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Risk revealed by Lloyd's

Clean technologies and hard-to-abate sectors

Lloyd's Futureset

AON

Carbon markets | CCUS | Low carbon buildings | Batteries and grid | Geothermal | Hard-to-abate sectors

Foreword

As extreme weather events are predicted to increase in frequency and severity in the years and decades ahead, there is an undeniable need for accelerated action across the public and private sectors. This action is crucial to build resilience, to adapt, and to create solutions that can reduce the impact of climate change.

For decades, the global insurance industry has been supporting individuals, businesses and governments in understanding, mitigating and managing the impact of increasingly severe climate-exacerbated disasters. Additionally, it has played an important role in supporting the development of renewable energy and climate innovation.

With 90% of the global economy committed to decarbonisation towards net zero, we are witnessing an unprecedented economic and societal transformation. Insurance continues to play a vital and unique role; enabling, investing in and protecting the efforts of multiple industries as they take climate-positive action to adapt and transition to a sustainable future.

This report, developed by Lloyd's Futureset and Aon, builds on the findings of Insuring a Sustainable Future— a report produced by the Sustainable Markets Initiative's Insurance Task Force, which highlights the opportunities for the insurance industry to support clients across five green technologies and three hard to abate sectors. These endeavours will, in turn, help to accelerate the transition towards a more resilient and sustainable future.

John Neal
CEO of Lloyd's and Chair of the Insurance Task Force

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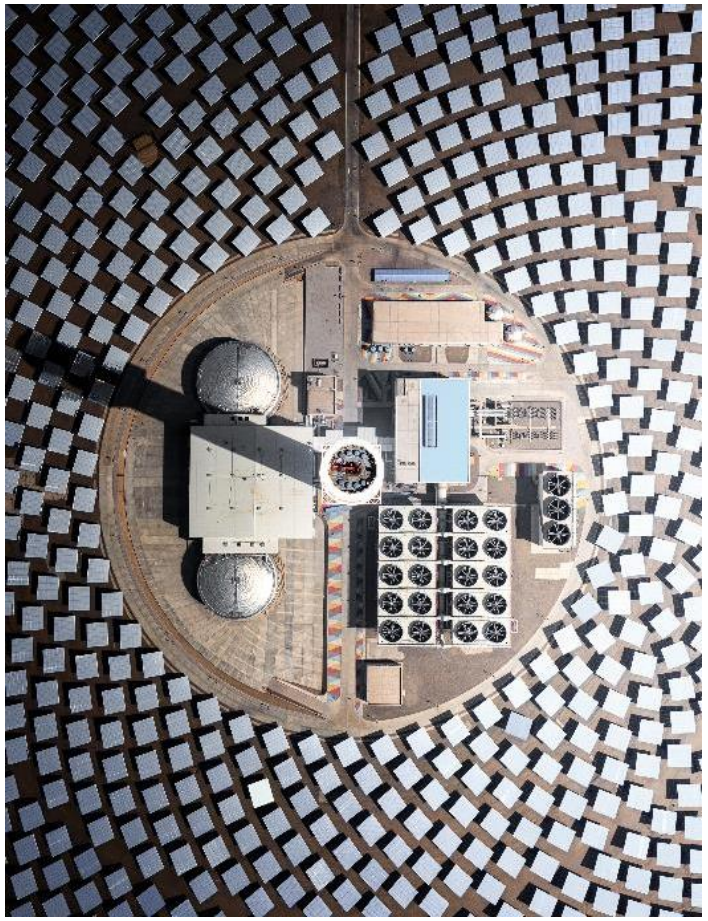
The insurance sector has a key role to play in enabling the growth of clean technologies, the scale up of emerging technologies, and the transition of hard to abate sectors

This report explores five emerging green technologies and three hard-to-abate sectors, highlighting the support that is already available from the insurance industry and how demand is likely to evolve over time

Insurance innovation across these technologies and sectors can support global progress and the acceleration of industry transitions towards a more resilient and sustainable future



Nascent technologies and emerging markets

- **Carbon markets**
- **CCUS**
- **Low carbon buildings**
- **Batteries and grid**
- **Geothermal**

Hard-to-abate sectors

- **Agribusiness**
- **Shipping**
- **Aviation**

Summary of key gaps, opportunities and themes

1. The insurance industry has an opportunity to develop and highlight a broader range of solutions across underwriting, investments and stewardship to better **demonstrate purpose-led impact ("nature, people and planet")**
2. While proven technologies such as solar and wind are critical to transition, **further support for emerging technologies will be crucial to facilitate a balanced, adaptable energy mix**
3. There is opportunity for the insurance industry to **support innovation in hard-to-abate sectors of the real economy, such as marine and aviation. In addition, insurers could look to form sector-based partnerships which encourage behavioural change to better support sustainable goals**

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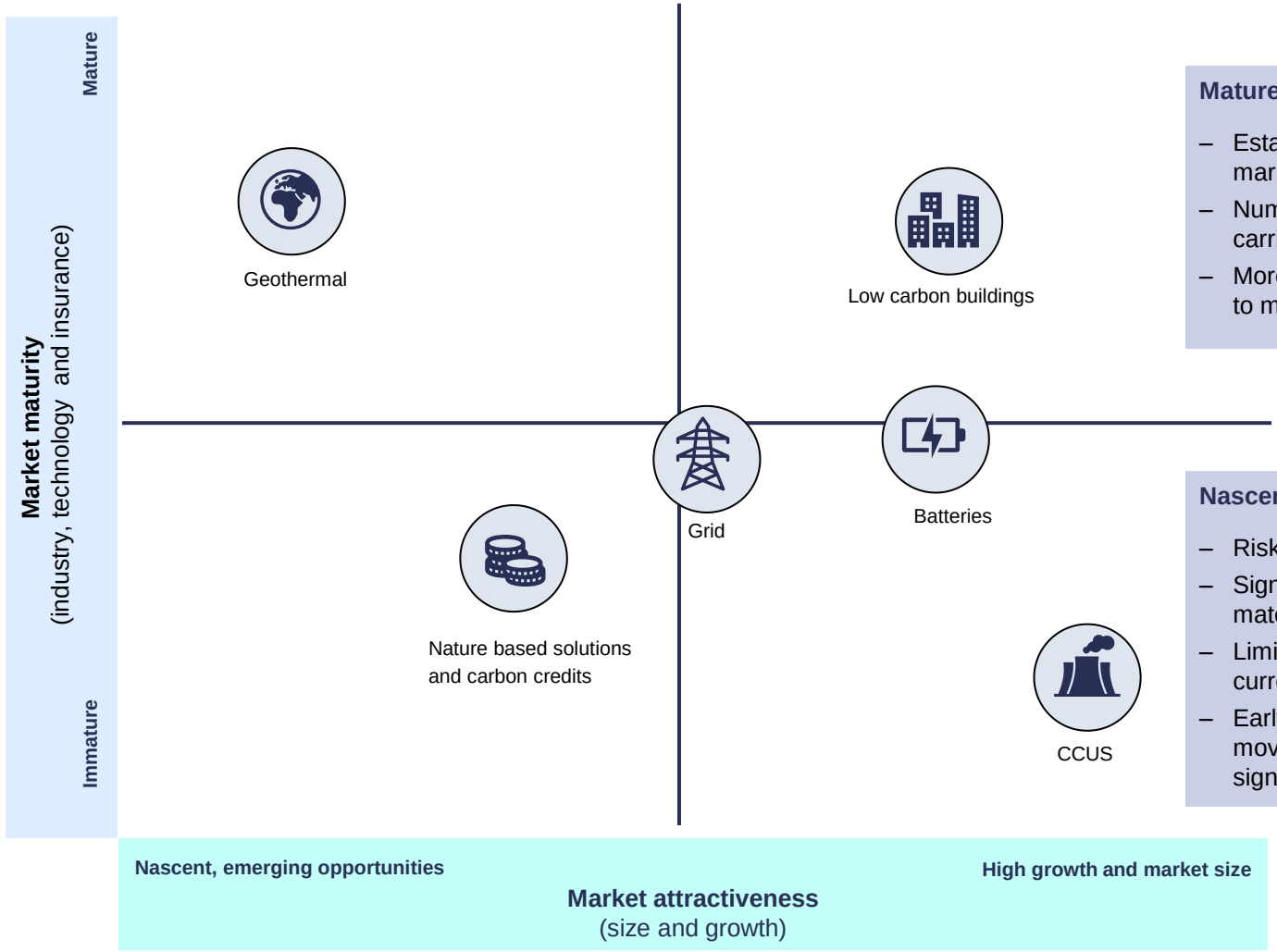
Building a larger presence in emerging 'transition' technologies could help the insurance industry to lead innovation and grow sustainably

