also aims to achieve a 55% reduction in greenhouse gas emissions from buildings by 2030.[391]
- **EU's Circular Economy Action Plan and European Green Deal**, it is supporting recycling through several initiatives including the Waste Framework Directive aims to ensure that construction and demolition waste is recycled in an environmentally sound way. It promotes waste prevention through smart design, extending lifetime of construction, recycle and improved planning on construction sites.[392]
- The **Green Building Rating System** (GRIHA) in India provides a framework for assessing the sustainability performance of buildings. India aims to achieve net-zero emissions for new buildings by 2050.[393]
- The **National Construction Code** (NCC) in Australia includes energy efficiency requirements for new buildings. These requirements are regularly updated to reflect the latest technologies and standards. Australia aims to achieve net zero emissions for new buildings by 2050.[394]
- The Netherlands has become the first country to implement mandatory requirements on embodied carbon in building regulations. Starting in 2018, new construction projects must adhere to a cap on whole life emissions. To receive approval, designers are required to assess and balance both operational and embodied emissions.[395]

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389 KPMG, Tackling embodied carbon within Australia's construction and infrastructure sector, 2023, Link
390 European Commission, Carbon Border Adjustment Mechanism, Link
391 EUR-Lex, Regulation on conditions for the marketing of construction products, Link
392 European Commission, Construction and demolition waste Link EUR-Lex, Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives Link
393 Green rating for integrated habitat assessment (GRIHA), Link
394 Government of Australia, National Construction Code (NCC), Link
395 Dutch Green Building Council, Whole life carbon, Link

- The European Union **Energy Performance of Buildings Directive (EPBD)** contains a number of energy efficiency measures, to promote the improvement of the energy performance of new and old buildings across the EU. It lays down a framework for calculating the integrated energy performance of buildings, energy certification of buildings, and inspection of heating and cooling systems in buildings. In 2024, revisions to the EPBD to boost energy performance of buildings entered into force include:
- All new buildings should be zero emission buildings by 2030 and the existing building stock should also be transformed into zero emission buildings by 2050.[396]
- The non-residential buildings must also be improved via minimum energy performance standards, leading to renovating the 16% worst-performing buildings by 2030 and up to 26% of the worst-performing ones by 2033.
- The EU aims to reduce the average primary energy use of residential buildings by 16% by 2030 and up to 22% by 2035, with each Member State having its own national trajectory and flexibility to choose the buildings and measures.
- The national measures must ensure that more than half of the energy savings (55%) come from renovating the worst-performing residential buildings.
- An Energy Performance Certificate (EPC) is required to confirm that these standards are met. The EU has a unified format and guidelines proposed for better EPCs, which will help people understand and compare energy efficiency across the EU.[397]

15.7.2 Future looking policies, regulations and incentives

Carbon policies and tariffs resulting in material substitution: Carbon pricing and CBAM will increase relative prices of emissions intensive inputs and fuels, providing long term impetus for materials substitution and the use of alternative fuels in construction (e.g. timber, and recycled raw material e.g. renewed steel).

Climate risk disclosures: Construction and real estate are heavily exposed to physical climate risk, particularly flooding and extreme heat, and emerging disclosure regimes will require the inclusion of adaptation measures taken to identify and reduce these risks. Similarly, disclosures will require the documentation of measures taken to reduce transition risk through switching to low carbon or more efficient alternatives.

Embodied carbon: Embodied carbon (the emissions produced during the whole lifecycle of a building and thus considered locked into its physical structure) is likely to become an increasing focus, the reduction of which will be incentivised by standards, government procurement and potentially mandatory requirements. There may also be a shift to focus on renovation rather than demolition and construction, even where the new building is considered green.

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396 In focus: Energy efficiency in buildings - European Commission (europa.eu)
397 New rules to boost energy performance of buildings (europa.eu)

15.8 Commercial Real Estate

15.8.1 Current regulatory and policy landscape

The global regulatory and policy landscape for buildings is mixed, with many countries with minimal regulation addressing building emissions or sustainability, and other regions, notably the European Union, that have clear approaches and defined programmes compatible with the Paris Agreement.

Building performance standards have been implemented in various countries, including the United States (specifically Washington DC and Nevada), and the United Kingdom. Notably, it is now illegal to lease properties in England and Wales that do not meet the mandated minimum levels of energy performance. Similarly, California's building energy codes aim to reduce energy consumption for new buildings by 80%.

The European Union Energy Performance of Buildings Directive mandates zero emission standards for new public buildings by 2028, and all new buildings by 2030, and addresses the complete phase out of fossil fuel boilers by among 2040, and mandates reporting on the Global Warming Potential for new buildings by 2030, among other elements.[398]

There has been legislation to **incentivize building electrification** such as the US Inflation Reduction Act of 2020, that enhance tax credits for commercial buildings that have improved energy efficiency. Germany's Renewable Energy Sources Act (EEG) is another such example.

There is a growing consensus that buildings should be subject to **emission trading mechanisms**, which would require buildings worldwide, likely starting with Europe, to pay a price for their emissions. Similarly, Tokyo's cap-and-trade mechanism makes it mandatory for buildings to participate in the city's emissions trading system.[399]

As of 2023, there are 77 national buildings adopted codes for non-residential buildings, of which the majority are mandatory.[400] Governments and organisations are supporting **green building certification programs**, such as LEED (Leadership in Energy and Environmental Design), WELL (International WELL Building Institute), and BREEAM (Building Research Establishment Environmental Assessment Method), that provide guidelines and criteria for assessing and certifying the energy efficiency of buildings. These programmes directly encourage developers to adopt sustainable building practices.

Additionally, real estate developers are **committing to global alliances** such as The Net Zero Carbon Building Commitment and The Zero-Carbon Building Accelerator (ZCBA) to speed up the global transition to efficient zero carbon buildings by 2050. [401]

398 United Nations Environment Programme Finance Initiative (UNEPFI), Global status report buildings construction 2023 (pg. 31), Link
399 European council for an energy efficient economy (ECEEE), EU to apply CO_2 emissions trading to buildings and transport, Link
400 United Nations Environment Programme Finance Initiative (UNEPFI), Global status report buildings construction 2023 (pg. 35), Link
401 World Green Building Council, The net zero carbon buildings commitment, Link

15.8.2 Future looking policies, regulations and incentives

Drivers of green new buildings: The development of increasingly stringent building standards and codes for new buildings will remain a significant driver of decarbonisation efforts, as will the growth of corporate net zero targets, of which buildings are a major component.

Climate risk disclosures: Construction and real estate are heavily exposed to physical climate risk, particularly flooding and extreme heat, and emerging disclosure regimes will require the inclusion of adaptation measures taken to identify and reduce these risks.

Existing stock decarbonisation: For existing commercial building stock, decarbonisation will be facilitated by the expansion of regulation around performance rating, disclosure and minimum standards, which is likely to expand to different building types and sizes over time.

Buildings as facilitators: Real estate is a key building block of an electrifying society and it is likely that emerging regulations will contain requirements around facilitating electrification, from low carbon heating to EV charging and behind the meter renewables that can support grid capacity, flexibility and functionality.

Aviation | Marine | Road Freight | Mining | Construction | Commercial Real Estate

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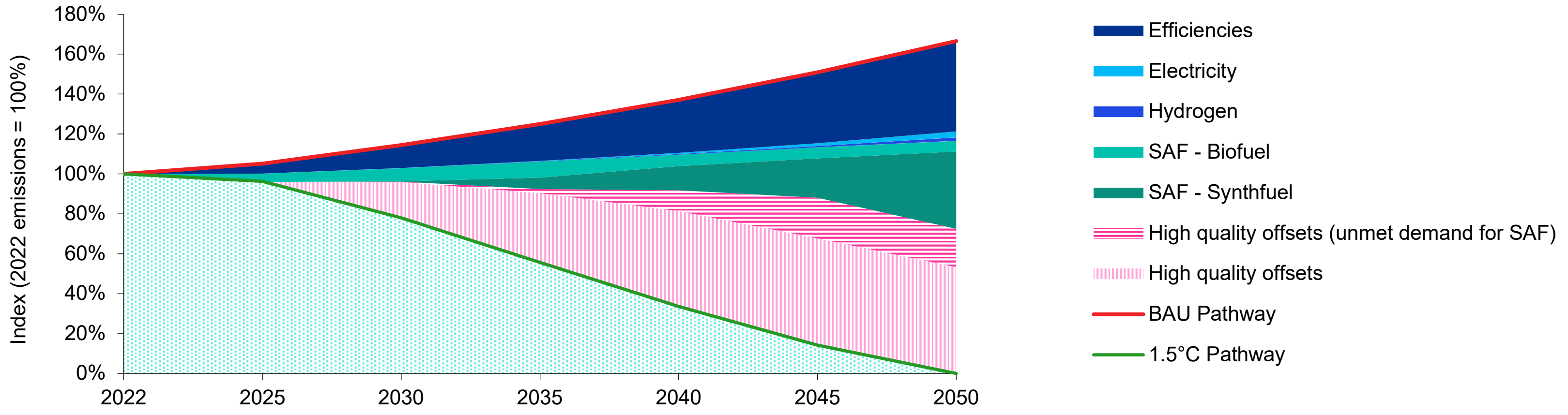
Potential Aviation sector decarbonisation pathway (2022-2050)



Aviation		2050					
Portfolio Segmentation	Assumed mix of business	Abatement activities					
		Electricity	Hydrogen	SAF - Biofuel	SAF - Synthfuel	Unabated / No Change	Efficiencies
Abatement (% CO2)		2%	1%	3%	23%	44%	27%
Aviation Hull - aircraft fuel							
Widebody	25%	0%	0%	1%	8%	15%	
Narrowbody	65%	1%	1%	3%	22%	38%	
Regional	5%	0%	0%	0%	1%	4%	
Turboprop	5%	1%	0%	0%	1%	3%	
Total	**100%**	**2%**	**1%**	**4%**	**32%**	**60%**	

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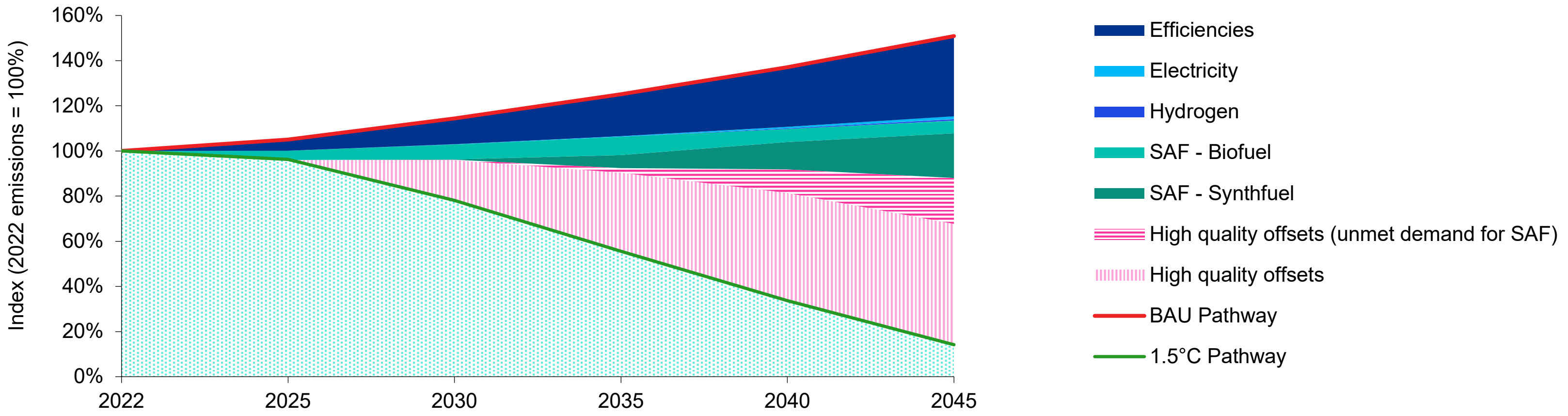
2050
2045
2040
2035
2030
2025

Potential Aviation sector decarbonisation pathway (2022-2045)



Aviation		2045					
		Abatement activities					
Portfolio Segmentation	Assumed mix of business	Electricity	Hydrogen	SAF - Biofuel	SAF - Synthfuel	Unabated / No Change	Efficiencies
Abatement (% CO2)		1%	0%	4%	14%	54%	26%
Aviation Hull - aircraft fuel							
Widebody	25%	0%	0%	1%	5%	18%	
Narrowbody	65%	1%	0%	4%	13%	47%	
Regional	5%	0%	0%	0%	1%	4%	
Turboprop	5%	0%	0%	0%	1%	4%	
Total	**100%**	**1%**	**1%**	**6%**	**20%**	**73%**	

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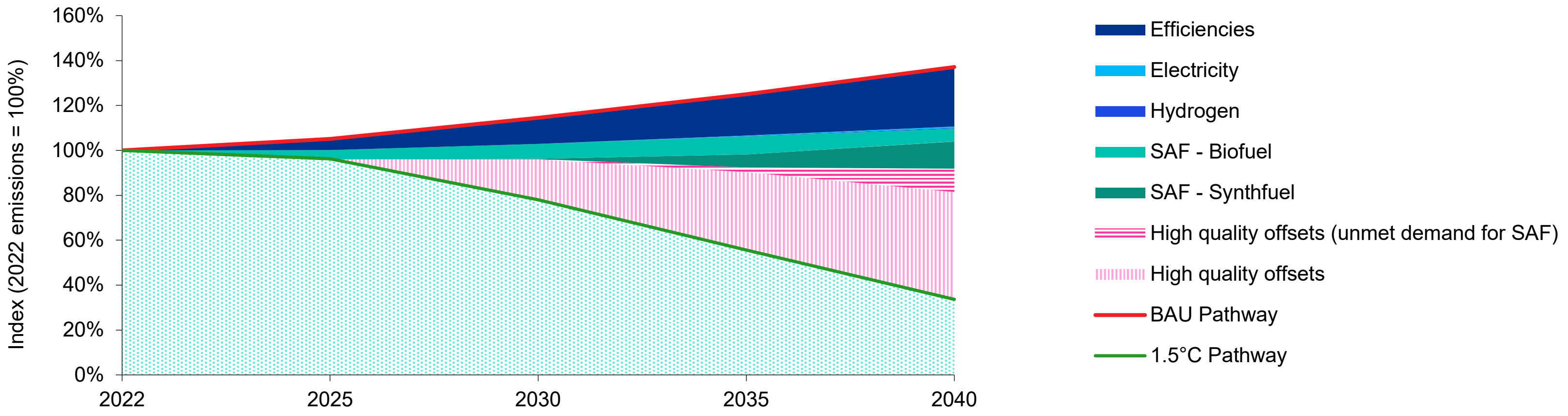
Potential Aviation sector decarbonisation pathway (2022-2040)



Aviation		2040					
		Abatement activities					
Portfolio Segmentation	Assumed mix of business	Electricity	Hydrogen	SAF - Biofuel	SAF - Synthfuel	Unabated / No Change	Efficiencies
Abatement (% CO2)		1%	0%	6%	12%	56%	26%
Aviation Hull - aircraft fuel							
Widebody	25%	0%	0%	2%	4%	19%	
Narrowbody	65%	1%	0%	5%	11%	49%	
Regional	5%	0%	0%	0%	0%	4%	
Turboprop	5%	0%	0%	0%	0%	4%	
Total	**100%**	**1%**	**0%**	**7%**	**16%**	**76%**	

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2050
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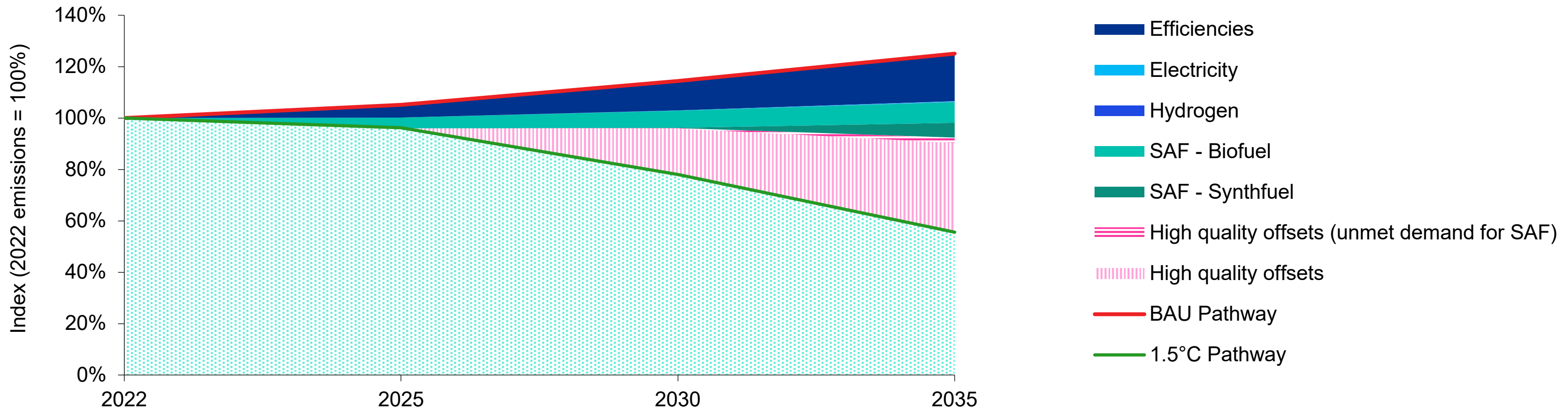
Potential Aviation sector decarbonisation pathway (2022-2035)



Aviation		2035					
Portfolio Segmentation	Assumed mix of business	Abatement activities					
		Electricity	Hydrogen	SAF - Biofuel	SAF - Synthfuel	Unabated / No Change	Efficiencies
Abatement (% CO2)		**0%**	**0%**	**12%**	**8%**	**53%**	**27%**
Aviation Hull - aircraft fuel							
Widebody	25%	0%	0%	4%	3%	18%	
Narrowbody	65%	0%	0%	11%	8%	46%	
Regional	5%	0%	0%	0%	0%	4%	
Turboprop	5%	0%	0%	0%	0%	4%	
Total	**100%**	**1%**	**0%**	**16%**	**11%**	**72%**	

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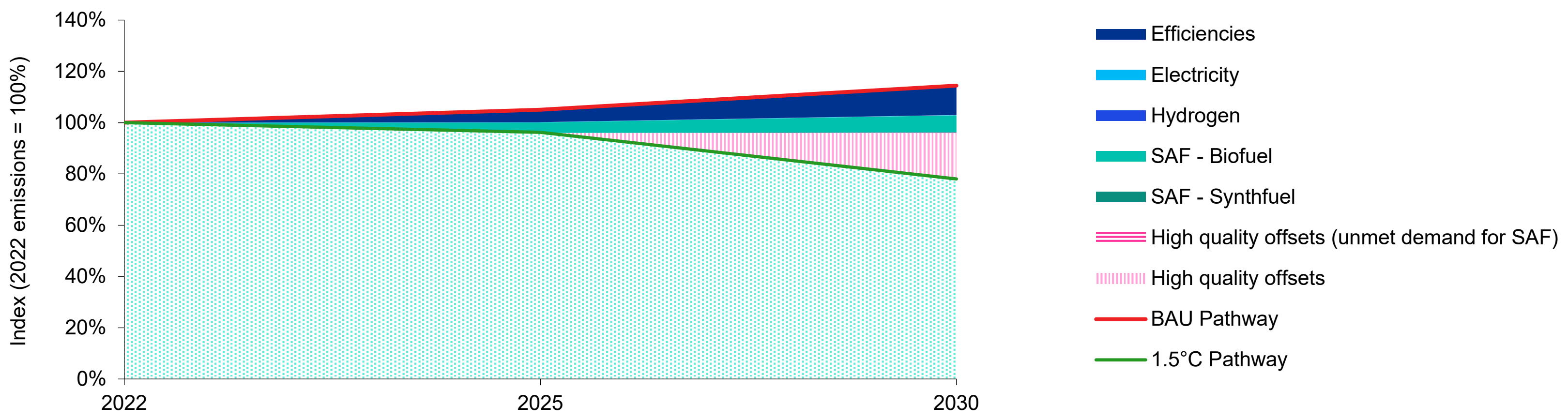
Potential Aviation sector decarbonisation pathway (2022-2030)



Aviation		2030					
		Abatement activities					
Portfolio Segmentation	Assumed mix of business	Electricity	Hydrogen	SAF - Biofuel	SAF - Synthfuel	Unabated / No Change	Efficiencies
Abatement (% CO2)		**0%**	**0%**	**18%**	**1%**	**50%**	**32%**
Aviation Hull - aircraft fuel							
Widebody	25%	0%	0%	7%	0%	18%	
Narrowbody	65%	0%	0%	18%	1%	46%	
Regional	5%	0%	0%	1%	0%	4%	
Turboprop	5%	0%	0%	1%	0%	4%	
Total	**100%**	**0%**	**0%**	**26%**	**1%**	**72%**	

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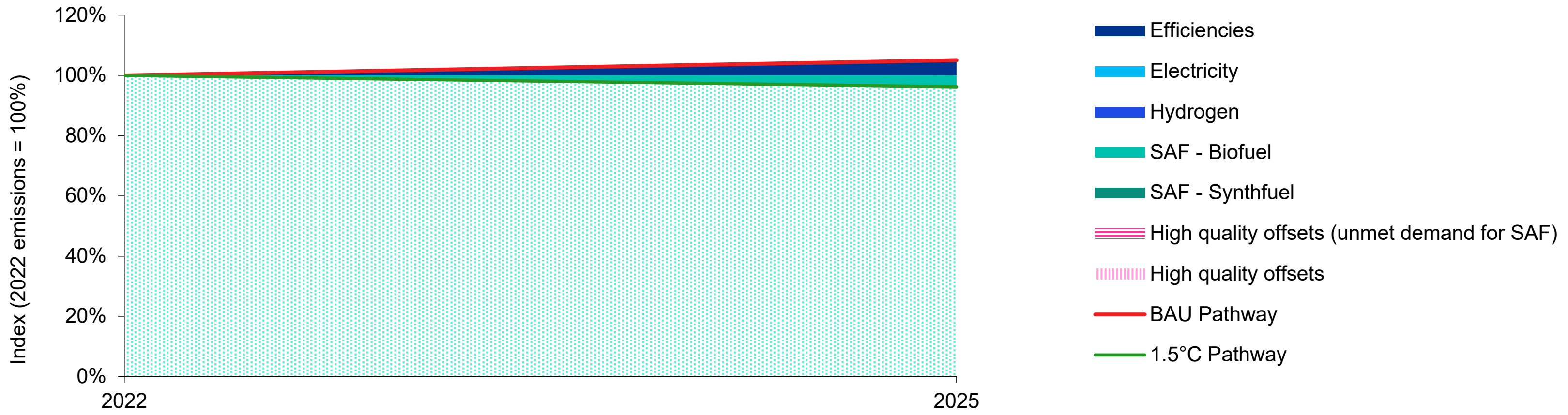
Potential Aviation sector decarbonisation pathway (2022-2025)



Aviation		2025					
		Abatement activities					
Portfolio Segmentation	Assumed mix of business	Electricity	Hydrogen	SAF - Biofuel	SAF - Synthfuel	Unabated / No Change	Efficiencies
Abatement (% CO2)		**0%**	**0%**	**46%**	**0%**	**0%**	**54%**
Aviation Hull - aircraft fuel							
Widebody	25%	0%	0%	26%	0%	0%	
Narrowbody	65%	0%	0%	68%	0%	0%	
Regional	5%	0%	0%	3%	0%	0%	
Turboprop	5%	0%	0%	3%	0%	0%	
Total	**100%**	**0%**	**0%**	**100%**	**0%**	**0%**	

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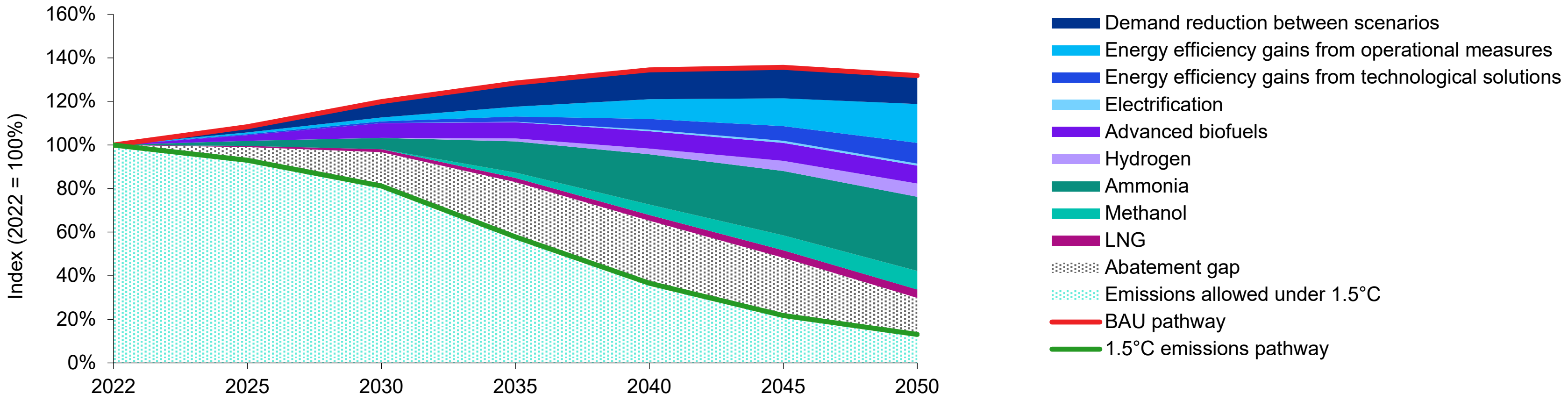
Potential Maritime sector decarbonisation pathway (2022-2050)



Marine		2050								
		Abatement activities								
Portfolio Segmentation	Assumed mix of business	LNG	Methanol	Ammonia	Hydrogen	Advanced biofuels	Electrification	Unabated / No Change	Energy efficiency gains from technological solutions	Energy efficiency gains from operational measures
Abatement (% CO2)		**3%**	**6%**	**26%**	**5%**	**6%**	**1%**	**33%**	**7%**	**14%**
Marine Hull - vessel fuel										
Container ship	35%	1%	3%	17%	3%	3%	1%	7%		
General Cargo ship	15%	1%	1%	7%	1%	1%	0%	4%		
Tankers	20%	1%	2%	1%	1%	2%	0%	14%		
Dry bulk carriers	15%	1%	1%	4%	1%	1%	0%	7%		
Multi purpose vessels	5%	0%	0%	1%	0%	0%	0%	2%		
Reefer ship	5%	0%	0%	1%	0%	0%	0%	2%		
Roll on / roll off vessels	5%	0%	0%	0%	0%	0%	0%	5%		
Total	**100%**	**4%**	**8%**	**32%**	**6%**	**8%**	**1%**	**41%**		

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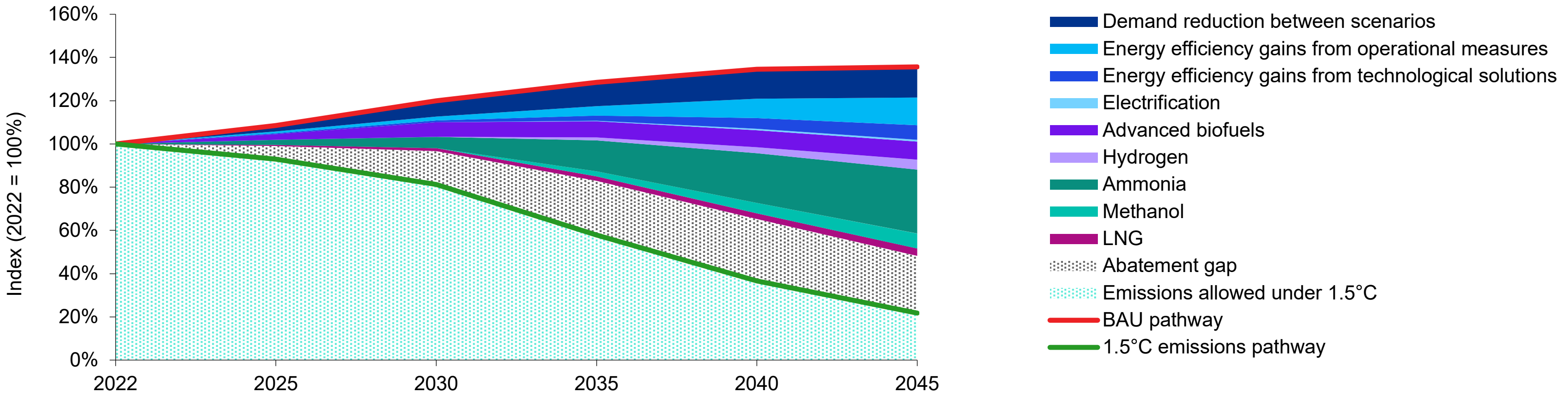
Potential Maritime sector decarbonisation pathway (2022-2045)



Marine		2045								
		Abatement activities								
Portfolio Segmentation	Assumed mix of business	LNG	Methanol	Ammonia	Hydrogen	Advanced biofuels	Electrification	Unabated / No Change	Energy efficiency gains from technological solutions	Energy efficiency gains from operational measures
Abatement (% CO2)		3%	5%	22%	3%	6%	1%	46%	5%	9%
Marine Hull - vessel fuel										
Container ship	35%	1%	2%	13%	2%	3%	1%	13%		
General Cargo ship	15%	0%	1%	6%	1%	1%	0%	6%		
Tankers	20%	1%	1%	1%	1%	1%	0%	15%		
Dry bulk carriers	15%	0%	1%	3%	1%	1%	0%	9%		
Multi purpose vessels	5%	0%	0%	1%	0%	0%	0%	3%		
Reefer ship	5%	0%	0%	1%	0%	0%	0%	3%		
Roll on / roll off vessels	5%	0%	0%	0%	0%	0%	0%	5%		
Total	**100%**	**3%**	**6%**	**25%**	**4%**	**7%**	**1%**	**54%**		

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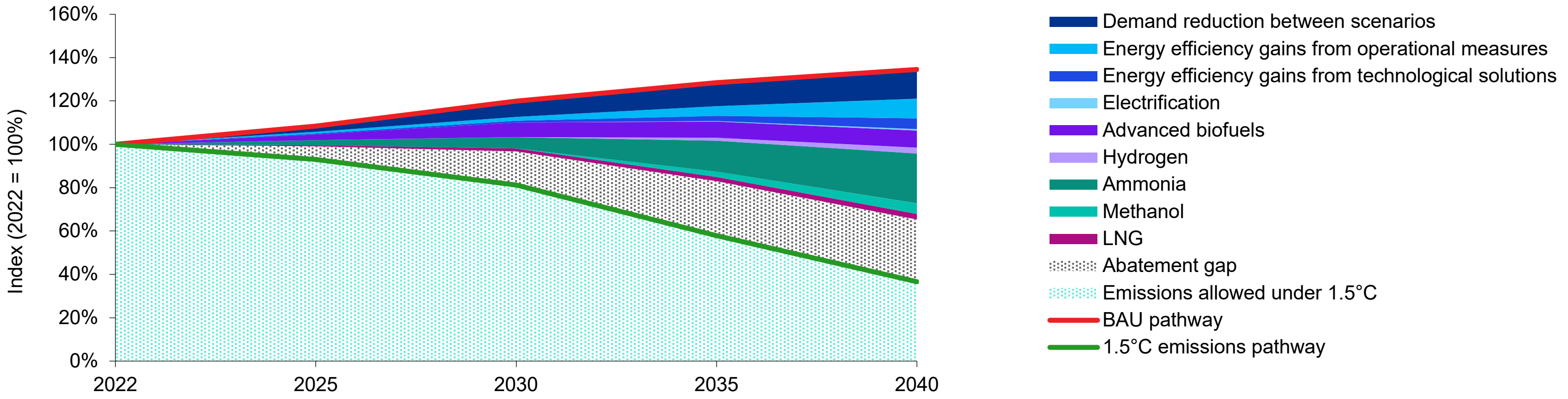
Potential Maritime sector decarbonisation pathway (2022-2040)



Marine		2040								
		Abatement activities								
Portfolio Segmentation	Assumed mix of business	LNG	Methanol	Ammonia	Hydrogen	Advanced biofuels	Electrification	Unabated / No Change	Energy efficiency gains from technological solutions	Energy efficiency gains from operational measures
Abatement (% CO2)		**2%**	**4%**	**17%**	**2%**	**6%**	**1%**	**59%**	**4%**	**7%**
Marine Hull - vessel fuel										
Container ship	35%	1%	1%	10%	1%	2%	1%	19%		
General Cargo ship	15%	0%	1%	4%	0%	1%	0%	8%		
Tankers	20%	0%	1%	0%	0%	1%	0%	17%		
Dry bulk carriers	15%	0%	1%	3%	0%	1%	0%	10%		
Multi purpose vessels	5%	0%	0%	1%	0%	0%	0%	3%		
Reefer ship	5%	0%	0%	1%	0%	0%	0%	3%		
Roll on / roll off vessels	5%	0%	0%	0%	0%	0%	0%	4%		
Total	**100%**	**2%**	**4%**	**19%**	**2%**	**7%**	**1%**	**65%**		