Opportunity assessment

The relative positioning of opportunities for the insurance industry have been weighted by:

1. **Attractiveness,** which considers both the growth and size of the market, and
2. **Maturity,** which takes into account both the wider industry and insurance market

	Criteria	Weighting
Market attractiveness	Growth	50%
	Size	50%
Market maturity	Maturity of industry	25%
	Maturity of tech	25%
	Insurance capacity	25%
	Insurance product maturity	25%



Mature, sizeable existing markets

- Established insurance products in market
- Number of existing products and carriers
- More innovative products required to meet emerging risks

Nascent, emerging opportunities

- Risks currently less known
- Significant opportunity expected to materialise in the longer term
- Limited insurance capacity currently
- Early action could support early mover advantage and capture significant future growth

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Carbon offsets are one of the most effective ways to reduce the impact of emissions for hard-to-abate sectors while net zero technology pathways continue to develop

Industry and insurance market dynamics

Carbon offsets are one of the most effective ways to reduce the impact of emissions for industries that are particularly difficult to de-carbonise – currently natured based solutions (NBS) projects form the basis of most carbon offsets.

For many companies that have committed to reaching net-zero emissions targets, carbon offsets will be needed to mitigate emissions they cannot otherwise avoid

Offset providers	Offset buyers
Native Energy	General motors (GM)
Sustainable Travel International	Barclays
Terrapass	Shell
MyClimate	Disney
3Dgrees	Toucan
	Delta

Increasing scrutiny is being placed on claims made by buyers of carbon offsets.

Delta Airlines currently faces a class action lawsuit alleging its carbon neutral claims, based on carbon offsets, are "false and misleading"

Key Growth Drivers

- **Net Zero targets**
- **Market size and sophistication**
- **Growth in tech-based products**

Headwinds

- **Worsening climate events**
- **Political risks**
- **Carbon offset legitimacy**

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Regulated entities in the real economy use compliance markets to meet their carbon emissions caps or baselines, while voluntary markets provide access to offsetting for all

Carbon markets overview

There are two key markets enabling the trading of carbon-related financial instruments, underpinned by a range of projects focused on emission avoidance and carbon removal:

Compliance markets (CCMs)

In a **compliance market**, regulated entities **buy and sell carbon allowances** to remain under pre-determined regulatory carbon emissions caps or baselines

Compliance markets are created and regulated by mandatory **national, regional, or international** carbon reduction schemes

Voluntary markets (VCMs)

In a **voluntary market,** individuals, companies and governments **trade carbon offsets** to reduce their carbon emissions footprint voluntarily

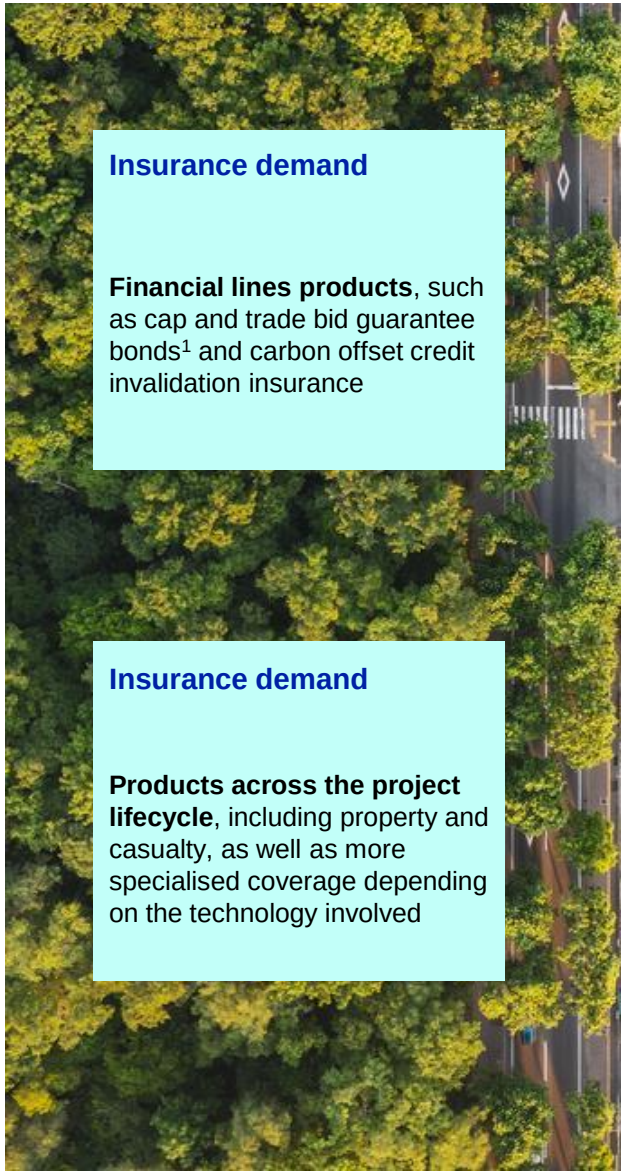
Participation in the voluntary market is **primarily motivated by corporate social responsibility (CSR)** and public relations, but many participants also treat carbon as any other financial instrument for trading

Typical sectors regulated with cap or baselines

Electricity and heat generation	Oil, acids and chemicals	Metals, glass, ceramics
Aviation and shipping	Pulp, paper and cardboard	Cement, lime

Projects issuing carbon offsets, certified and verified emissions reductions (CERs and VERs)

Forestry and land Use	Renewable energy	Chemical/ industrial	Household and community
Waste disposal	Energy efficiency	Agriculture	Transport



Insurance demand

Financial lines products, such as cap and trade bid guarantee bonds[1] and carbon offset credit invalidation insurance

Insurance demand

Products across the project lifecycle, including property and casualty, as well as more specialised coverage depending on the technology involved

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The term "carbon credits" is regularly used to describe "carbon allowances" and "carbon offsets"

Carbon markets overview

	Carbon allowance	Carbon offset
Definition	A **carbon allowance** is a tradable permit or certificate to emit one metric tonne of CO_2 or equivalent greenhouse gas (GHG)	A **carbon offset** is a certificate awarded for a proactive initiative that reduces or removes emissions
Associated market	**Compliance markets** ("cap-and-trade" and "baseline-and-credit" systems) **1. Primary markets** – Issuer is typically the state/a relevant authority of the state **2. Secondary markets** – CCM scheme participants trade allowances directly but also use secondary markets to trade allowances as spot trades, forwards, or derivatives (futures and options)	**Voluntary markets (VCMs) and compliance markets (CCMs)** **1. Primary markets** – CCM issuer typically the state/a relevant authority of the state **2. Secondary markets** – CCM scheme participants buy offsets directly, but also use secondary markets, trading allowances as spot trades, forwards, or derivatives (futures and options)
Regulation	**Compliance market** – Government or state-led schemes for carbon allowances	**Voluntary market** – The standard issuer or registry generally sets methodology and criteria for project certification and generation of carbon offsets, but project developers may also propose new methodologies for programme approval and adoption **Compliance market** – Individual regulators set their own rules defining which offset projects are eligible to count towards meeting compliance requirements. Voluntary offsets, unless explicitly accepted into the compliance regime, are not allowed to fulfil compliance market demand
Description	– In a **cap-and-trade scheme** (e.g. California cap-and-trade scheme, EU ETS[2] and the RGGI[3]), an upper limit (cap) on emissions is fixed, and carbon allowances are either issued for free based on specific criteria or auctioned – Under a **baseline-and-credit scheme** (e.g. the Technology Innovation and Emissions Reduction Regulation in Alberta, Canada), baseline emissions levels are defined for individual regulated entities, and credits are issued to entities that have reduced their emissions below this level, which they can sell to others looking to stay below their baselines	– In the voluntary carbon market, entities that are not regulated as part of an existing government scheme and even individuals, can purchase carbon offsets in order to reduce their carbon footprint – Some regulated entities may buy or trade carbon offsets to make up a small proportion of their emissions reductions (where permitted[4]), or to voluntarily exceed their required baseline, or reduce below their cap