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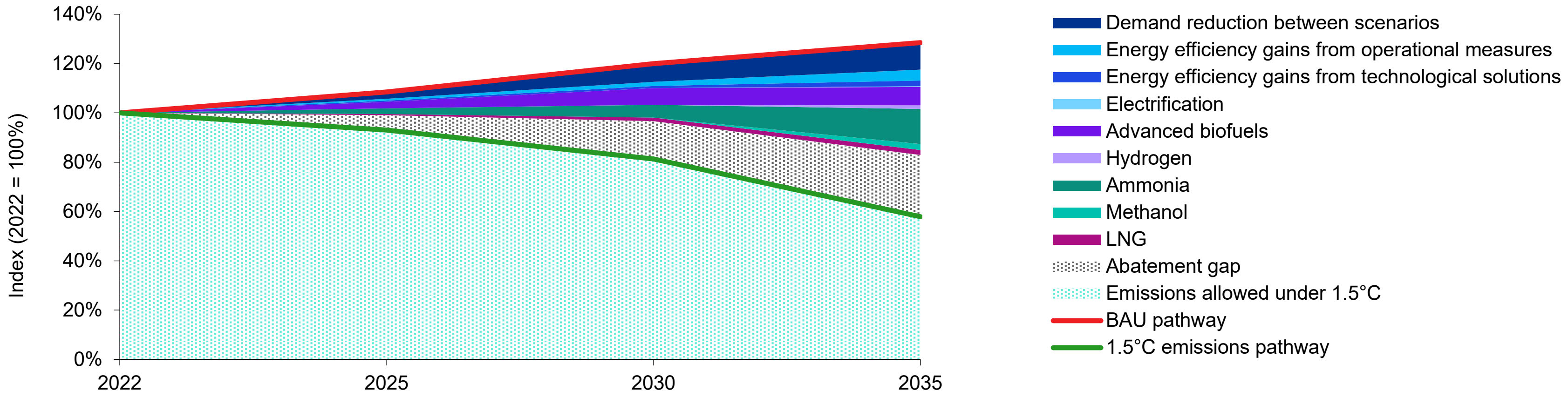
Potential Maritime sector decarbonisation pathway (2022-2035)



Marine		2035								
		Abatement activities								
Portfolio Segmentation	Assumed mix of business	LNG	Methanol	Ammonia	Hydrogen	Advanced biofuels	Electrification	Unabated / No Change	Energy efficiency gains from technological solutions	Energy efficiency gains from operational measures
Abatement (% CO2)		**2%**	**2%**	**11%**	**1%**	**6%**	**0%**	**73%**	**2%**	**3%**
Marine Hull - vessel fuel										
Container ship	35%	1%	1%	6%	0%	2%	0%	25%		
General Cargo ship	15%	0%	0%	3%	0%	1%	0%	11%		
Tankers	20%	0%	0%	0%	0%	1%	0%	18%		
Dry bulk carriers	15%	0%	0%	2%	0%	1%	0%	12%		
Multi purpose vessels	5%	0%	0%	1%	0%	0%	0%	4%		
Reefer ship	5%	0%	0%	1%	0%	0%	0%	4%		
Roll on / roll off vessels	5%	0%	0%	0%	0%	0%	0%	4%		
Total	**100%**	**2%**	**2%**	**12%**	**1%**	**6%**	**0%**	**77%**		

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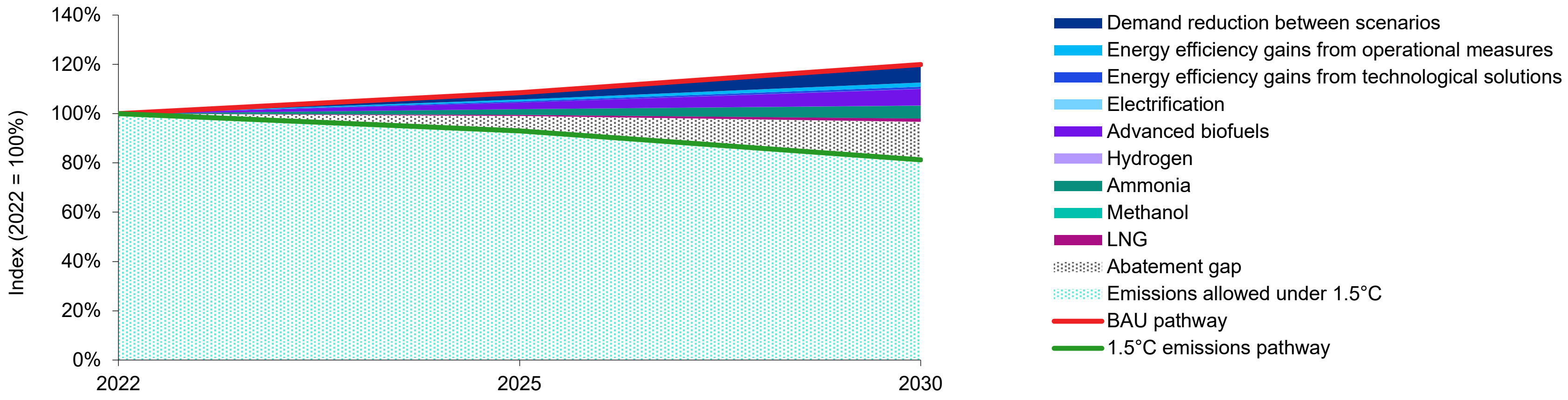
Potential Maritime sector decarbonisation pathway (2022-2030)



Marine		2030								
		Abatement activities								
Portfolio Segmentation	Assumed mix of business	LNG	Methanol	Ammonia	Hydrogen	Advanced biofuels	Electrification	Unabated / No Change	Energy efficiency gains from technological solutions	Energy efficiency gains from operational measures
Abatement (% CO2)		**1%**	**0%**	**4%**	**0%**	**6%**	**0%**	**87%**	**1%**	**1%**
Marine Hull - vessel fuel										
Container ship	35%	0%	0%	2%	0%	2%	0%	30%		
General Cargo ship	15%	0%	0%	1%	0%	1%	0%	13%		
Tankers	20%	0%	0%	0%	0%	1%	0%	19%		
Dry bulk carriers	15%	0%	0%	1%	0%	1%	0%	13%		
Multi purpose vessels	5%	0%	0%	0%	0%	0%	0%	4%		
Reefer ship	5%	0%	0%	0%	0%	0%	0%	4%		
Roll on / roll off vessels	5%	0%	0%	0%	0%	0%	0%	5%		
Total	**100%**	**1%**	**0%**	**4%**	**0%**	**6%**	**0%**	**89%**		

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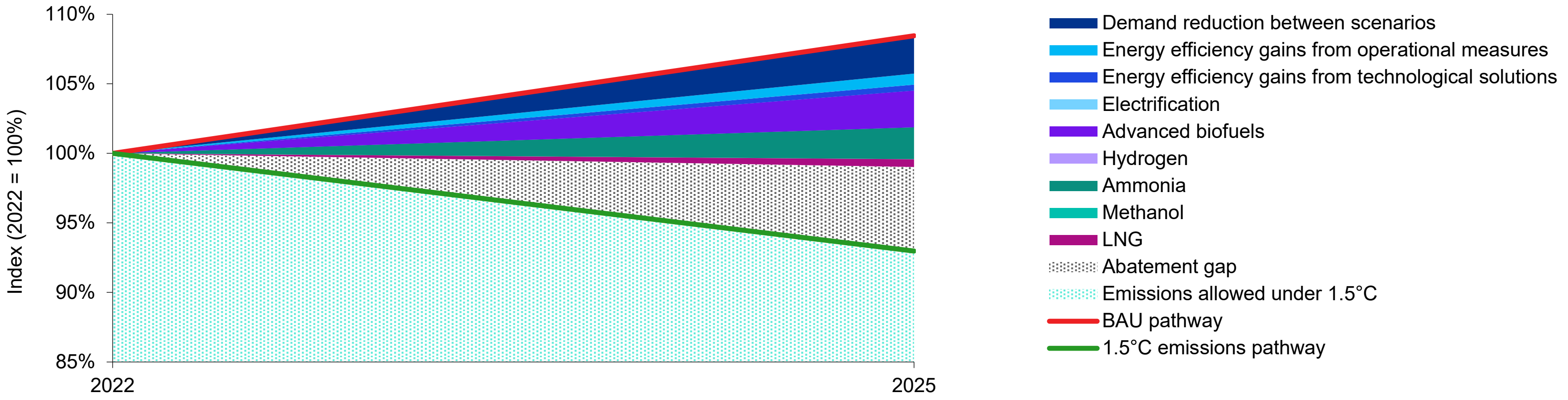
Potential Maritime sector decarbonisation pathway (2022-2025)



Marine		2025								
		Abatement activities								
Portfolio Segmentation	Assumed mix of business	LNG	Methanol	Ammonia	Hydrogen	Advanced biofuels	Electrification	Unabated / No Change	Energy efficiency gains from technological solutions	Energy efficiency gains from operational measures
Abatement (% CO2)		1%	0%	2%	0%	2%	0%	94%	0%	1%
Marine Hull - vessel fuel										
Container ship	35%	0%	0%	1%	0%	1%	0%	33%		
General Cargo ship	15%	0%	0%	0%	0%	0%	0%	14%		
Tankers	20%	0%	0%	0%	0%	0%	0%	19%		
Dry bulk carriers	15%	0%	0%	0%	0%	0%	0%	14%		
Multi purpose vessels	5%	0%	0%	0%	0%	0%	0%	5%		
Reefer ship	5%	0%	0%	0%	0%	0%	0%	5%		
Roll on / roll off vessels	5%	0%	0%	0%	0%	0%	0%	5%		
Total	**100%**	**1%**	**0%**	**2%**	**0%**	**2%**	**0%**	**95%**		

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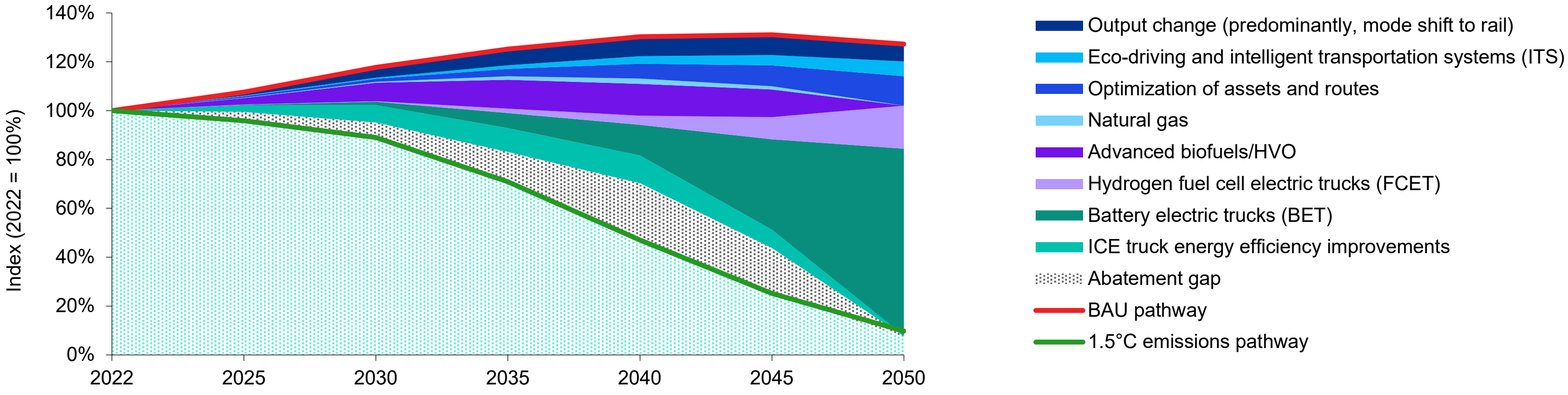
Potential Road Freight decarbonisation pathway (2022-2050)



Road freight		2050								
		Abatement activities								
Portfolio Segmentation	Assumed mix of business	Battery electric trucks	Hydrogen fuel cell electric trucks	Biofuels	Natural Gas	Output change (predominantly, mode shift to rail)	Unabated / No Change	ICE truck energy efficiency improvements	Optimisation of assets and routes	Eco-driving and intelligent transportation systems (ITS)
Abatement (% CO2)		**60%**	**14%**	**0%**	**0%**	**6%**	**6%**	**0%**	**9%**	**5%**
Small van	5%	5%	0%	0%	0%	0%	0%			
LWB and XLWB Vans	5%	5%	0%	0%	0%	0%	0%			
Articulated Lorry	40%	22%	10%	0%	0%	3%	5%			
Rigid lorry	25%	15%	6%	0%	0%	2%	2%			
Tanker lorry	25%	24%	0%	0%	0%	1%	0%			
Total	**100%**	**70%**	**16%**	**0%**	**0%**	**7%**	**7%**			

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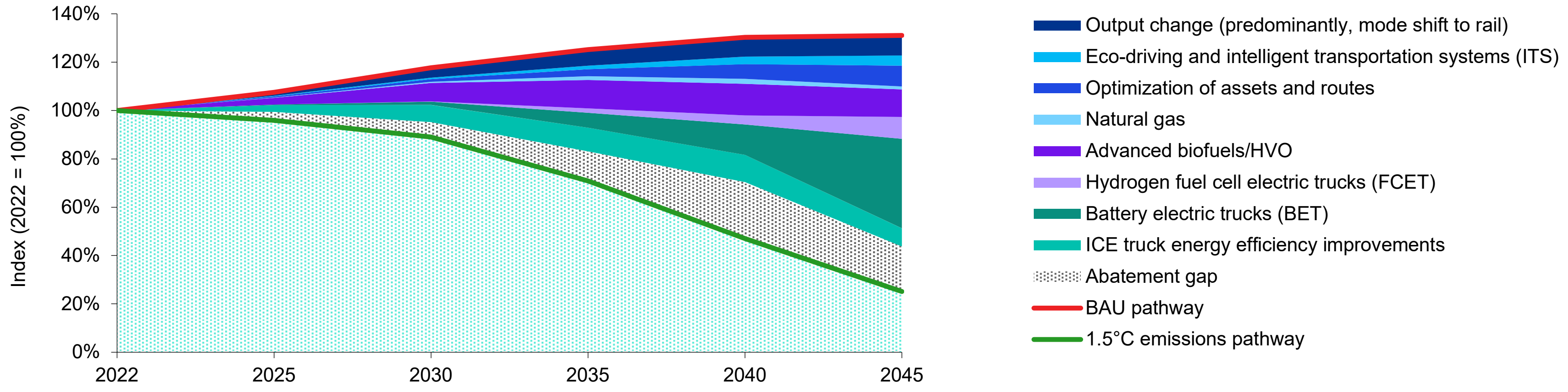
Potential Road Freight decarbonisation pathway (2022-2045)



Road freight		2045								
		Abatement activities								
Portfolio Segmentation	Assumed mix of business	Battery electric trucks	Hydrogen fuel cell electric trucks	Biofuels	Natural Gas	Output change (predominantly, mode shift to rail)	Unabated / No Change	ICE truck energy efficiency improvements	Optimisation of assets and routes	Eco-driving and intelligent transportation systems (ITS)
Abatement (% CO2)		28%	7%	9%	1%	6%	33%	6%	7%	3%
Small van	5%	1%	0%	1%	0%	0%	4%			
LWB and XLWB Vans	5%	1%	0%	1%	0%	0%	3%			
Articulated Lorry	40%	12%	5%	4%	0%	4%	15%			
Rigid lorry	25%	9%	3%	3%	0%	2%	8%			
Tanker lorry	25%	11%	0%	3%	0%	1%	10%			
Total	**100%**	**33%**	**8%**	**10%**	**1%**	**7%**	**40%**			

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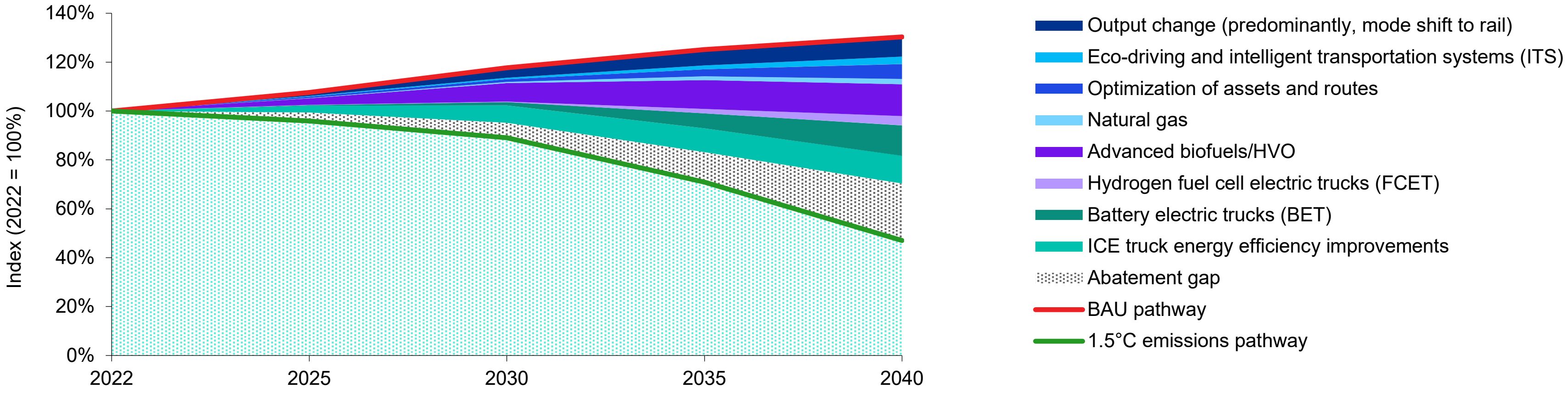
Potential Road Freight decarbonisation pathway (2022-2040)



Road freight		2040								
		Abatement activities								
Portfolio Segmentation	Assumed mix of business	Battery electric trucks	Hydrogen fuel cell electric trucks	Biofuels	Natural Gas	Output change (predominantly, mode shift to rail)	Unabated / No Change	ICE truck energy efficiency improvements	Optimisation of assets and routes	Eco-driving and intelligent transportation systems (ITS)
Abatement (% CO2)		**10%**	**3%**	**10%**	**2%**	**6%**	**54%**	**9%**	**5%**	**2%**
Small van	5%	1%	0%	1%	0%	0%	3%			
LWB and XLWB Vans	5%	1%	0%	1%	0%	0%	3%			
Articulated Lorry	40%	3%	2%	5%	1%	4%	26%			
Rigid lorry	25%	2%	1%	3%	0%	2%	16%			
Tanker lorry	25%	4%	0%	3%	0%	1%	17%			
Total	**100%**	**11%**	**3%**	**12%**	**2%**	**7%**	**64%**			

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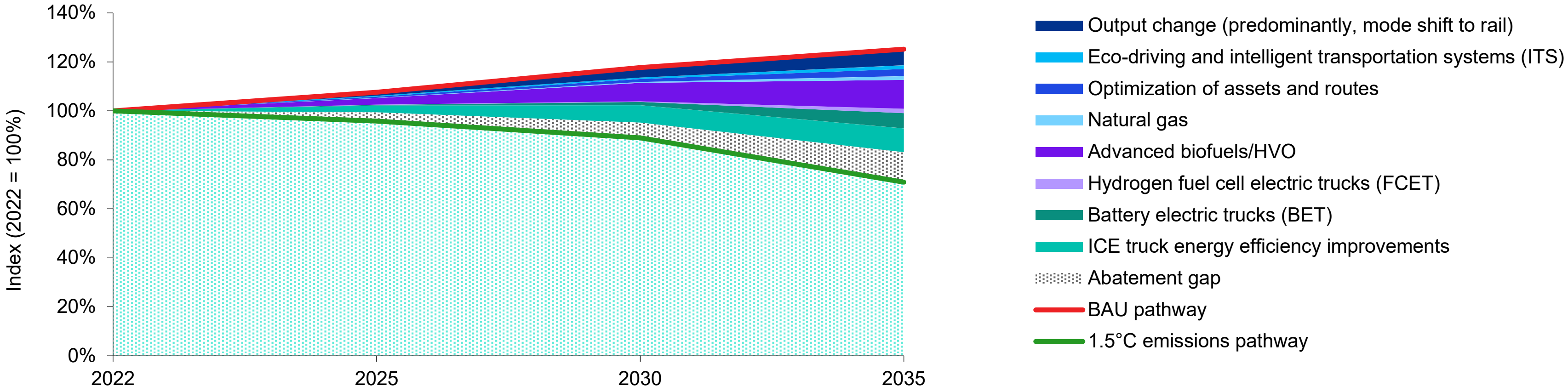
Potential Road Freight decarbonisation pathway (2022-2035)



Road freight		2035								
		Abatement activities								
Portfolio Segmentation	Assumed mix of business	Battery electric trucks	Hydrogen fuel cell electric trucks	Biofuels	Natural Gas	Output change (predominantly, mode shift to rail)	Unabated / No Change	ICE truck energy efficiency improvements	Optimisation of assets and routes	Eco-driving and intelligent transportation systems (ITS)
Abatement (% CO2)		**5%**	**1%**	**9%**	**1%**	**5%**	**66%**	**8%**	**2%**	**1%**
Small van	5%	1%	0%	1%	0%	0%	4%			
LWB and XLWB Vans	5%	1%	0%	1%	0%	0%	4%			
Articulated Lorry	40%	2%	1%	4%	1%	3%	30%			
Rigid lorry	25%	1%	1%	3%	0%	2%	19%			
Tanker lorry	25%	2%	0%	3%	0%	1%	19%			
Total	**100%**	**6%**	**2%**	**11%**	**1%**	**6%**	**75%**			

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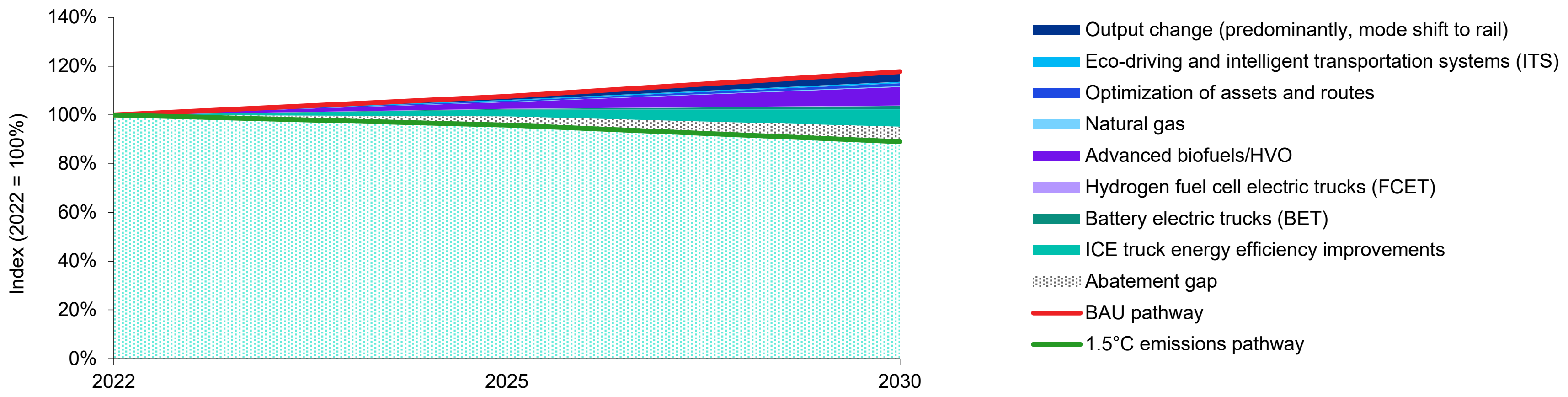
Potential Road Freight decarbonisation pathway (2022-2030)



Road freight		2030								
		Abatement activities								
Portfolio Segmentation	Assumed mix of business	Battery electric trucks	Hydrogen fuel cell electric trucks	Biofuels	Natural Gas	Output change (predominantly, mode shift to rail)	Unabated / No Change	ICE truck energy efficiency improvements	Optimisation of assets and routes	Eco-driving and intelligent transportation systems (ITS)
Abatement (% CO2)		1%	0%	6%	0%	4%	81%	6%	1%	0%
Small van	5%	0%	0%	0%	0%	0%	4%			
LWB and XLWB Vans	5%	0%	0%	0%	0%	0%	4%			
Articulated Lorry	40%	0%	0%	3%	0%	2%	35%			
Rigid lorry	25%	0%	0%	2%	0%	1%	22%			
Tanker lorry	25%	0%	0%	2%	0%	1%	22%			
Total	**100%**	**1%**	**0%**	**7%**	**0%**	**4%**	**87%**			

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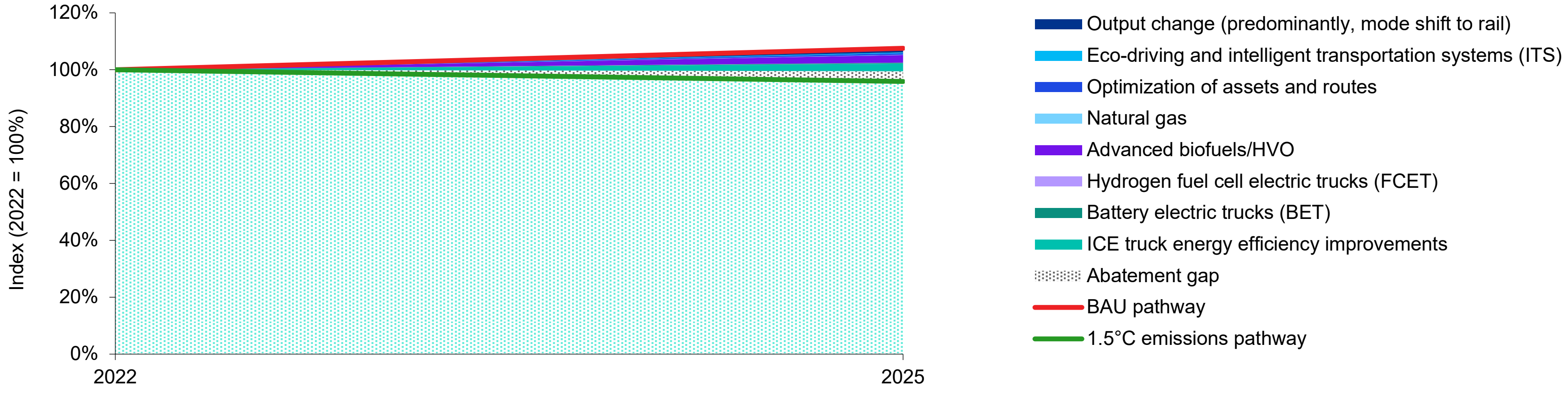
2050 | 2045 | 2040 | 2035 | 2030 | 2025

Potential Road Freight decarbonisation pathway (2022-2025)



Road freight		2025								
		Abatement activities								
Portfolio Segmentation	Assumed mix of business	Battery electric trucks	Hydrogen fuel cell electric trucks	Biofuels	Natural Gas	Output change (predominantly, mode shift to rail)	Unabated / No Change	ICE truck energy efficiency improvements	Optimisation of assets and routes	Eco-driving and intelligent transportation systems (ITS)
Abatement (% CO2)		**0%**	**0%**	**2%**	**0%**	**1%**	**92%**	**3%**	**0%**	**0%**
Small van	5%	0%	0%	0%	0%	0%	5%			
LWB and XLWB Vans	5%	0%	0%	0%	0%	0%	5%			
Articulated Lorry	40%	0%	0%	1%	0%	1%	38%			
Rigid lorry	25%	0%	0%	1%	0%	0%	24%			
Tanker lorry	25%	0%	0%	1%	0%	0%	24%			
Total	**100%**	**0%**	**0%**	**3%**	**0%**	**1%**	**96%**			

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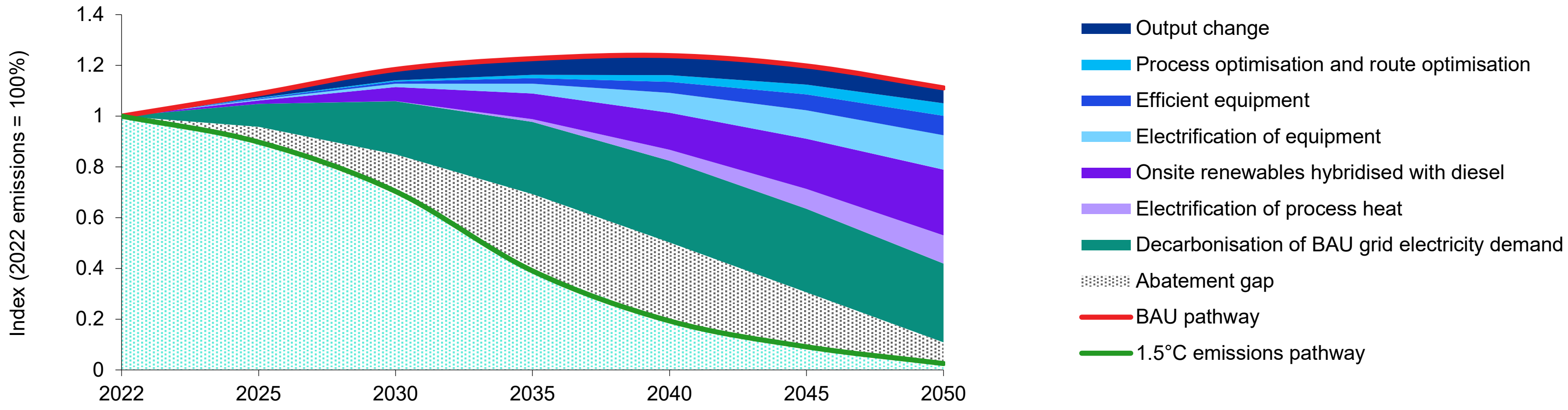
Potential mining sector decarbonisation pathway (2022-2050)



Mining		2050						
Portfolio segmentation		Abatement activities						
Segment	Assumed mix of business	Decarbonisation of BAU grid electricity demand	Electrification	Onsite renewables hybridised with diesel	Output change	Unabated / No Change	Efficient equipment	Process optimisation and route optimisation
Abatement (% CO2)		28%	22%	23%	5%	10%	7%	4%
Iron and Ferro-alloy metals	55%	17%	14%	14%	3%	6%		
Non-ferrous metals	25%	8%	6%	7%	2%	3%		
Precious metals	10%	3%	2%	3%	1%	1%		
Industrial Minerals	5%	2%	1%	1%	0%	1%		
Mineral Fuels	5%	2%	1%	1%	0%	1%		
Total	**100%**	**32%**	**25%**	**26%**	**6%**	**11%**		

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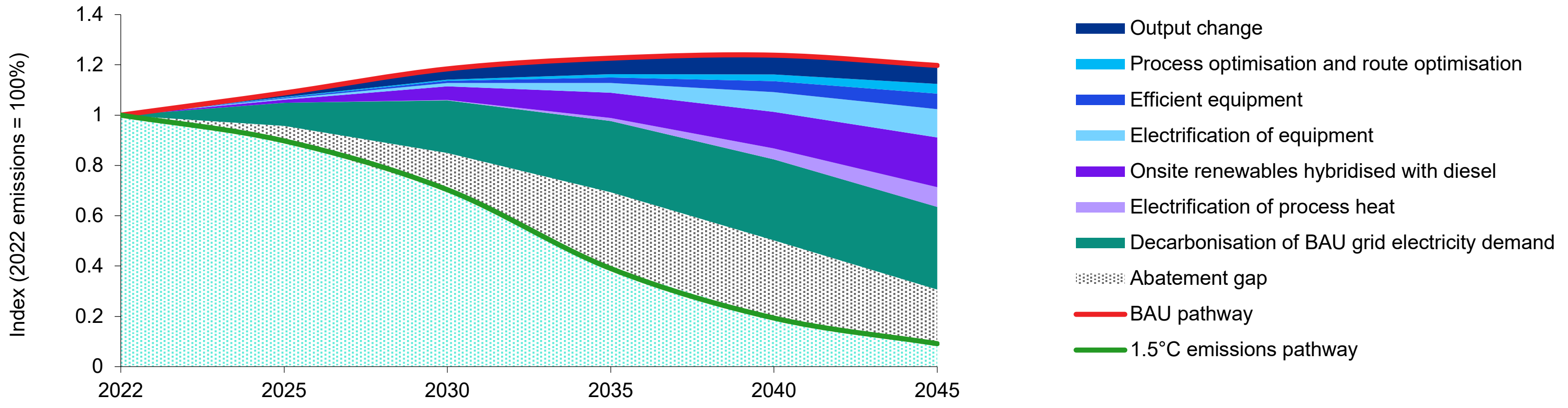
Potential mining sector decarbonisation pathway (2022-2045)



Mining		2045						
Portfolio segmentation		Abatement activities						
Segment	Assumed mix of business	Decarbonisation of BAU grid electricity demand	Electrification	Onsite renewables hybridised with diesel	Output change	Unabated / No Change	Efficient equipment	Process optimisation and route optimisation
Abatement (% CO2)		26%	10%	12%	6%	41%	4%	2%
Iron and Ferro-alloy metals	55%	15%	6%	7%	4%	24%		
Non-ferrous metals	25%	7%	3%	3%	2%	11%		
Precious metals	10%	3%	1%	1%	1%	4%		
Industrial Minerals	5%	1%	1%	1%	0%	2%		
Mineral Fuels	5%	1%	1%	1%	0%	2%		
Total	**100%**	**28%**	**10%**	**12%**	**7%**	**43%**		