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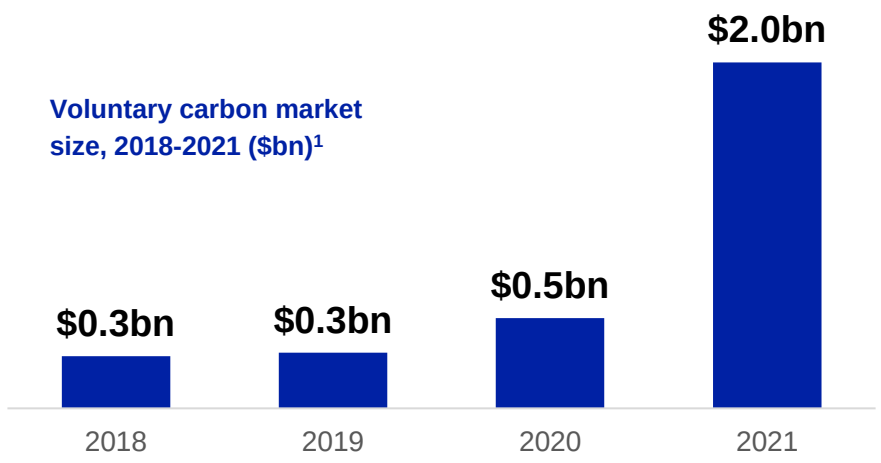
There will be an increasing demand for insurance products to support organisations, as more start to leverage carbon offsetting to meet their emissions targets

Global investment breakdown



Current market trends

- The voluntary carbon market declined at a -21% CAGR from 2011 - 2017, before growing significantly at an 89% CAGR between 2018 and 2021
- The **281% increase in market size from 2020 to 2021** was driven by rising prices for traded carbon offset credits for projects such as reforestation, "blue" carbon from initiatives involving coastal and marine ecosystems, and avoided forest conversion
- Global climate and sustainability goals, such as net zero pledges, are driving growing demand in the voluntary carbon market

Growth drivers

Net zero targets – Already over 20% of the world's largest 2,000 companies have committed to reaching net zero emissions, and more are continuing to do so. Carbon offsets play a key role for many of those companies

Market size and sophistication – Voluntary carbon markets are becoming larger and more sophisticated, providing more options for companies to purchase offsets

Growth in tech-based projects – NBS carbon offsets are currently the focus of carbon offset projects, however post 2030 it is expected that tech-based offset projects will likely outpace nature-based solutions

Headwinds

Worsening climate events – Many naturally-based carbon offset projects are particularly exposed to natural catastrophe events such as forest fires and hurricanes. Worsening climate conditions could pose a significant threat to the industry

Political risk – The Zimbabwean Government recently announced all existing carbon contracts will be voided to introduce a new revenue split arrangement for emission reducing projects. This could occur in other nations, opening up further political risks

Carbon offset legitimacy – Some NBS schemes have come under investigation over their credibility. A study on schemes in the Brazilian Amazon found they had overstated their emission reductions. Additionally, new EU proposals aim to ban environmental claims based solely on carbon offsetting

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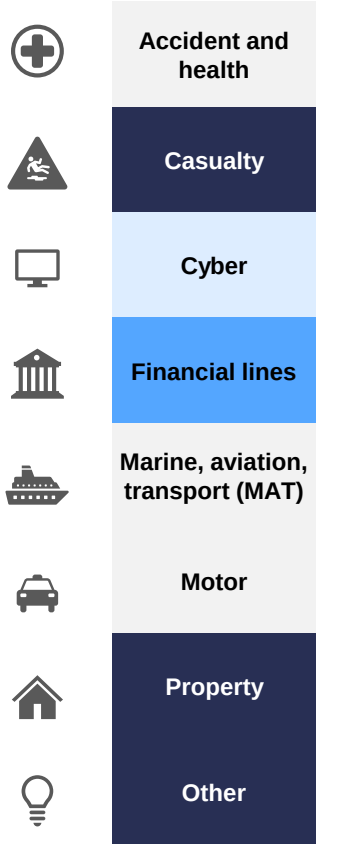
Carbon offset projects require both standard and specialist products. Insurers are well placed to work with developers to tailor their offerings whilst facilitating positive solutions

(Re)insurance class of business impact



Key coverage sought for NBS projects

Property: Protection against physical losses to assets that generate carbon offsets. For example, natural disasters and pest infestations can damage or destroy forests, wetlands and mangroves. Coverage for project developers can include ecosystem restoration costs and carbon revenue loss protection for specified events

Casualty (environmental liability): Protection against the risk of carbon offset projects resulting in negative environmental impacts. This may include compensation to 3rd parties for property damage, clean-up costs, statutory clean-up notices and natural resource damages

Other – political risk: Protection against the changing political landscape and instability in some of the project host countries. Specifically, policies can protect against invalidation, seizure, and other political and regulatory risks arising from government actors

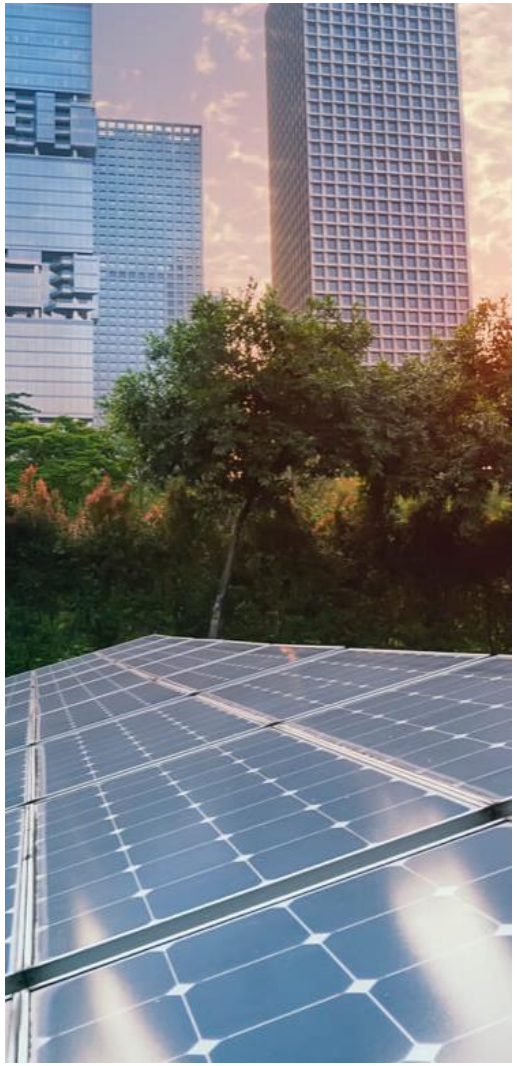
Other – financial lines[1]: Protection against losses arising from commercialisation of the Carbon Credit such as crime coverage to help protect against illegal logging and fraud, credit insurance, surety bonds and carbon credit invalidation insurance as well as negligent or deliberate misrepresentation

Gaps in coverage currently offered

- Risk of **property damage** from natural catastrophes are well covered in the existing insurance market but increased frequency and severity means **capacity is reducing at a time when demand is increasing**
- There is an increasing demand for **parametric solutions** to provide indemnity in case of severe weather-related risks, due to quick deployment of a pre-determined payment. However, lack of understanding in the market, difficulty in assessing the data in a changing landscape, and lack of reinsurance capacity means there are **few offerings currently in the market**
- **Environmental liability** products on offer for NBS generally are limited to high value projects with only the large global carriers having appetite due to the complex and rapidly changing regulatory environment
- Some carriers have started to offer protection in the event of **carbon storage site leaks** via Environmental Liability insurance but products in this area are currently very limited
- **Regulatory risks** are not covered in the market and regulatory bodies have stepped in to offer political risk cover in the absence of offering from the private market. E.g. The World Bank's insurance arm, the Multilateral Investment Guarantee Agency (MIGA) announced in June 2023 that it intends to step in to offer political risk insurance and facilitate investment in NBS
- **Cap and trade bid guarantee bond products** have been developed for the compliance market to guarantee pay out if an auction participant is awarded carbon credits. However, these are in their infancy with only one product currently on the market and product design considerations will be key to conform with regulatory guidance and requirements
- Also available in the market is **underperformance**, **reversal and fraud cover** which includes risks such as same credits being sold to multiple owners as well as other cover such as third-party negligence
- There is currently no coverage for products that specialise in carbon offset verification for example, errors and omissions cover