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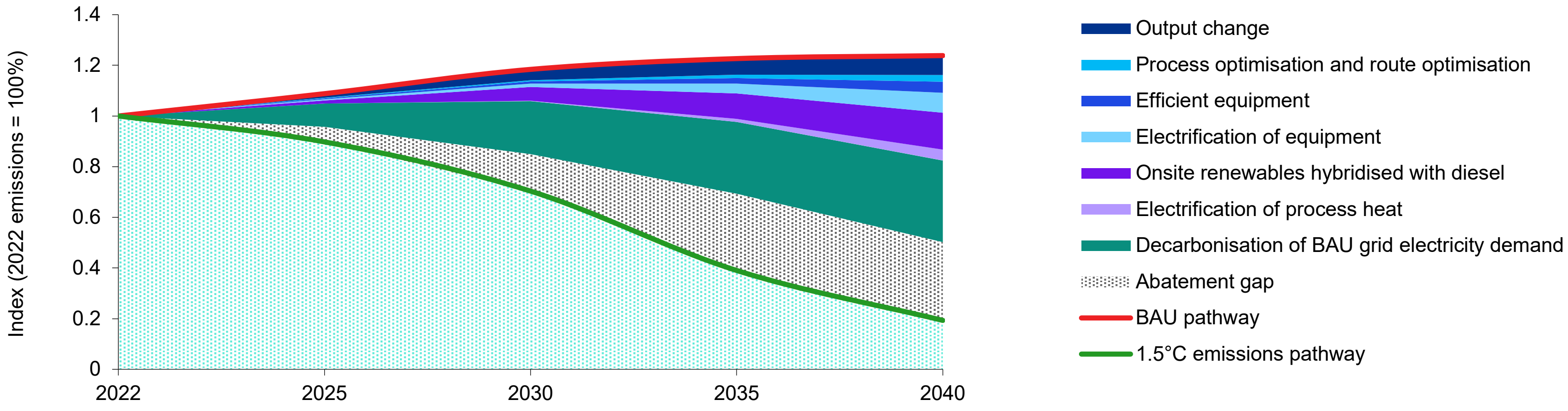
Potential mining sector decarbonisation pathway (2022-2040)



Mining		2040						
Portfolio segmentation		Abatement activities						
Segment	Assumed mix of business	Decarbonisation of BAU grid electricity demand	Electrification	Onsite renewables hybridised with diesel	Output change	Unabated / No Change	Efficient equipment	Process optimisation and route optimisation
Abatement (% CO2)		26%	10%	12%	6%	41%	4%	2%
Iron and Ferro-alloy metals	55%	15%	6%	7%	4%	24%		
Non-ferrous metals	25%	7%	3%	3%	2%	11%		
Precious metals	10%	3%	1%	1%	1%	4%		
Industrial Minerals	5%	1%	1%	1%	0%	2%		
Mineral Fuels	5%	1%	1%	1%	0%	2%		
Total	**100%**	**28%**	**10%**	**12%**	**7%**	**43%**		

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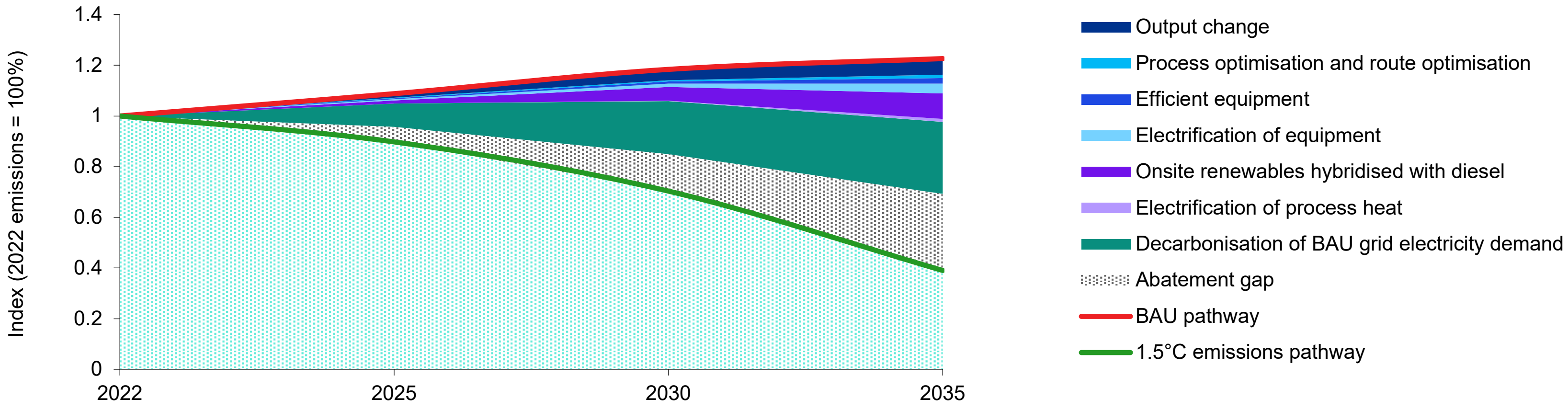
Potential mining sector decarbonisation pathway (2022-2035)



Mining		2035						
Portfolio segmentation		Abatement activities						
Segment	Assumed mix of business	Decarbonisation of BAU grid electricity demand	Electrification	Onsite renewables hybridised with diesel	Output change	Unabated / No Change	Efficient equipment	Process optimisation and route optimisation
Abatement (% CO2)		23%	4%	8%	5%	56%	2%	1%
Iron and Ferro-alloy metals	55%	13%	2%	5%	3%	32%		
Non-ferrous metals	25%	6%	1%	2%	1%	15%		
Precious metals	10%	2%	0%	1%	1%	6%		
Industrial Minerals	5%	1%	0%	0%	0%	3%		
Mineral Fuels	5%	1%	0%	0%	0%	3%		
Total	**100%**	**24%**	**4%**	**8%**	**5%**	**58%**		

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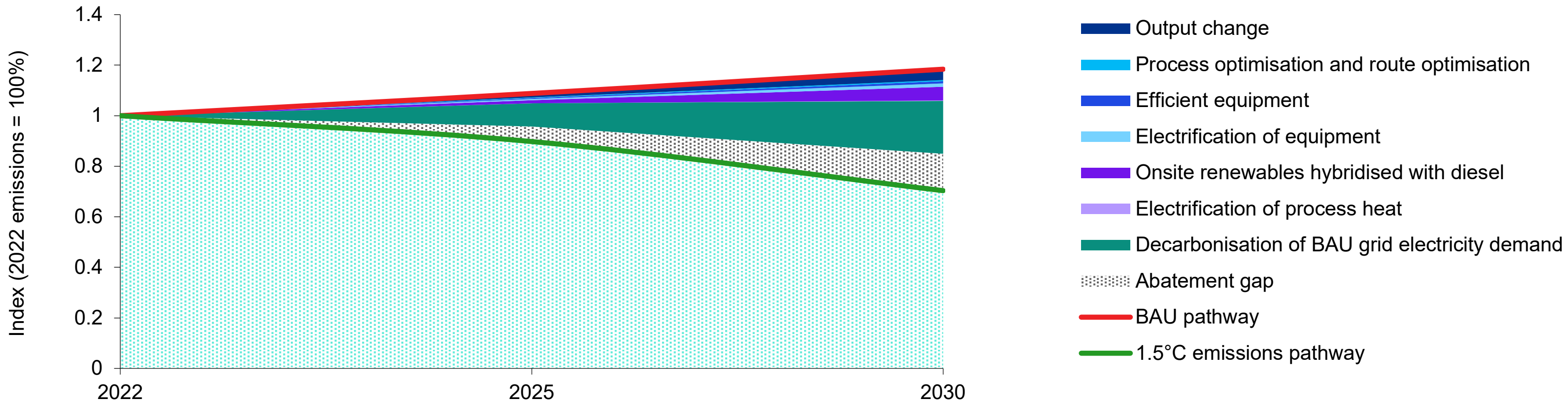
Potential mining sector decarbonisation pathway (2022-2030)



Mining		2030						
Portfolio segmentation		Abatement activities						
Segment	Assumed mix of business	Decarbonisation of BAU grid electricity demand	Electrification	Onsite renewables hybridised with diesel	Output change	Unabated / No Change	Efficient equipment	Process optimisation and route optimisation
Abatement (% CO2)		18%	1%	5%	4%	72%	1%	0%
Iron and Ferro-alloy metals	55%	10%	1%	3%	2%	40%		
Non-ferrous metals	25%	4%	0%	1%	1%	18%		
Precious metals	10%	2%	0%	0%	0%	7%		
Industrial Minerals	5%	1%	0%	0%	0%	4%		
Mineral Fuels	5%	1%	0%	0%	0%	4%		
Total	**100%**	**18%**	**1%**	**5%**	**4%**	**73%**		

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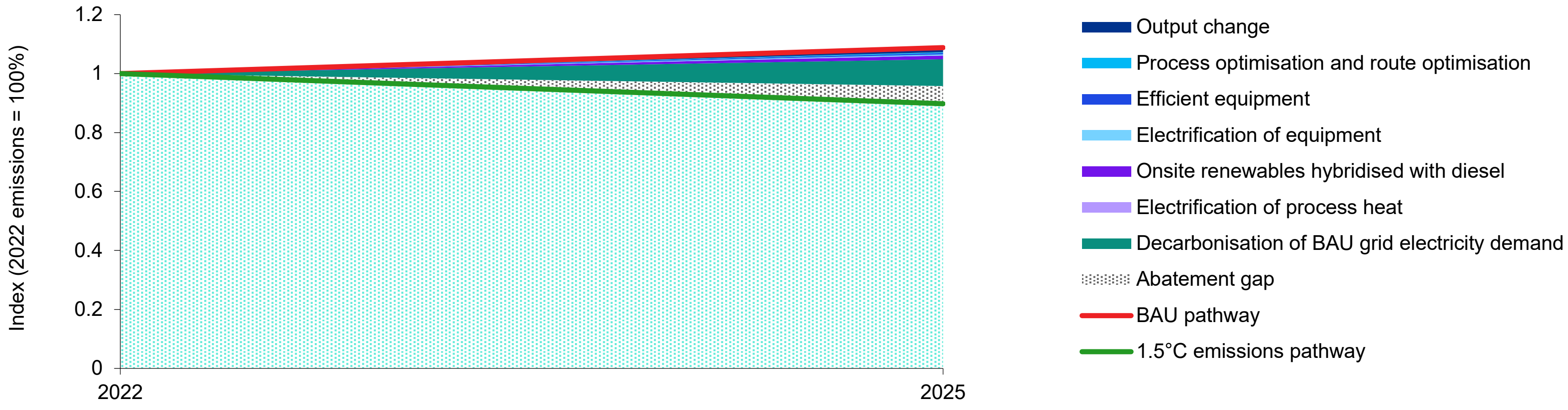
Potential mining sector decarbonisation pathway (2022-2025)



Mining		2025						
Portfolio segmentation		Abatement activities						
Segment	Assumed mix of business	Decarbonisation of BAU grid electricity demand	Electrification	Onsite renewables hybridised with diesel	Output change	Unabated / No Change	Efficient equipment	Process optimisation and route optimisation
Abatement (% CO2)		8%	0%	1%	1%	88%	0%	0%
Iron and Ferro-alloy metals	55%	5%	0%	1%	1%	49%		
Non-ferrous metals	25%	2%	0%	0%	0%	22%		
Precious metals	10%	1%	0%	0%	0%	9%		
Industrial Minerals	5%	0%	0%	0%	0%	4%		
Mineral Fuels	5%	0%	0%	0%	0%	4%		
Total	**100%**	**8%**	**0%**	**1%**	**1%**	**89%**		

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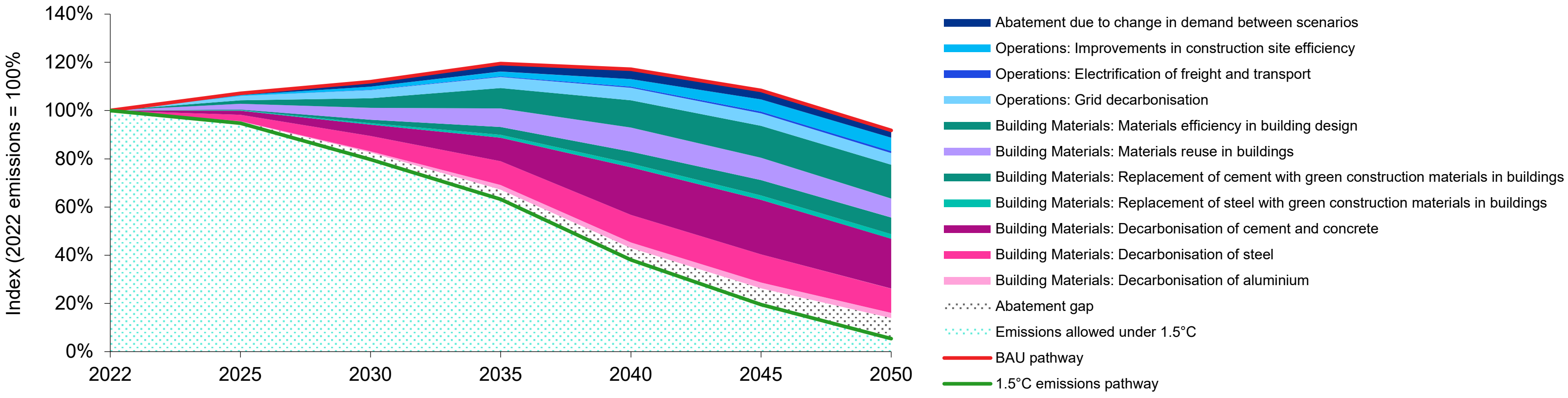
Potential Construction sector decarbonisation pathway (2022-2050)



Construction		2050								
Portfolio segmentation		Abatement activities								
Segment	Assumed mix of business	Decarbonisation of aluminium	Decarbonisation of steel	Decarbonisation of cement and concrete	Replacement of steel with green construction materials in buildings	Replacement of cement with green construction materials in buildings	Materials reuse in buildings	Materials efficiency in building design	Operations	Unabated / No Change
Abatement (% projected CO2)		2%	11%	23%	2%	8%	9%	16%	13%	16%
Retail	35%	1%	4%	8%	1%	3%	3%	6%	4%	5%
Office	25%	1%	3%	6%	1%	2%	2%	4%	3%	4%
Industrial	15%	0%	2%	3%	0%	1%	1%	2%	2%	2%
Mixed Use	15%	0%	2%	3%	0%	1%	1%	2%	2%	2%
Hospitality/ Services	10%	0%	1%	2%	0%	1%	1%	2%	1%	2%

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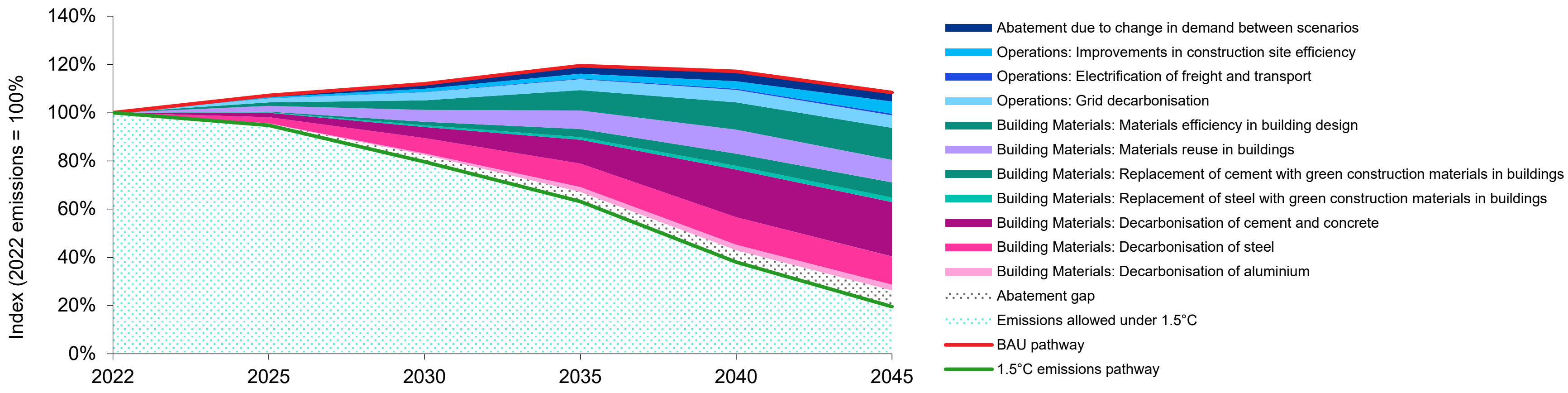
Potential Construction sector decarbonisation pathway (2022-2045)



Construction		2045								
Portfolio segmentation		Abatement activities								
Segment	Assumed mix of business	Decarbonisation of aluminium	Decarbonisation of steel	Decarbonisation of cement and concrete	Replacement of steel with green construction materials in buildings	Replacement of cement with green construction materials in buildings	Materials reuse in buildings	Materials efficiency in building design	Operations	Unabated / No Change
Abatement (% projected CO2)		2%	11%	22%	2%	6%	9%	13%	10%	25%
Retail	35%	1%	4%	8%	1%	2%	3%	4%	4%	9%
Office	25%	1%	3%	5%	0%	2%	2%	3%	3%	6%
Industrial	15%	0%	2%	3%	0%	1%	1%	2%	2%	4%
Mixed Use	15%	0%	2%	3%	0%	1%	1%	2%	2%	4%
Hospitality/ Services	10%	0%	1%	2%	0%	1%	1%	1%	1%	3%

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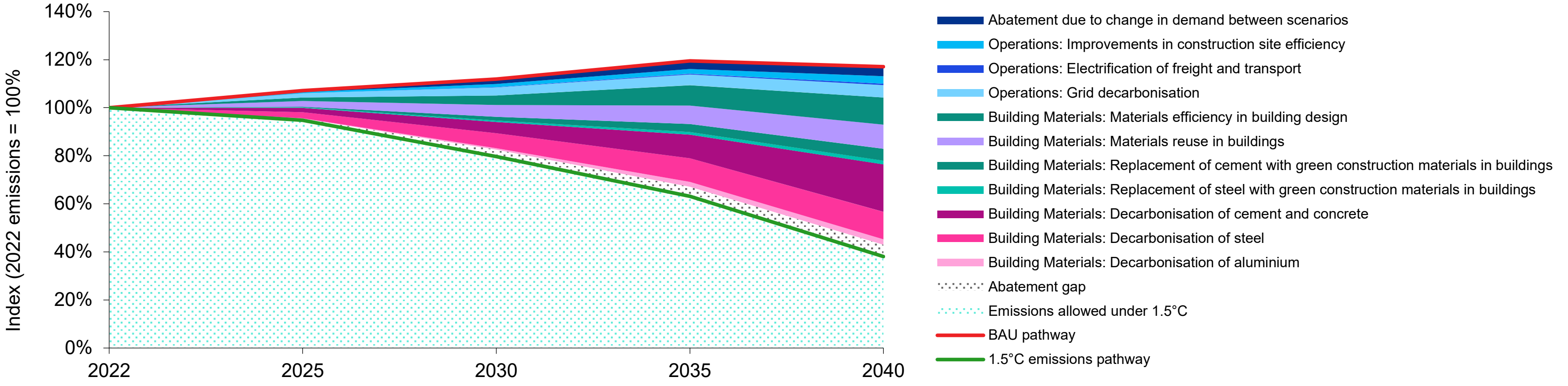
Potential Construction sector decarbonisation pathway (2022-2040)



Construction		2040								
Portfolio segmentation		Abatement activities								
Segment	Assumed mix of business	Decarbonisation of aluminium	Decarbonisation of steel	Decarbonisation of cement and concrete	Replacement of steel with green construction materials in buildings	Replacement of cement with green construction materials in buildings	Materials reuse in buildings	Materials efficiency in building design	Operations	Unabated / No Change
Abatement (% projected CO_2)		2%	10%	17%	1%	4%	9%	10%	8%	38%
Retail	35%	1%	4%	6%	0%	2%	3%	3%	3%	13%
Office	25%	1%	3%	4%	0%	1%	2%	2%	2%	10%
Industrial	15%	0%	2%	3%	0%	1%	1%	1%	1%	6%
Mixed Use	15%	0%	2%	3%	0%	1%	1%	1%	1%	6%
Hospitality/ Services	10%	0%	1%	2%	0%	0%	1%	1%	1%	4%

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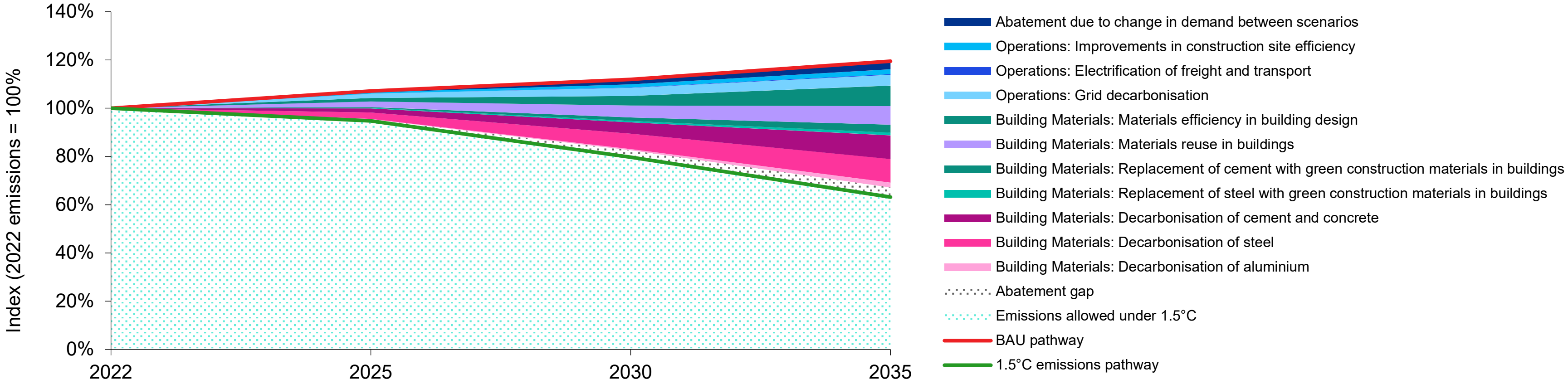
Potential Construction sector decarbonisation pathway (2022-2035)



Construction		2035								
Portfolio segmentation		Abatement activities								
Segment	Assumed mix of business	Decarbonisation of aluminium	Decarbonisation of steel	Decarbonisation of cement and concrete	Replacement of steel with green construction materials in buildings	Replacement of cement with green construction materials in buildings	Materials reuse in buildings	Materials efficiency in building design	Operations	Unabated / No Change
Abatement (% projected CO2)		2%	8%	8%	1%	3%	7%	7%	6%	58%
Retail	35%	1%	3%	3%	0%	1%	2%	3%	2%	20%
Office	25%	0%	2%	2%	0%	1%	2%	2%	1%	14%
Industrial	15%	0%	1%	1%	0%	0%	1%	1%	1%	9%
Mixed Use	15%	0%	1%	1%	0%	0%	1%	1%	1%	9%
Hospitality/ Services	10%	0%	1%	1%	0%	0%	1%	1%	1%	6%

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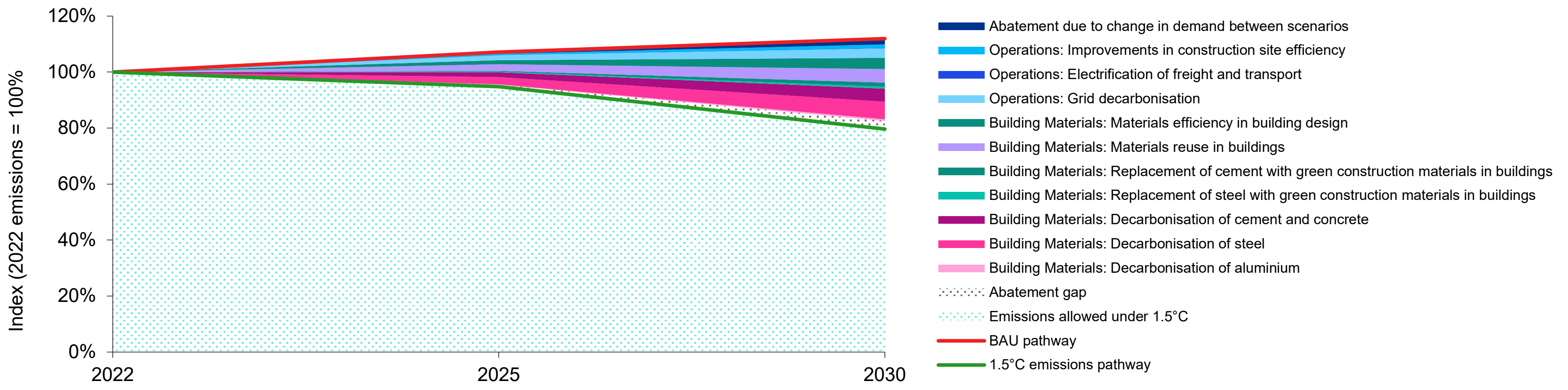
Potential Construction sector decarbonisation pathway (2022-2030)



Construction		2030								
Portfolio segmentation		Abatement activities								
Segment	Assumed mix of business	Decarbonisation of aluminium	Decarbonisation of steel	Decarbonisation of cement and concrete	Replacement of steel with green construction materials in buildings	Replacement of cement with green construction materials in buildings	Materials reuse in buildings	Materials efficiency in building design	Operations	Unabated / No Change
Abatement (% projected CO_2)		1%	6%	4%	1%	1%	4%	4%	4%	75%
Retail	35%	0%	2%	1%	0%	0%	2%	1%	2%	26%
Office	25%	0%	1%	1%	0%	0%	1%	1%	1%	19%
Industrial	15%	0%	1%	1%	0%	0%	1%	1%	1%	11%
Mixed Use	15%	0%	1%	1%	0%	0%	1%	1%	1%	11%
Hospitality/ Services	10%	0%	1%	0%	0%	0%	0%	0%	0%	8%

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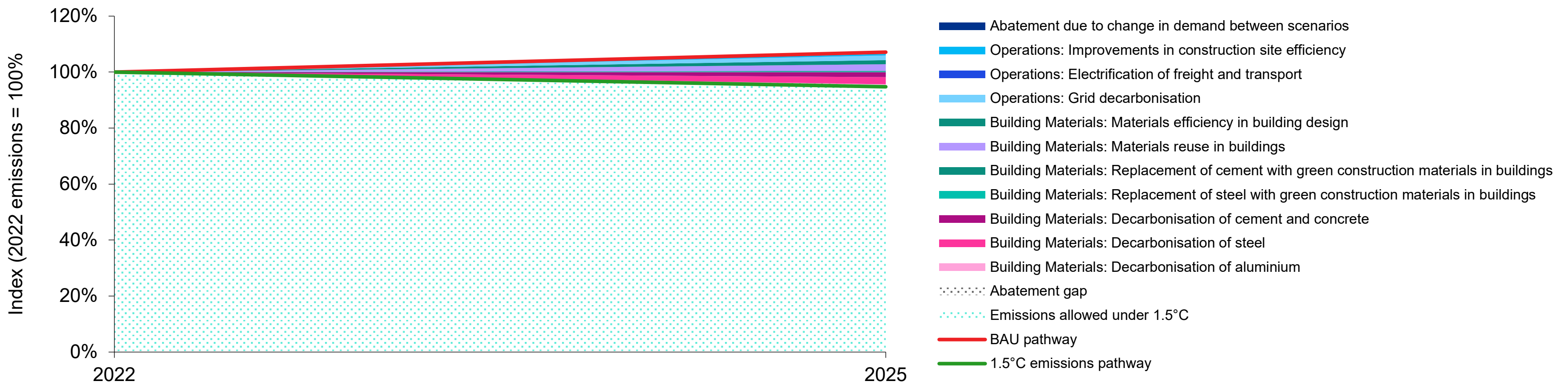
Potential Construction sector decarbonisation pathway (2022-2025)



Construction		**2025**								
Portfolio segmentation		**Abatement activities**								
Segment	**Assumed mix of business**	**Decarbonisation of aluminium**	**Decarbonisation of steel**	**Decarbonisation of cement and concrete**	**Replacement of steel with green construction materials in buildings**	**Replacement of cement with green construction materials in buildings**	**Materials reuse in buildings**	**Materials efficiency in building design**	**Operations**	**Unabated / No Change**
Abatement (% projected CO_2)		**0%**	**2%**	**2%**	**0%**	**0%**	**2%**	**1%**	**2%**	**90%**
Retail	35%	0%	1%	1%	0%	0%	1%	0%	1%	31%
Office	25%	0%	1%	0%	0%	0%	1%	0%	1%	22%
Industrial	15%	0%	0%	0%	0%	0%	0%	0%	0%	13%
Mixed Use	15%	0%	0%	0%	0%	0%	0%	0%	0%	13%
Hospitality/ Services	10%	0%	0%	0%	0%	0%	0%	0%	0%	9%

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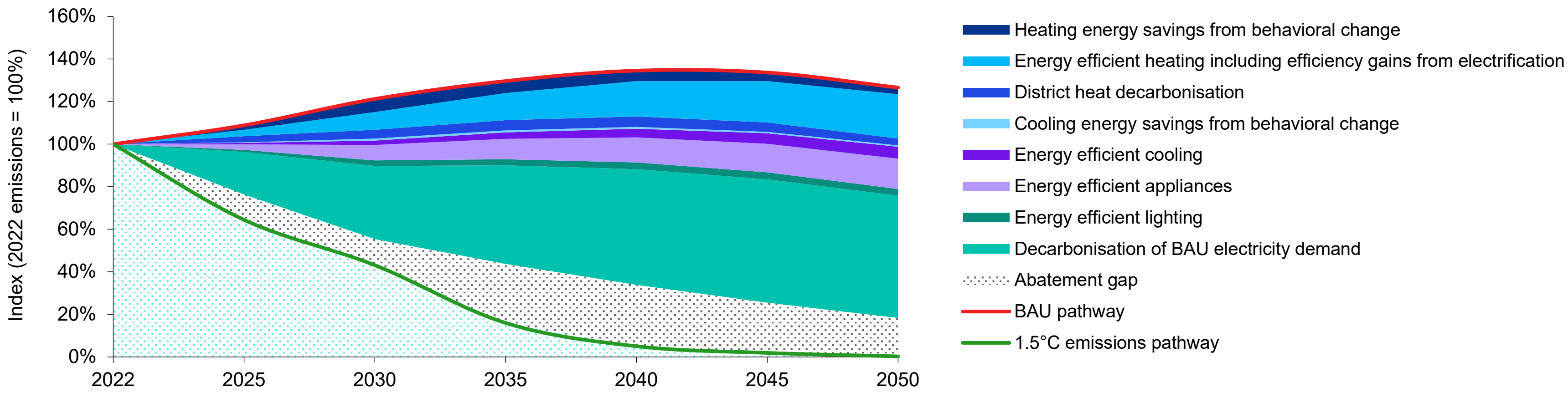
Potential decarbonisation pathway for Commercial Real Estate (2022-2050)



Commercial Real Estate		2050								
Portfolio segmentation		Abatement activities								
Segment	Assumed mix of business	Decarbonisation of BAU electricity demand	Energy efficient lighting	Energy efficient appliances	Energy efficient cooling	Cooling energy savings from behavioral change	District heat decarbonisation	Energy efficient heating including efficiency gains from electrification	Heating energy savings from behavioral change	Unabated / No Change
Abatement (% projected CO2)		47%	3%	12%	5%	1%	3%	17%	0%	15%
Retail	30%	14%	1%	3%	1%	0%	1%	5%	0%	4%
Office	25%	12%	1%	3%	1%	0%	1%	4%	0%	4%
Industrial	20%	9%	1%	2%	1%	0%	1%	3%	0%	3%
Mixed Use	15%	7%	0%	2%	1%	0%	0%	3%	0%	2%
Hospitality/Services	10%	5%	0%	1%	0%	0%	0%	2%	0%	1%

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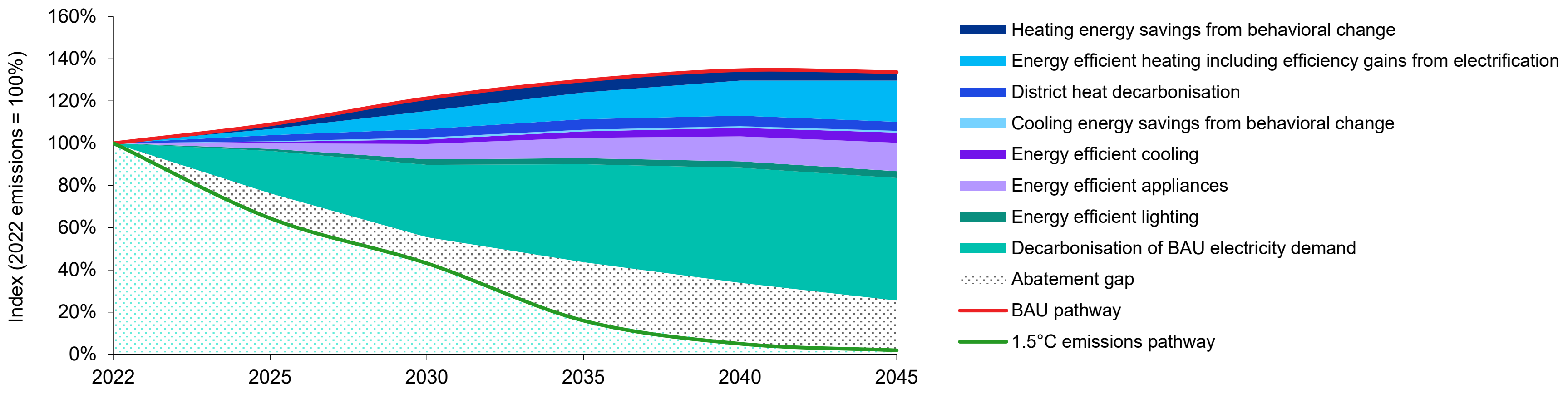
Potential decarbonisation pathway for Commercial Real Estate (2022-2045)