New insurance solutions are being developed to protect both compliance and voluntary carbon markets

Example market offerings



Provider	Product	Market	Product description
Marsh	**Carbon offset credit under-performance, reversal & fraud**	**Voluntary**	– Marsh's insurance addresses key risks associated with buying carbon offset credits in the unregulated VCM – Risks include schemes not delivering anticipated amount of sequestered carbon, captured carbon being lost, or purchaser being a victim of fraud
AON	**Cap and trade bid guarantee bonds**	**Compliance**	– The bonds serve as a financial guarantee to the auction administrator that the qualified bidder will remit payment for any allowances the bidder wins at auction – These bonds are used in California to meet its goal of reducing GHG emissions
HOWDEN	**Carbon offset credit fraud and negligence cover**	**Voluntary**	– Protects purchasers of carbon offset credits in the voluntary market in partnership with Respira International and Nephila Capital, launched in 2022 – Provides cover for third-party negligence and fraud, backed by lead capacity from Nephila and other Lloyd's syndicates
VOLANTE GLOBAL	**Carbon offset credit invalidation insurance**	**Both**	– Protects carbon offset credit purchasers against loss due to the invalidation of credits held on their balance sheet – In the event of invalidation, the product provides funds to purchase replacement credits
Kita	**Carbon Credit Purchase Protection cover**	**Voluntary**	– Kita was part of the Lloyd's Lab eighth cohort and was approved as a Lloyd's coverholder in December 2022 – Kita launched its product in early 2023, which protects the purchaser of carbon offset credits against under-delivery where seller fails to deliver credits on the terms specified in purchase agreement
Oka	**Comprehensive carbon offset credit protection[1]**	**Both**	– Oka is seeking to offer comprehensive insurance policies to replace carbon offset credits that have been reversed, invalidated, double-counted, or stolen – Oka launched in early 2023, raising over $7m in a seed funding round led by Aquiline Technology growth
Parhelion	**California Air Resources Board carbon offset credit invalidation insurance**	**Compliance**	– Provides protection to the project developer in the case of carbon offset credit invalidation per the California Cap & Trade Programme Regulations, with the owner of the underlying credits receiving the relevant compensation – This is the oldest product in the carbon credit market, launched in 2011

1 Executive summary

2 **Nascent technologies and emerging markets**

- Carbon markets
- **CCUS**
- Low carbon buildings
- Batteries and grid
- Geothermal

3 Hard-to-abate sectors

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Carbon capture technology development is gaining momentum, with up to 200 projects planned by 2030, many of which require both standard and specialist insurance products

Industry and insurance market dynamics

- CCUS refers to a suite of technologies that enable mitigation of CO_2 emissions from large point sources such as power plants, refineries, and other industrial facilities
- In the IEA Clean Technology Scenario, which sets out a pathway consistent with the Paris Agreement, CCUS contributes almost one-fifth of the emissions reductions needed across the industry sectors, particularly in hard-to-abate areas
- **The development of the CCUS market varies greatly across regions where North America sees a proliferation of smaller projects, whilst Europe and Asia see fewer, larger projects**

200+

The IEA project pipeline includes announced ambitions for 200 new carbon capture facilities to be operating by 2030 capturing over 220MT CO_2 per year

The CCUS process involves CO_2 capture, transportation and storage in geological formations or use in certain industries (e.g. food). There are several key stakeholder types throughout the CCUS process which will may have differing insurance requirements

1) Capture

Capture by combustion or direct air capture

2) Transportation

Through pipelines, by water or rail and road tankers

3) Storage and uses

Deep geological storage, mineral storage or direct usage

Key growth drivers

- **Government regulation**
- **Provides an emissions stopgap**

Headwinds

- **High cost of production**
- **Technological maturity**
- **Public perception**

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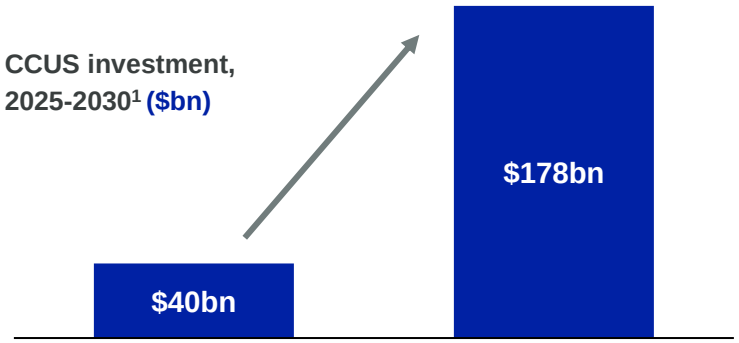
Investment in CCUS is expected to grow significantly towards 2030 as it becomes more commercially viable through policy change, incentives and technology maturity

Global investment breakdown



Current market trends

- CCUS project performance remains uncertain – as of 2022, research globally notes that 80% of projects have either failed to launch, or failed after launch
- Global policy changes are garnering increasing interest in CCUS:
  - **US – $3.7bn** investment in CO_2 removal projects under the Biden administration
  - **UK – £1bn** CCS Infrastructure Fund formed (CIF)
  - **APAC – $1.2bn** investment, largely from projects in Australia and Malaysia

Growth drivers

Government regulation - Stronger climate targets and investment incentives through government regulation have injected new momentum into the market e.g. UK CCF Infrastructure Fund, $3.7bn Biden administration investment

Provides an emissions stopgap - CCUS provides fast temporary solutions to allow nations to continue to use high emitting industries whilst still limiting their emission

Headwinds

High cost of production - CCS technologies remain costly to implement, construct and operate. Additionally, the cost of infrastructure to support CCUS including pipelines and storage sits remains expensive, especially in regions where alternative lower-cost technologies are available

Technological maturity - Next-generation carbon capture technologies are seeking to use less energy, be lower cost and enable the large-scale capture of CO_2

Public perception - The public remain concerned around the capture and storage of CO_2 and the potential for leakage risks and environmental impacts. Governments and other actors are seeking to address these concerns through education and engagement