Commercial Real Estate		2045								
Portfolio segmentation		Abatement activities								
Segment	Assumed mix of business	Decarbonisation of BAU electricity demand	Energy efficient lighting	Energy efficient appliances	Energy efficient cooling	Cooling energy savings from behavioral change	District heat decarbonisation	Energy efficient heating including efficiency gains from electrification	Heating energy savings from behavioral change	Unabated / No Change
Abatement (% projected CO2)		**45%**	**2%**	**10%**	**4%**	**1%**	**3%**	**15%**	**0%**	**20%**
Retail	30%	13%	1%	3%	1%	0%	1%	5%	0%	6%
Office	25%	11%	1%	3%	1%	0%	1%	4%	0%	5%
Industrial	20%	9%	0%	2%	1%	0%	1%	3%	0%	4%
Mixed Use	15%	7%	0%	2%	1%	0%	0%	2%	0%	3%
Hospitality/Services	10%	4%	0%	1%	0%	0%	0%	2%	0%	2%

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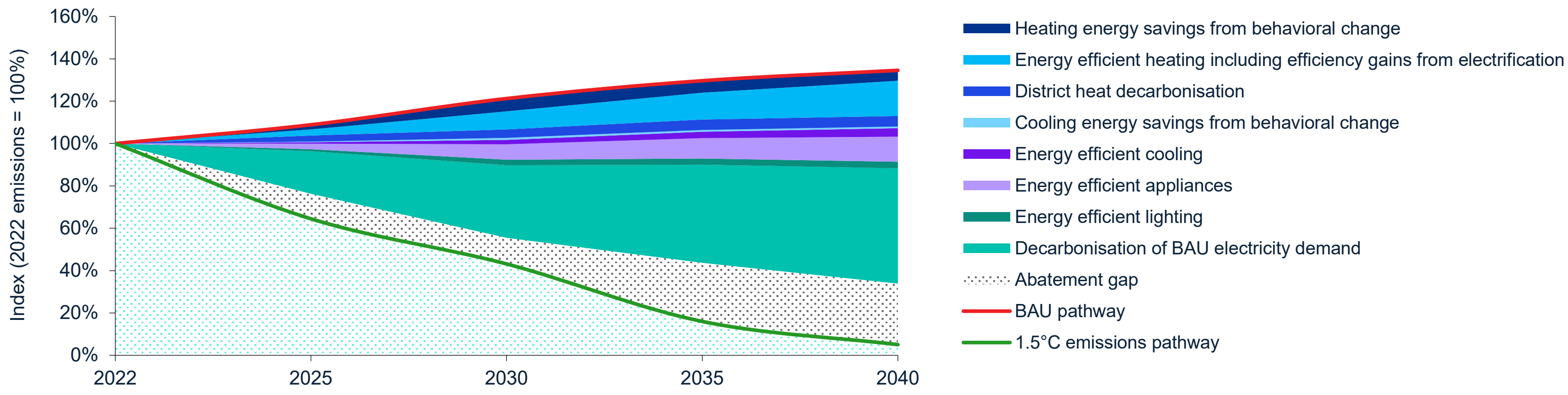
Potential decarbonisation pathway for Commercial Real Estate (2022-2040)



Commercial Real Estate		2040								
Portfolio segmentation		**Abatement activities**								
Segment	**Assumed mix of business**	**Decarbonisation of BAU electricity demand**	**Energy efficient lighting**	**Energy efficient appliances**	**Energy efficient cooling**	**Cooling energy savings from behavioral change**	**District heat decarbonisation**	**Energy efficient heating including efficiency gains from electrification**	**Heating energy savings from behavioral change**	**Unabated / No Change**
Abatement (% projected CO_2)		**42%**	**2%**	**9%**	**3%**	**1%**	**4%**	**13%**	**0%**	**26%**
Retail	30%	13%	1%	3%	1%	0%	1%	4%	0%	8%
Office	25%	11%	1%	2%	1%	0%	1%	3%	0%	7%
Industrial	20%	8%	0%	2%	1%	0%	1%	3%	0%	5%
Mixed Use	15%	6%	0%	1%	0%	0%	1%	2%	0%	4%
Hospitality/Services	10%	4%	0%	1%	0%	0%	0%	1%	0%	3%

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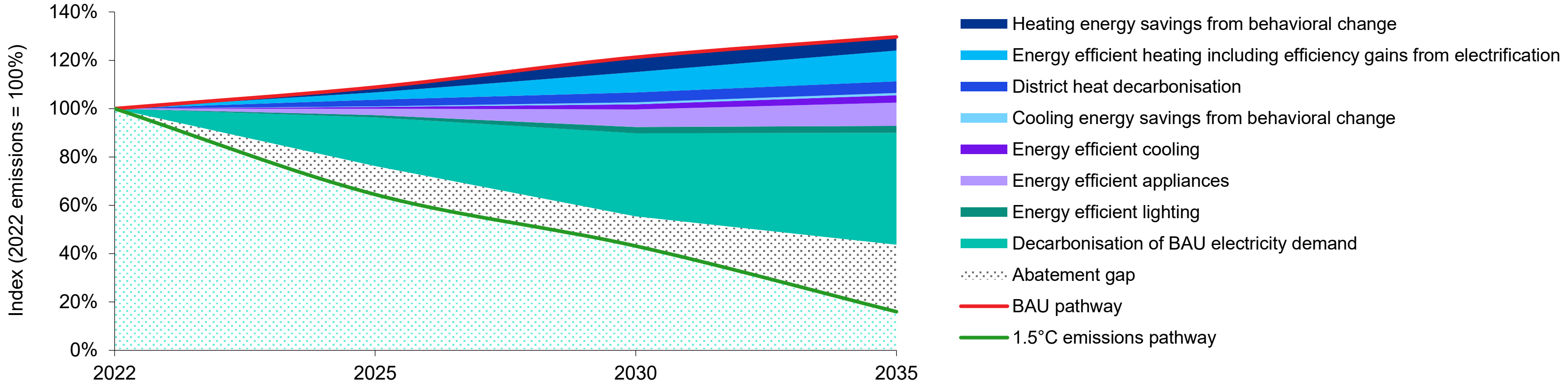
Potential decarbonisation pathway for Commercial Real Estate (2022-2035)



Commercial Real Estate		2035								
Portfolio segmentation		Abatement activities								
Segment	Assumed mix of business	Decarbonisation of BAU electricity demand	Energy efficient lighting	Energy efficient appliances	Energy efficient cooling	Cooling energy savings from behavioral change	District heat decarbonisation	Energy efficient heating including efficiency gains from electrification	Heating energy savings from behavioral change	Unabated / No Change
Abatement (% projected CO2)		**37%**	**2%**	**8%**	**2%**	**1%**	**4%**	**10%**	**0%**	**35%**
Retail	30%	11%	1%	2%	1%	0%	1%	3%	0%	11%
Office	25%	9%	1%	2%	1%	0%	1%	3%	0%	9%
Industrial	20%	7%	0%	2%	0%	0%	1%	2%	0%	7%
Mixed Use	15%	6%	0%	1%	0%	0%	1%	2%	0%	5%
Hospitality/Services	10%	4%	0%	1%	0%	0%	0%	1%	0%	4%

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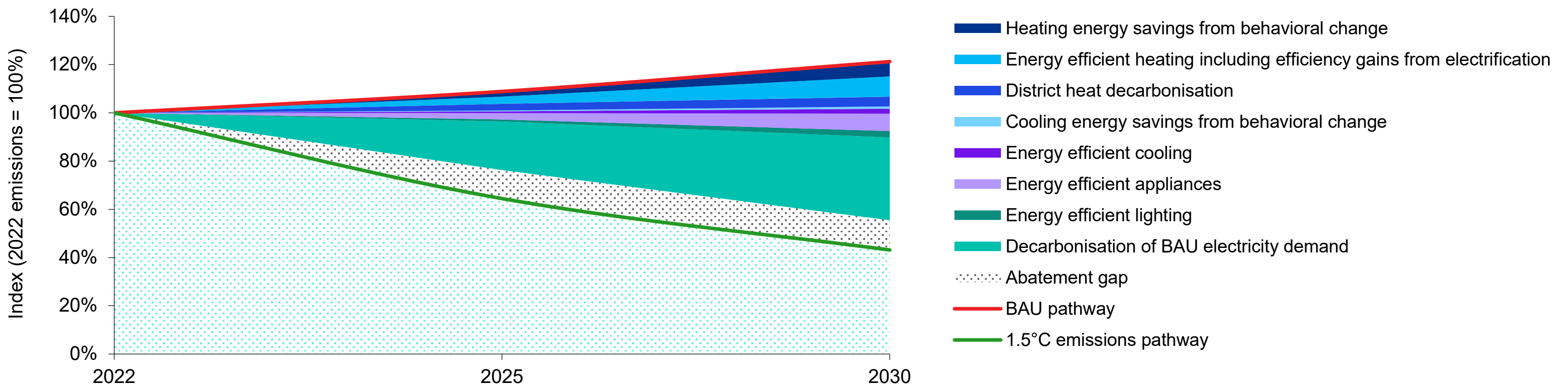
Potential decarbonisation pathway for Commercial Real Estate (2022-2030)



Commercial Real Estate		2030								
Portfolio segmentation		Abatement activities								
Segment	Assumed mix of business	Decarbonisation of BAU electricity demand	Energy efficient lighting	Energy efficient appliances	Energy efficient cooling	Cooling energy savings from behavioral change	District heat decarbonisation	Energy efficient heating including efficiency gains from electrification	Heating energy savings from behavioral change	Unabated / No Change
Abatement (% projected CO2)		30%	2%	6%	2%	1%	4%	7%	0%	48%
Retail	30%	9%	1%	2%	1%	0%	1%	2%	0%	14%
Office	25%	7%	1%	2%	0%	0%	1%	2%	0%	12%
Industrial	20%	6%	0%	1%	0%	0%	1%	1%	0%	10%
Mixed Use	15%	4%	0%	1%	0%	0%	1%	1%	0%	7%
Hospitality/Services	10%	3%	0%	1%	0%	0%	0%	1%	0%	5%

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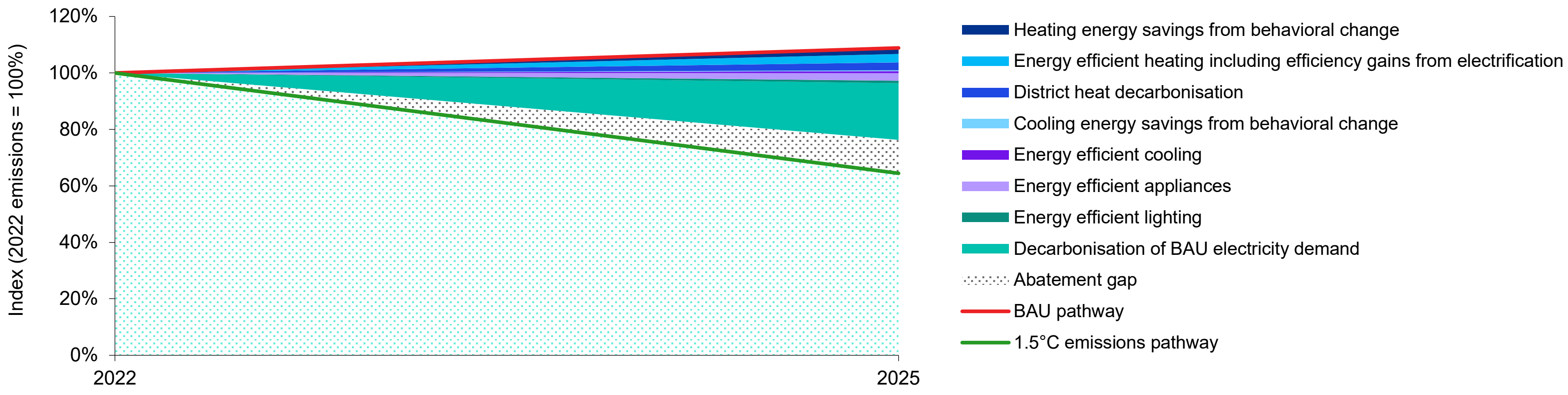
Potential decarbonisation pathway for Commercial Real Estate (2022-2025)



Commercial Real Estate		2025								
Portfolio segmentation		Abatement activities								
Segment	Assumed mix of business	Decarbonisation of BAU electricity demand	Energy efficient lighting	Energy efficient appliances	Energy efficient cooling	Cooling energy savings from behavioral change	District heat decarbonisation	Energy efficient heating including efficiency gains from electrification	Heating energy savings from behavioral change	Unabated / No Change
Abatement (% projected CO2)		19%	1%	2%	1%	0%	3%	3%	0%	71%
Retail	30%	6%	0%	1%	0%	0%	1%	1%	0%	21%
Office	25%	5%	0%	1%	0%	0%	1%	1%	0%	18%
Industrial	20%	4%	0%	0%	0%	0%	1%	1%	0%	14%
Mixed Use	15%	3%	0%	0%	0%	0%	0%	0%	0%	11%
Hospitality/Services	10%	2%	0%	0%	0%	0%	0%	0%	0%	7%

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17 Glossary

Abbreviation	Full Form	Meaning
AFIR	Alternative Fuels Infrastructure Regulation	A regulation aimed at promoting the development of infrastructure for alternative fuels. AFIR supports the transition to cleaner energy sources in the transport sector.
AI	Artificial Intelligence	The simulation of human intelligence in machines that are programmed to think and learn like humans.
AIoT	Automated Intelligence of Things	The integration of artificial intelligence with the Internet of Things (IoT). AIoT enables smart devices to analyse data and make decisions autonomously.
APUs	Auxiliary Power Units	Devices on aircraft that provide energy for functions other than propulsion, such as powering electrical systems when the main engines are off.
ATF	Aviation Turbine Fuel	A type of fuel used in jet engines. ATF is designed to meet the specific requirements of aircraft performance and safety.
BECCS	Bio-Energy with Carbon Capture and Storage	A carbon removal technique that combines biomass energy generation with carbon capture technology to remove CO2 from the atmosphere during bioenergy production.
BETs	Battery Electric Trucks	BETs are trucks powered entirely by batteries, which store electrical energy to drive the electric motor. They are a key component in reducing greenhouse gas emissions in the transportation sector, especially for short to medium-haul routes.
BI Claims	Business Interruption Claims	Claims for loss of income due to a business interruption. These claims are typically made under business interruption insurance policies, which cover the loss of income that a business suffers after a disaster while its facility is either closed or in the process of being rebuilt.
BREEAM	Building Research Establishment Environmental Assessment Method	A sustainability assessment method for buildings and infrastructure. BREEAM evaluates the environmental performance of projects and promotes sustainable design.
BVCM	Beyond Value Chain Mitigation	Beyond value chain mitigation (BVCM) was first defined in the Corporate Net-Zero Standard of the Science Based Targets initiative (SBTi). The term refers to mitigation action or investments that fall outside companies' value chains.
CAPEX	Capital Expenditure	Funds used by a company to acquire, upgrade, and maintain physical assets such as property, industrial buildings, or equipment. CapEx is often used to undertake new projects or investments.

Abbreviation	Full Form	Meaning
Carbon Credit(s)	Carbon Credit(s)	A permit that allows the holder to emit a certain amount of carbon dioxide or other greenhouse gases. One credit permits the emission of a mass equal to one ton of carbon dioxide. Credits can be traded in the carbon market, providing economic incentives for reducing emissions.
CBAM	Carbon Border Adjustment Mechanism	An EU policy to impose a carbon price on imports of certain goods. CBAM aims to prevent carbon leakage and promote global climate action.
CCS	Carbon Capture and Storage	A technology that captures carbon dioxide emissions from industrial processes and stores them underground. CCS is considered a key tool for reducing greenhouse gas emissions.
CCUS	Carbon Capture, Utilisation, and Storage	Technologies to capture and store carbon dioxide emissions. The captured CO_2 can be stored underground or used in various industrial processes, helping to reduce the overall concentration of greenhouse gases in the atmosphere.
CDM	Clean Development Mechanism	A mechanism under the Kyoto Protocol that allows emission-reduction projects in developing countries to earn certified emission reduction (CER) credits. These credits can be traded and sold, and used by industrialized countries to meet part of their emission reduction targets under the Kyoto Protocol.
CEAP	EU Circular Economy Action Plan	An EU strategy to promote a circular economy, where resources are reused and recycled. CEAP aims to reduce waste, increase resource efficiency, and support sustainable growth.
CHE	Cargo Handling Equipment	Equipment used for loading, unloading, and moving cargo in ports and terminals. Examples include cranes, forklifts, and conveyor belts.
CII	Carbon Intensity Indicator	A metric used to measure the carbon emissions per unit of transport work. CII helps in monitoring and reducing the carbon footprint of shipping operations.
CMDC5	Clean Maritime Demonstration Competition	A UK government initiative to support the development of innovative clean maritime technologies. CMDC aims to accelerate the transition to zero-emission shipping.
COP	Conference of the Parties	The supreme decision-making body of the United Nations Framework Convention on Climate Change (UNFCCC). It meets annually to review the implementation of the Convention and any other legal instruments that the COP adopts, and to make decisions necessary to promote the effective implementation of the Convention.
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation	A global market-based measure to offset carbon emissions from international aviation. Airlines are required to purchase carbon credits to offset any emissions that exceed a baseline level, helping to achieve carbon-neutral growth in the aviation sector.