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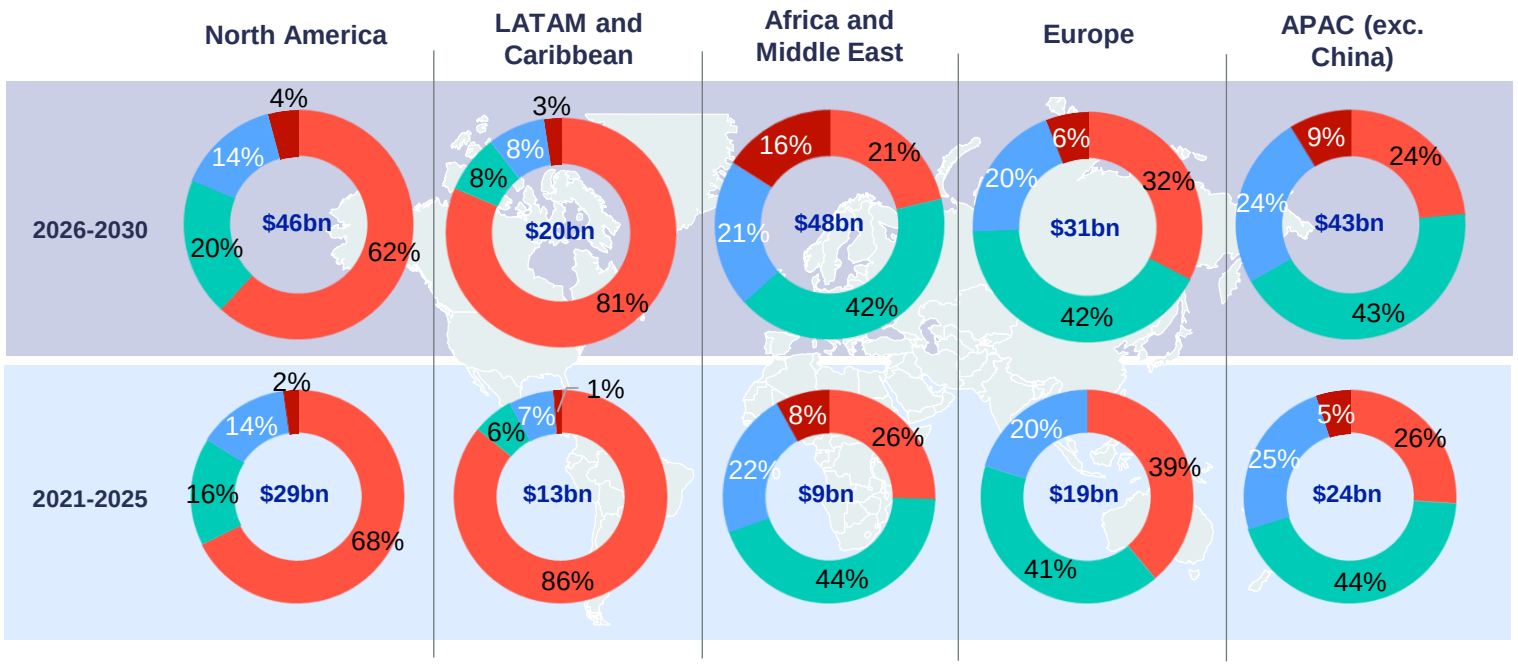
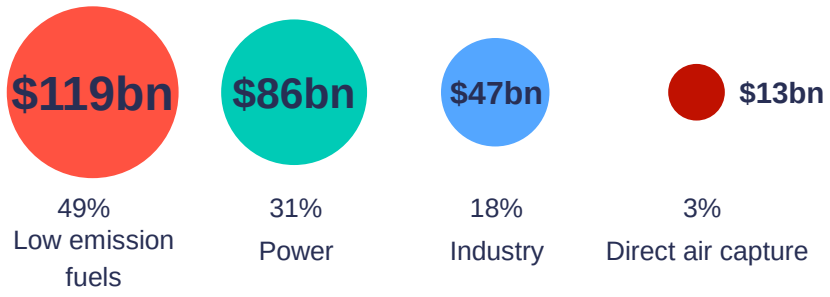
The US is the global CCUS leader, with regulated industries driving investment in CCUS to limit overall carbon emissions

Global carbon capture investment

Overall global CCUS investment, $bn 2021-2030





Regional region regulatory outlook

North America

The US is the global CCUS leader, accounting for 60% of current and 50% of planned future capacity, with 85% of emissions coming from plants located within 100km of a planned CCUS site

Mexico developed a legal framework through a study supported by World Bank to test and identify adjustments for their current legal process

LATAM and Caribbean

Trinidad and Tobago are looking to replicate the same model as the UK and become a carbon hub for the region

EU

Most of Europe's offshore CO_2 storage capacity is in the North Sea, where there are numerous oil and gas fields and saline aquifers

In the EU, the CCS directive provides a comprehensive legal framework ensuring fair and open access to CO_2 storage sites

APAC ex. China

Indonesia is a front-runner in Asia with regards to creating regulatory frameworks for CCUS activities

Australia is planning to scale up its CCUS capabilities to meet demand form top buyers such as Japan and Korea

Middle East & Africa

C. 90% of power in South Africa is generated through fossil fuels, of which 72% is coal. Two power stations are now equipped with CCUS

Middle East currently has 3 operational CCUS facilities, 2 CO_2-EOR projects in Saudi Arabia and Abu Dhabi and a CCS project in Qatar

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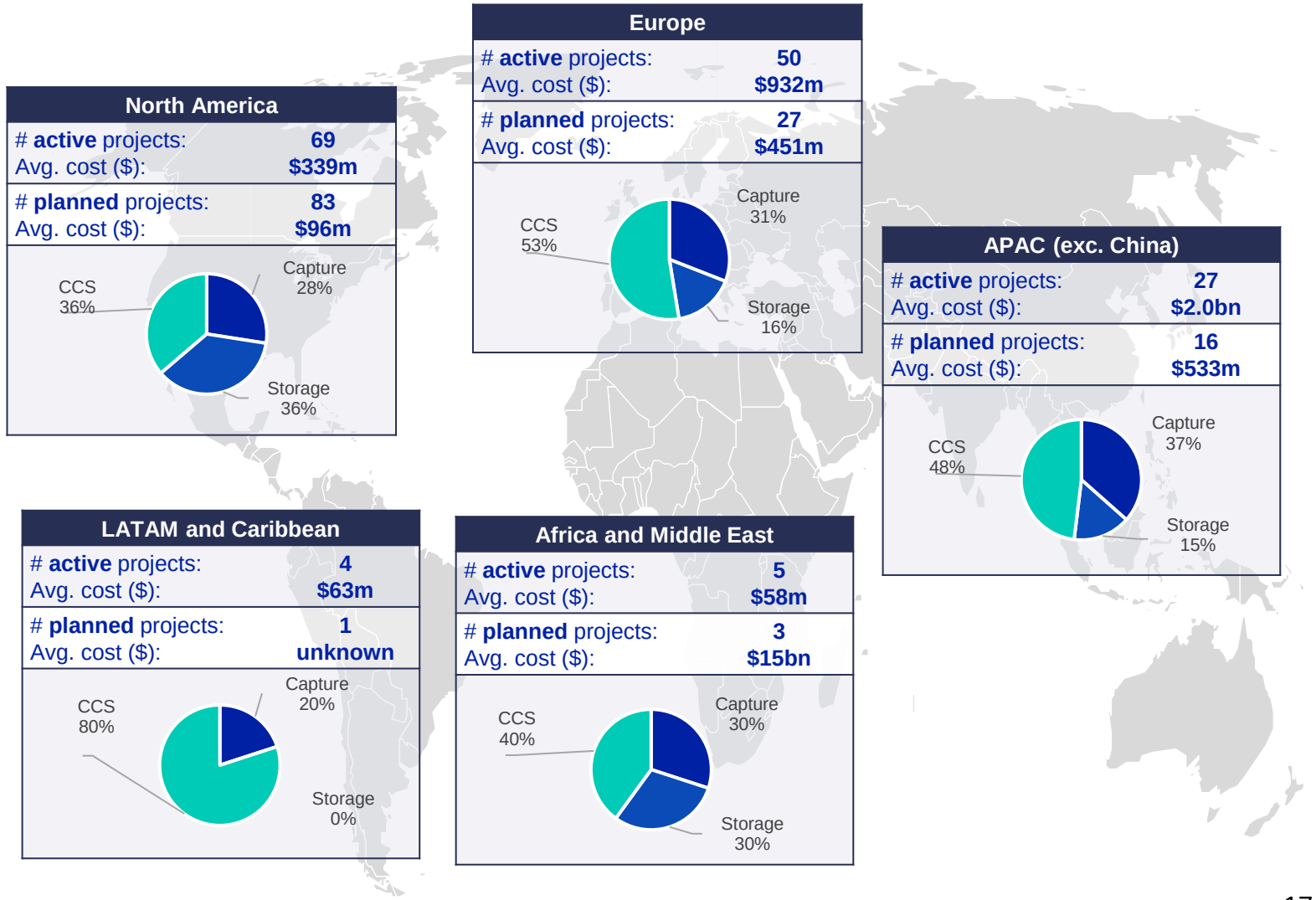
The US's mature fossil fuel industry combined with investment from the DOE's Office of Fossil Energy has resulted in a strong pipeline of lower cost CC projects

Regional considerations

- **United States:** leaders in CCUS due to an abundance of oil and gas reserves, 45Q tax credit incentives for CCUS projects and public partnerships driving technology development
- **Australia:** gas companies need to quickly adopt to CCUS to continue operating under Australia's ambitious 2030 GHG reduction target (26-28%)
- **Canada**: hopes to capture and store 15 million tons of CO_2 per year by 2030. This is expected to contribute to the country's goal of reducing GHG emissions by 40–45% from 2005 levels
- **Norway:** initiative "Longship" is solely committed to facilitating a cost-effective solution to CCUS, with up to 2/3rds of funding for CCUS projects being provided by the government
- **United Kingdom:** government approach sets out the plan to deliver 4 CCUS low carbon industrial clusters. The North Sea offers high potential for storage due to extensive reservoirs, good geology, existing infrastructure with appropriate regulations and low Nat Cat exposure
- **Japan:** is a global leader in the manufacturing industry, and CCUS could help keep many of its thermal power generation assets online while achieving their ambitious 2030 GHG targets (31% to 37% below 2013)

Regional plant size and status



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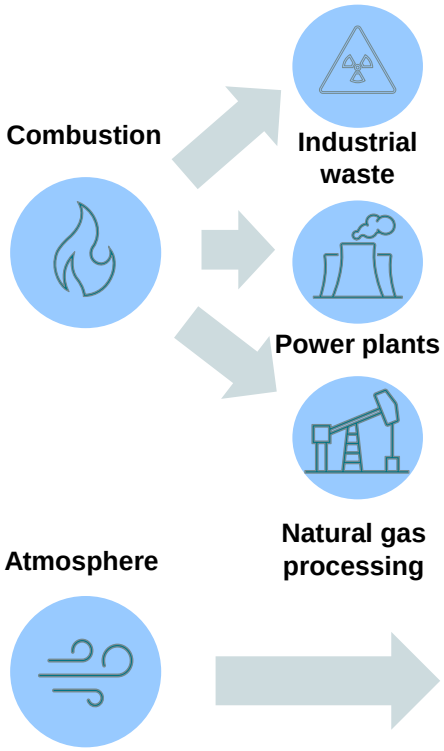
CCUS provides a near-term solution for carbon emissions control in hard-to-abate sectors, insurance needs for stakeholders across the value chain are expected grow

Carbon Capture | Filtration | Transportation | Storage and uses



Post-combustion
- CO_2 is captured from the exhaust gases and most used by power plants

Pre-combustion
- Traps the CO_2 before burning the fossil fuel by using a gasifier to form synthetic gas. The hydrogen produced from this can be used as fuel, the production of fertiliser, chemical gas fuel, and power production

Oxyfuel combustion
- Burning the fuel in pure oxygen instead of air, produces only water and CO_2 allowing easy filtration. Used by modern power stations

Direct air capture
- It is possible to scrub CO2 from the open atmosphere, but efficient processes are still being researched. The estimated energy needed is only slightly more than for capture from large emission

Pipelines

Pumping though pipelines is the cheapest and most reliable technology

Water

Rail and road tankers

Deep geological storage
- Also known as 'geo-sequestration', storage in deep geological formations such as: Sedimentary rocks, 'Un-mineable' coal and Saline aquifers

Mineral storage
- Captured CO_2 is reacted with naturally occurring iron (Fe), magnesium (Mg) and calcium (Ca) minerals.

Uses
- Power Stations: Enhanced oil recovery
- Food Industry: using CO_2 in soft drinks, dry ice for transportation
- Feedstock: convert to polymers, building materials, chemicals, and synthetic fuels
- Combine with hydrogen to produce fuel by combining it with hydrogen "Power-to-X" solution

Key stakeholders		
– Power plants – Steel, concrete manufacturers – Refineries – Food industries	Sourcing, processing/preparation, and storage are largely handled by the same stakeholders, with occasional specialist support	– Oil production companies – Food industries – Chemical plants – Private fuel companies

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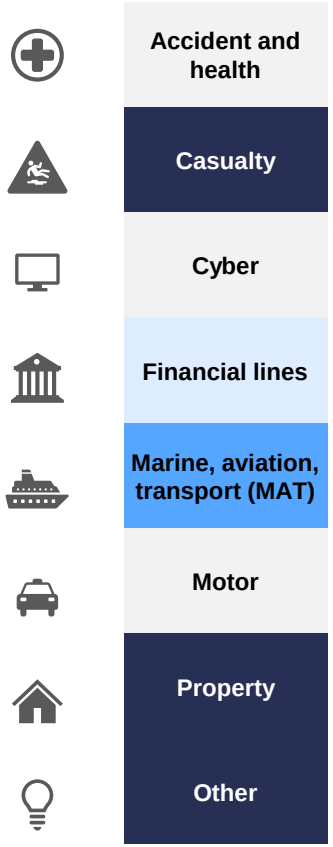
Whist the CCUS market is still developing, there is a clear opportunity for insurers to use their experience in tailoring standard products to transition innovation

(Re)insurance class of business impact



Impact

High	Med	Low	-

Key coverage sought for CCUS projects

Other (construction): Construction/erection all risks (CAR/EAR), decennial liability and delay in start-up (DSU) coverage will become increasingly popular, as new projects exit design phases and begin construction in the coming years

Property: Operations cover related to business interruption and property damage

Environmental liability (casualty): Storage site leaks both onshore and offshore could impact the underlying ecosystem and cause environmental damage

Financial lines[1]: Surety and trade credit coverages, e.g. for raw materials traded across international markets

MAT: Pumping CO_2 through pipelines is the cheapest and most reliable technology, but there will also be instances of transportation on water or using rail or road tankers

Gaps in coverage currently offered

- **Construction** covers such as CAR/EAR, decennial, DSU and loss of well control are risks considered standard in the market and well covered by the construction market. However, as investment increases and the technology becomes more prolific there is like to be an increased need for specialist standalone insurance which is currently limited in the market
- Clusters, such as the East Coast Cluster in the UK, offer significant opportunity, as does the retrofitting of current processes for CCUS

- Few projects are expected to be **operational** in the short term, thus currently low demand exists for operational programmes
- The operational stage poses additional complexity due to variance in the business models of CCUS clients compared to traditional energy clients e.g. Exploration & Production (E&P) clients

- **Liabilities related to CO_2 storage** and "cavern integrity" have generally been considered "uninsurable" by the market with no insurance coverage available
- Additionally, there is **limited cover for CO_2 leakage indemnity** due to a lack of detailed understanding in the market of the geology
- Few carriers are offering third party liability, pollution clean-up under construction, operational, decommissioning and post-close phases

- Limited cover available in the market to cover **leakage risk and associated loss of carbon tax breaks or tax credits**
- Cover not generally available for revenue guarantee or technology performance issues

- **Pipelines cover** is available via natural resources teams and marine transport via marine teams

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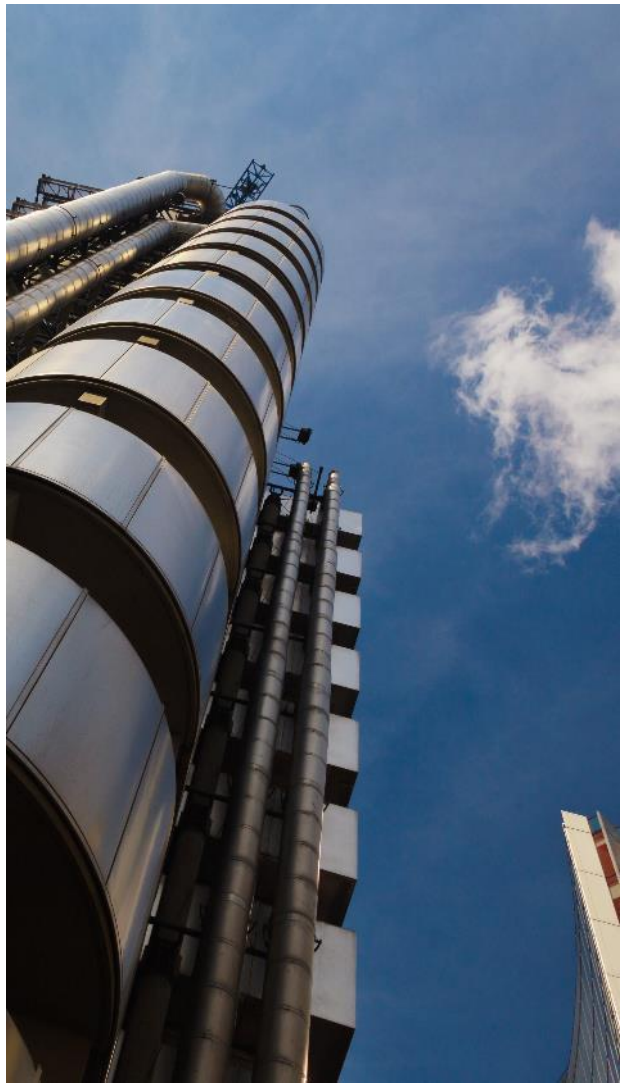
CCUS construction risks are typically well supported by the insurance industry, with new solutions emerging to cover more specific risks related to carbon capture