Abbreviation	Full Form	Meaning
CSDDD	Corporate Sustainability Due Diligence Directive	An EU directive requiring companies to identify and mitigate adverse impacts on human rights and the environment, including the development of a 1.5°C aligned Climate Transition Plan. CSDDD aims to promote corporate accountability and sustainability.
DACC	Direct Air Carbon Capture	Technology that captures carbon dioxide (CO_2) directly from the atmosphere. The captured CO_2 can be stored underground or used in various industrial processes, helping to reduce the overall concentration of greenhouse gases in the atmosphere.
DACCS	Direct Air Carbon Capture and Storage	A technology that captures carbon dioxide directly from the air and stores it underground. DACCS is considered a potential tool for mitigating climate change.
DER	Distributed Energy Resources	Small-scale power generation or storage technologies located close to where energy is used. DERs include solar panels, wind turbines, and battery storage systems.
DME	Dimethyl Ether	A clean-burning alternative fuel that can be produced from natural gas, biomass, or coal. DME is used as a substitute for diesel in transportation and as a propellant in aerosols.
EEDI	Energy Efficiency Design Index	A mandatory measure for new ships to ensure they meet minimum energy efficiency levels. EEDI promotes the design and construction of more energy-efficient vessels.
EEXI	Energy Efficiency Existing Ship Index	A measure of a ship's energy efficiency based on its design and technical specifications. EEXI is used to assess and improve the energy performance of existing ships.
EOR	Enhanced Oil Recovery	Techniques used to increase the amount of crude oil that can be extracted from an oil field. EOR methods include injecting water, gas, or chemicals into the reservoir.
EPA	Environmental Protection Agency	An independent agency of the United States federal government tasked with environmental protection matters. The EPA develops and enforces regulations to protect human health and the environment.
EPBD	Energy Performance of Buildings Directive	An EU directive aimed at improving the energy efficiency of buildings. EPBD sets minimum energy performance standards and promotes the use of renewable energy in buildings.

Abbreviation	Full Form	Meaning
ESG	Environmental, Social, and Governance	Criteria for measuring a company's sustainability and societal impact. Environmental criteria consider how a company performs as a steward of nature, social criteria examine how it manages relationships with employees, suppliers, customers, and communities, and governance deals with a company's leadership, audits, internal controls, and shareholder rights.
ETM	Energy Transition Mechanism	A financial mechanism to support the retirement of coal plants and the deployment of clean energy. ETM aims to accelerate the shift to low-carbon energy sources.
ETS	Emissions Trading System	A market-based approach to controlling pollution by providing economic incentives for reducing the emissions of pollutants. Companies are given or can buy a limited number of permits to emit a specific amount of greenhouse gases, and they can trade these permits with other companies.
EVs	Electric Vehicles	Vehicles powered entirely or partially by electricity, offering a cleaner alternative to traditional gasoline-powered vehicles.
FCET	Hydrogen Fuel Cell Electric Trucks	Trucks powered by hydrogen fuel cells, which generate electricity through a chemical reaction between hydrogen and oxygen. These trucks emit only water vapor and heat, offering a zero-emission solution for heavy-duty transport.
FCETs	Hydrogen Fuel Cell Electric Trucks (FCET)	FCETs are vehicles that use hydrogen fuel cells to generate electricity, which powers the truck's electric motor. They are considered a sustainable alternative to traditional diesel trucks, offering zero emissions and longer ranges suitable for heavy-duty and long-haul applications.
FEGP	Fixed Electric Ground Power	Provides electrical power to aircraft on the ground, reducing the need for running auxiliary power units or engines.
FLOW	Floating Offshore Wind	Wind turbines that are mounted on floating structures and anchored to the seabed. FOW allows for the development of wind farms in deeper waters where traditional fixed turbines are not feasible.
GDP	Gross Domestic Product	The total monetary value of all goods and services produced within a country's borders in a specific time period. It is a broad measure of a nation's overall economic activity and an indicator of economic health and growth.
GEODE	Geothermal Energy from Oil and Gas Demonstrated Engineering	A project exploring the use of geothermal energy in oil and gas operations. GEODE aims to demonstrate the feasibility of integrating geothermal energy into existing infrastructure.

Abbreviation	Full Form	Meaning
GFANZ	Glasgow Financial Alliance for Net Zero	A coalition of financial institutions committed to achieving net-zero greenhouse gas emissions by 2050. GFANZ supports the alignment of financial flows with climate goals.
GGFR	Global Gas Flaring Reduction Partnership	A World Bank initiative to reduce gas flaring and venting in oil production. GGFR promotes the use of associated gas for energy production and environmental protection.
GHG	Greenhouse Gas	Gases in the Earth's atmosphere that trap heat, contributing to the greenhouse effect and global warming. Common GHGs include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), which are released through activities such as burning fossil fuels, deforestation, and industrial processes.
GSE	Ground Support Equipment	Equipment used to support the operations of aircraft on the ground, including maintenance, servicing, and handling.
HFO	Heavy Fuel Oil	A type of fuel oil used in ships and industrial plants. It is a residual fuel, meaning it is the leftover product from the refining process of crude oil.
HVDC	High-Voltage Direct Current	A technology for transmitting electricity over long distances with minimal losses. HVDC is used for connecting renewable energy sources to the grid.
IATA	International Air Transport Association	A trade association for the world's airlines, representing about 290 airlines or 82% of total air traffic. It supports aviation with global standards for airline safety, security, efficiency, and sustainability.
ICAO	International Civil Aviation Organisation	A specialized agency of the United Nations that sets international standards and regulations for aviation safety, security, efficiency, and environmental protection. It works with member states and industry groups to ensure safe and orderly growth of international civil aviation.
IEA	International Energy Agency	An organisation that works to ensure reliable, affordable, and clean energy. It provides policy advice, data, and analysis on energy issues, and promotes energy security, economic growth, and environmental sustainability.
IMO	International Maritime Organisation	A specialized agency of the United Nations responsible for regulating shipping. The IMO sets global standards for the safety, security, and environmental performance of international shipping.
IoT	Internet of Things	A network of physical objects embedded with sensors, software, and other technologies to connect and exchange data with other devices and systems over the internet.

Abbreviation	Full Form	Meaning
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services	An international body that assesses the state of biodiversity and ecosystem services. IPBES provides scientific information to support policy decisions on biodiversity conservation.
IPCC	Intergovernmental Panel on Climate Change	A United Nations body responsible for assessing the science related to climate change. It provides policymakers with regular scientific assessments on climate change, its implications, and potential future risks, as well as strategies for mitigation and adaptation.
IRENA	International Renewable Energy Agency	An intergovernmental organisation that supports countries in their transition to a sustainable energy future.
ITMOs	Internationally Transferred Mitigation Outcomes	Units of greenhouse gas emissions reductions that can be transferred between countries under the Paris Agreement. They allow countries to meet their NDCs by purchasing emissions reductions from other countries, promoting international cooperation in climate action.
JETP	Just Energy Transition Partnership	A collaborative initiative to support countries in transitioning to sustainable energy systems. ETP focuses on policy development, capacity building, and technology deployment.
LEED	Leadership in Energy and Environmental Design	A certification program for green buildings. LEED provides a framework for healthy, efficient, and sustainable building design and construction.
LTO	Landing and Take-Off	Refers to aircraft operations close to airports, including taxiing, landing, take-off, and climb-out until reaching altitude or descent until final approach.
MARPOL	International Convention for the Prevention of Pollution from Ships	An international treaty designed to minimize pollution from ships. MARPOL covers various forms of pollution, including oil, chemicals, and garbage.
MASS	Maritime Autonomous Surface Ships	Ships that can operate independently of human intervention. These vessels use advanced technologies such as artificial intelligence and sensors to navigate and perform tasks.
MEPC82	Maritime Environment Protection Committee	A committee within the IMO responsible for addressing environmental issues related to shipping. The MEPC develops regulations to prevent pollution from ships.
MGO	Marine Gas Oil	A type of marine fuel that is lighter and cleaner than heavy fuel oil. MGO is used in ships' engines and is compliant with international emissions regulations.
MIGA	Multilateral Investment Guarantee Agency	An international financial institution that offers political risk insurance and credit enhancement to investors and lenders. It aims to promote foreign direct investment in developing countries by mitigating risks such as expropriation, political violence, and breach of contract.

Abbreviation	Full Form	Meaning
MMCZCS	Maersk Mc-Kinney Moller Centre for Zero Carbon Shipping	A research and development centre focused on decarbonising the maritime industry. The centre collaborates with industry stakeholders to develop sustainable shipping solutions.
NBS Activities	Nature-Based Solutions Activities	Actions that use natural processes and ecosystems to address societal challenges, such as climate change, water security, and biodiversity loss. These activities include reforestation, wetland restoration, and sustainable agriculture practices that enhance ecosystem resilience and provide multiple benefits.
NDC	Nationally Determined Contributions	Climate action plans submitted by countries under the Paris Agreement. They outline each country's efforts to reduce national emissions and adapt to the impacts of climate change, with the aim of limiting global warming to well below 2°C above pre-industrial levels.
NSAs	Non-State Actors	Entities that participate in international relations without being a sovereign state. They include organisations such as non-governmental organisations (NGOs), multinational corporations, and other groups that influence international policies and actions.
NZE	Net Zero Emissions	Achieving a balance between the amount of greenhouse gases emitted into the atmosphere and the amount removed or offset. This can be accomplished through a combination of reducing emissions and implementing carbon capture and storage technologies or other offsetting measures.
OGCI	Oil and Gas Climate Initiative	An initiative led by oil and gas companies aiming to demonstrate industry leadership in reducing greenhouse gas emissions.
OPS	Onshore Power Supply	A system that allows ships to plug into the local electricity grid while docked. This reduces emissions from ships' engines while they are in port.
Paris Agreement	Paris Agreement	An international treaty adopted in 2015 under the UNFCCC, aiming to limit global warming to well below 2°C, preferably to 1.5°C, compared to pre-industrial levels. It requires countries to set and communicate their climate goals through NDCs and to strengthen these efforts over time.
PCA	Pre-Conditioned Air	Air that is conditioned (heated or cooled) and supplied to an aircraft on the ground to maintain a comfortable cabin temperature.
PCA Unit	Pre-Conditioned Air Unit	A device that supplies pre-conditioned air to an aircraft on the ground, ensuring passenger comfort and reducing the need for onboard systems.
PIPE	Protecting the Infrastructure of Pipelines and Enhancing Safety Act	A US law aimed at improving the safety and security of pipeline infrastructure. The PIPES Act includes measures for preventing pipeline accidents and enhancing emergency response.

Abbreviation	Full Form	Meaning
SAF	Sustainable Aviation Fuel	Renewable or waste-derived aviation fuel that significantly reduces carbon emissions compared to traditional jet fuel. It is produced from sustainable resources like waste oils, agricultural residues, or non-food crops, and can be blended with conventional jet fuel to power aircraft.
SBT	Science Based Target	Targets for reducing greenhouse gas emissions that are in line with the latest climate science. These targets are designed to meet the goals of the Paris Agreement.
SDGs	Sustainable Development Goals	A collection of 17 global goals set by the United Nations in 2015. They aim to address a wide range of global challenges, including poverty, inequality, climate change, environmental degradation, peace, and justice, with a target to achieve these goals by 2030.
SEEMP	Ship Energy Efficiency Management Plan	A plan developed by ship operators to improve the energy efficiency of their vessels. SEEMP includes best practices for fuel-efficient operations and maintenance.
SETI	Single-Engine Taxi-In	Involves using only one engine for taxiing an aircraft when arriving at its destination to save fuel.
SETO	Single-Engine Taxi-Out	Means using just one engine during taxiing when departing from an airport, aimed at reducing fuel consumption.
SMRs	Small Modular Reactors	Compact nuclear reactors that can be built in factories and transported to sites for installation. SMRs offer a flexible and scalable option for nuclear power generation.
SSP2	Shared Socioeconomic Pathway 2	One of the scenarios used in climate modelling and research. It represents a “middle-of-the-road” pathway where social, economic, and technological trends follow historical patterns, providing a baseline for comparing other more extreme scenarios.
STEPS	IEA’s Stated Policies Scenario (STEPS)	STEPS is a scenario developed by the International Energy Agency (IEA) that evaluates the impact of current and announced energy policies. It provides a conservative benchmark for future energy system developments, focusing on the implementation of existing policies rather than speculative future actions
TCO	Total Cost of Ownership	The complete cost of acquiring and operating an asset over its entire lifecycle. TCO includes purchase price, maintenance, operation, and disposal costs.
TCX Risk Code (Lloyd’s)	TCX Risk Code (Lloyd’s)	A classification system used by Lloyd’s of London to categorise and assess various types of risks. It helps underwriters and insurers to evaluate the potential risks associated with different insurance policies and to manage their portfolios effectively.

Abbreviation	Full Form	Meaning
TISFD	Taskforce on Inequality and Social-related Financial Disclosures	A group focused on developing a framework for reporting on social and inequality-related financial risks. TISFD aims to enhance transparency and accountability in addressing social issues.
TRL	Technology Readiness Level	A scale used to assess the maturity of a particular technology. It ranges from TRL 1, which represents basic principles observed, to TRL 9, which indicates that the technology is fully mature and has been proven through successful deployment in an operational environment.
UNEP's Emissions Gap Report	UNEP's Emissions Gap Report	An annual assessment by the United Nations Environment Programme (UNEP) that evaluates the gap between anticipated future emissions and the levels consistent with limiting global warming to 1.5°C or 2°C. It provides insights into the progress of countries' climate commitments and highlights areas needing urgent action.
UNFCCC	United Nations Framework Convention on Climate Change	The UNFCCC is an international environmental treaty aimed at addressing climate change. It provides a framework for negotiating specific international treaties (called "protocols" or "agreements") that may set binding limits on greenhouse gases.
VCM	Voluntary Carbon Market	A market where carbon credits are traded voluntarily, outside of regulatory frameworks. Companies and individuals can purchase carbon credits to offset their emissions, supporting projects that reduce or remove greenhouse gases from the atmosphere.
Virtual PPA	Virtual Power Purchase Agreement	A financial agreement to purchase renewable energy. Unlike a traditional PPA, a virtual PPA does not involve the physical delivery of electricity. Instead, it is a financial contract that provides price certainty and renewable energy credits to the buyer.
VLSFO	Very-Low Sulphur Fuel Oil	A type of marine fuel with a sulphur content of 0.5% or less. VLSFO is used to comply with the IMO's 2020 sulphur cap regulations.
VPPs	Virtual Power Plants	A network of decentralized power generating units, such as solar panels and wind turbines, that are managed collectively. VPPs optimize the production and distribution of renewable energy.
VRE	Variable Renewable Energy	Refers to renewable energy sources such as wind or solar power that are not continuously available due to factors outside human control, like weather.
WELL	International WELL Building Institute	An organisation that promotes health and well-being in buildings through the WELL Building Standard. IWBI focuses on enhancing human health and comfort in the built environment.
WETO	World Energy Transitions Outlook	This report provides comprehensive pathways and strategies to transform the global energy system, aiming to meet the Paris Agreement targets. It emphasizes the need for accelerated

Abbreviation	Full Form	Meaning
		adoption of renewable energy and energy efficiency measures to achieve a sustainable and low-carbon future.
WTW	Well-to-Wake Emissions	The total greenhouse gas emissions from the production, transportation, and use of a fuel. Well-to-wake analysis helps in assessing the environmental impact of different fuels.
ZCBA	Zero-Carbon Building Accelerator	An initiative to support the development of zero-carbon buildings. ZCBA provides resources and guidance for achieving net-zero emissions in the built environment.
ZEMBA	Zero Emission Maritime Buyers Alliance	An alliance of companies committed to purchasing zero-emission maritime transport services. ZEMBA aims to accelerate the transition to zero-emission shipping.

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