Example market offerings



Provider	Product description
Marsh	– Long-term insurance structures for the operation and maintenance of **carbon capture, utilisation and storage** infrastructure – Also provides insurance to cover the loss of value of the carbon captured if there is a failure of containment
Liberty Mutual Insurance	– Through its wholesale business arm, Ironshore, Liberty Mutual has expressed ambitions to broaden its **environmental liability** coverage to protect against CCS risks (through SPILLS[1] and CELL[2] product lines), which could include pollution cover, financial insurance, and tax credit cover – Liberty would evaluate coverage options on a risk-by-risk basis
ZURICH	– Zurich offers **Carbon Capture and Sequestration (CCS) liability** insurance, which covers losses associated with these operations – It also offers '**Geological Sequestration Financial Assurance**' which ensures a steady source of finance after a plant closes to "cap" the well and monitor the carbon stored
AON	– Aon is in the process of developing a variety of products to support the Construction and Operations lifecycle of CCS projects, with pre-and post-combustion capture technologies, Direct Air Capture and CO_2 Enriched Concrete, as well as other technologies in scope
HOWDEN	– Howden has launched a first-of-its-kind insurance facility covering the leakage of carbon dioxide (CO_2) from commercial-scale carbon capture and storage facilities

Example industry partnerships

Climeworks and Swiss Re strategic partnership

– Orca was the first Direct Air Capture (DAC) facility of scale in the world and is an initiative by Climeworks

– Swiss Re committed to its own net zero operational emissions by 2030 through a 10-year DAC and storage purchase agreement with Climeworks, along with agreement to collaborate on developing risk management knowledge and risk transfer solutions

1 Executive summary

2 **Nascent technologies and emerging markets**

- Carbon markets
- CCUS
- **Low carbon buildings**
- Batteries and grid
- Geothermal

3 Hard-to-abate sectors

Low carbon buildings

LLOYD'S

Buildings account for a large proportion of global energy consumption and GHG emissions, making retrofits and green property coverage critical components of the net zero transition

Industry and insurance market dynamics

Retrofitting aims to reduce the associated environmental impacts through upgrading the building using modern technologies to retrofit better energy management and efficiency, improving ventilation, and reducing heat loss

Green property is any plan, project or technique that might lessen or eliminate negative environmental impacts whilst minimising future impacts e.g. by installing new heating tech such as Heat pumps and Hydrogen boilers

c.40% **of global energy consumption is through buildings, along with 25% water usage, and 33% greenhouse gas emissions**

Developers/investors/ manufacturers	Government organisations	Financial institutions
In most markets developers/ investors will be responsible for insurance	In certain jurisdictions the government is responsible for insurance and are key owners of low efficiency buildings	Owners of large real estate portfolios will be likely key clients
Honeywell	Worcester Bosch Group	European Investment Bank	Infrastructure Ontario	J.P. Morgan	Blackstone
Johnson Controls	Viessmann	New York Sate of Opportunity	Canada Infrastructure Bank	Schroders	Brookfield Asset Management

Key growth drivers

- **Legislation**
- **Futureproofing**
- **Net zero targets**

Headwinds

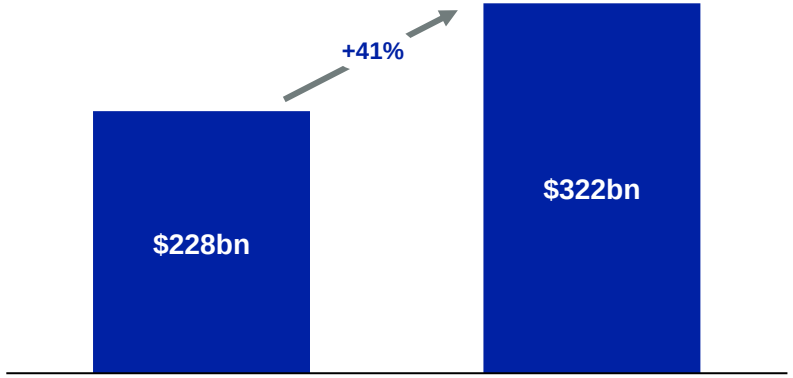
- **Greenwashing**
- **Supply chain issues**
- **The role of technology**

LLOYD'S

While investment is expected to grow, a lack of consistency in policy is likely to hamper acceleration of retrofits for commercial properties

Global investment breakdown

Retrofits and green buildings (heating[1]) investment, 2025 – 2030 ($bn)[2]



Current market trends

- The Renovation Wave in the European Green Deal aims to renovate 35 million inefficient buildings by 2030, funded by NextGenerationEU and private institutions
- However, it is estimated that €200bn p/a would be needed to meet the current net zero targets, and the current rate of retro-fitting would need to be tripled
- Lack of long-term clarity and certainty about the policy and regulatory strategy for decarbonising buildings and lack of trust due to previous policy failures is likely to hamper acceleration of retrofits for commercial properties

Growth drivers

Legislation and incentives – The UK government now requires all >£5m a year government contracts to commit to net-zero by 2050, whilst from 2027-30, in the EU, it will be mandatory to disclose all potential emissions over the building's lifecycle. In the US, the Inflation Reduction Act of 2022 included >$5 Billion incentives to drive low carbon procurement in buildings and construction

Futureproofing – In a post-pandemic world, there is a renewed drive to shift towards sustainable practices, whilst minimising shocks to livelihoods and ensuring societal changes are resilient to any future, unexpected economic shocks

Net zero targets – It is estimated that the global construction sector must decarbonise by almost 100% by 2050 to ensure Paris Climate agreements are achieved

Headwinds

Greenwashing – 'greenwashing' claims may arise against construction professionals as developers focus on sustainability and energy performance. Developers may make bold 'net zero' claims, with a resultant risk of litigation if those claims aren't met

Supply chain issues – Post pandemic there have been supply issues with building materials. The drive to build green may exacerbate these issues with the requirement to only use green materials, therefore leading to delays on completion dates or the installation of non-green products

The role of technology – From June 2022, all new residential buildings in England and Wales required to have electronic vehicle charging points. As buildings become smarter and more connected with technology this increases the potential for technology failure and cyber risks

The buildings and construction value chain is complex, with low-carbon solutions adding further demand for tailored insurance solutions

Manufacturing → Construction → Real Estate → Uses

Building value chain

Stakeholder
– Manufacturers of building materials

Technology applications
– Low carbon materials used to reduce embodied carbon in manufacturing of materials e.g. mass timber

Stakeholder
– Contractors carrying out the construction of buildings/infrastructure

Technology applications
– Electrification of equipment including site vehicles
– Use of heat pumps
– Design and process optimisation for demand reduction

Stakeholder
– Real estate owners and investors

Technology applications
– Carbon credits
– Decarbonisation of assets and portfolios

Stakeholder
– Occupants of buildings including residential and commercial

Technology applications
– Smart devices
– Renovation of buildings: use, maintenance, repair, replacement, refurbishment
– Energy and water operation

Influencer value chain

Stakeholders

All parties play a major role in very early phases of buildings, and decisions have a big influence on how much carbon the buildings will emit in the future

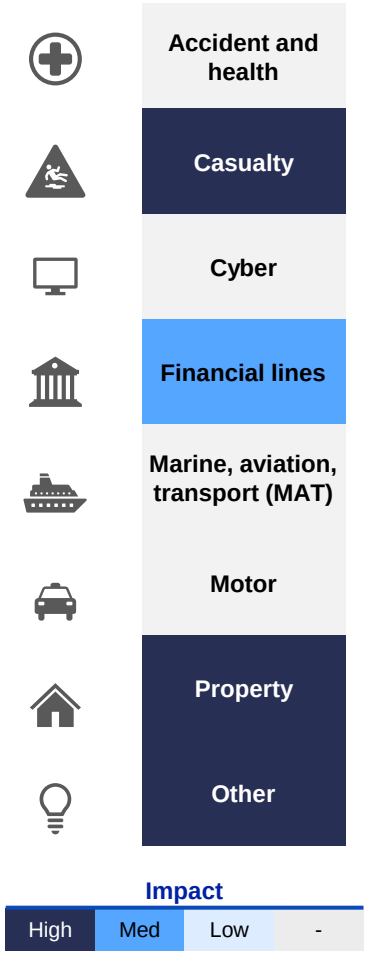
Responsible for determining if and how constructed

Companies in the value chain must cooperate and engage to collectively reduce indirect emissions of the building system while meeting their respective reduction goals

LLOYD'S

As global policies mature in line with transition pathways, investment in retrofits will follow, presenting a material opportunity for the insurance industry to support clients

(Re)insurance class of business impact



Key coverage sought for projects

Financial lines: Professional indemnity to cover against breach of contractual obligation to exercise reasonable care and skill from contractors, engineers and architects involved in design and construction works. Warranties or energy performance guarantees related to efficiencies gained by the technology could be increasingly important as regulations tighten. These would typically sit outside existing policy provisions and would likely need to be covered through an add-on.

Casualty: Public and employers' liability to provide cover against the associated risks within buildings projects including personal injury or death

Other (Construction): Anticipated growth in construction/erection all risks (CAR/EAR), decennial liability and delay in start-up (DSU) coverage, as new projects exit design phases and begin construction in the coming years

Other (Cyber): Connected devices and smart technology is likely to be increasingly utilised in combination with energy efficiency, creating additional cyber risks

Gaps in coverage currently offered

- There is limited capacity currently available for **energy performance guarantee** – this is a crucial element to provide investors with cover should the investment in retrofits and energy efficient technology not be covered by the actual energy savings
- Warranties and performance guarantees require careful consideration to ensure the cover is insurable
- There is a potential for developers to make bold net-zero claims, with a resultant risks of litigation if not substantiated. BNY Mellon were charged in 2022 of misstatements and omissions about ESG considerations in making investment decisions. Given this is an emerging risk, there are no specific products but could be included under **errors & omissions (E&O) policies** in future
- Constructing and improving buildings to be more sustainable does not create materially different risks to existing **property and liability construction exposures** and would generally fall within markets appetites. However, carriers will need to consider the impacts of new technologies and/or materials to the exposure. For example, increasing the likelihood and severity of fire losses through the greater use of timber and structural insulation panels in new construction projects
- **Prototypical methods of construction and materials** being used can materially alter the exposure profile, particularly for latent defects (which can take a number of years to emerge), and result in unexpected losses which could also be complex and expensive to settle. These challenges will need to be addressed by insurance markets to ensure a sustainable insurance offering for low carbon buildings
- **Cyber risk** from smart technology in homes generally can be covered under traditional Home Insurance currently however for businesses as this technology becomes more prolific there may be a need for separate cover. As the market matures, the growth in connected devices and distributed energy resources is expanding the potential cyberattack surface of electricity systems, raising cyber risks with wide reaching consequences

Change is being driven from both ends of the insurance lifecycle, with a growing number of innovative products available and commitments to 'Build Back Better' through the claims process

Example market offerings

Provider	Product description
AXA XL Insurance Reinsurance	– **Builders risk insurance programmes** provide risk-specific coverage for mass timber project risks – Accelerates use of cross-laminated timber across construction projects
Munich RE	– **Energy efficiency insurance** designed for those investing in energy-saving measures – Covers cost of installed assets, project revenue, and annual gaps in energy savings
Marsh	– **Resilient Repairs** clause encourages the replacement and repair of assets in environmentally friendly way, with additional cost covered by insurers
AIG	– **Property coverages** evaluate environmental variables like flood and fire to offer insurance against a specific risk profile of new sustainable construction supplies & methods
Liberty Specialty Markets	– LSM provide **eco-friendly upgrades** that allow customers to replace damaged property with products of equal value, while covering additional costs associated with upgrades of a higher green standard. – This could include replacing a damaged roof and covering the cost of adding solar panels
Halifax	– **Halifax Home Insurance** have partnered with Ideavate Limited to make homes greener – During the claims process Halifax will then provide options for how they can structure the repair to include options such as wall insulation and solar panels
FLOOD RE	– The **Build Back Better scheme** enables homeowners to install property flood resilience measures, up to £10k, when repairing their properties after a flood – There are 10 participating insurers signed up to the programme including Hiscox, LV NFU Mutual, Aviva etc

Example industry partnerships

Sustainable Markets Initiative

SMI Sustainable Buildings Taskforce

– Made up of global CEOs from throughout the building industry

– Collaborating to accelerate delivery of net zero buildings to reduce carbon emissions

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LLOYD'S

Battery energy storage systems (BESS) are expected to play a pivotal role in reducing dependency on high carbon energy generation, accelerating the growth of renewables

Industry and insurance market dynamics

- Battery pack prices have declined by 89% since 2010, driving growth in the sector which will play a crucial role in the energy transition
- Demand for batteries is expected to **grow more than 8x by 2030** and insurers will play a key role in helping clients manage the associated risks
- Energy storage is one of the emerging techs in which both **insurers and distribution partners have developed the most dedicated capabilities**

60% **Increase in installed capacity of grid-scale batteries in 2021 vs 2020**

Grid efficiency | Stationary energy storage | Industrial uses | Commercial and residential

Different applications of BESS require different characteristics, broadly summarised as **high power** (ancillary) or **high energy** (bulk energy). This is due to **variables in design** such as:

- Power rating (MW); storage duration (h); cycling or lifetime; self-discharge (%); energy density; efficiency (%); response time

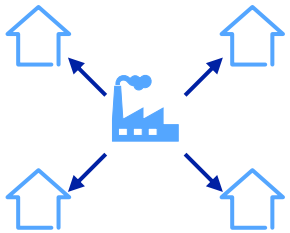
Key growth drivers	Headwinds
Government regulation	High cost of production
National renewable energy policy	Geopolitical uncertainty
Technology advances	Infrastructure costs
	Supply chain dependencies

LLOYD'S

To achieve net zero ambitions, global electricity grids require a significant upgrade to shift to flexible 'distributed' generation models

Example electricity grid evolution

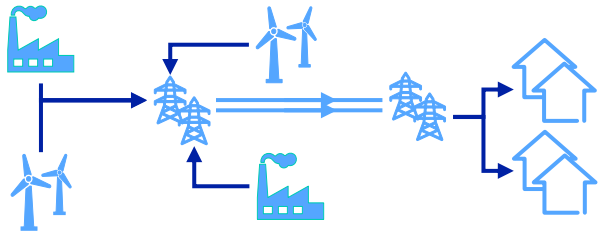
Historical



Local generation

- In developing economies such as the UK, Europe and the US, local power facilities initially generated electricity for industry, gradually broadening their reach to supply to local communities
- Historically, coal was the main source of energy

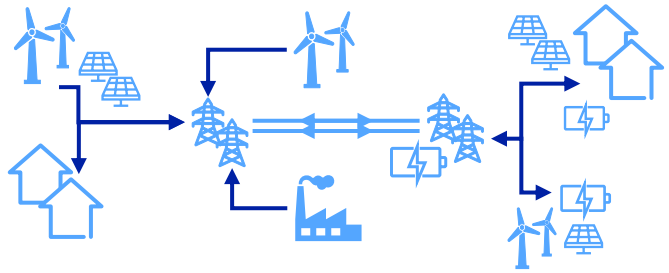
As-is



Large-scale transmission and distribution

- Today, power generators are connected to "synchronous grids" with centralised control of transmission and distribution
- Renewable generators range from "large-scale" generation such as offshore wind, to small, "distributed" schemes such as household or small-scale solar with volatile outputs at varying voltage
- Designed specifically for large-scale energy generation, with unidirectional flow, global power grids are not suited to the volatile and often "embedded" nature of expanding renewables

To-be



Distributed generation

- Large investments and significant re-engineering is required to counteract regional bottlenecks and develop "distributed" generation on an interconnected and flexible grid
- Excess supply of renewable electricity is either stored locally or transmitted towards high-demand centers through distribution system operators, allowing for almost unlimited addition of renewable electricity generation to the grid
- Expected decrease in future generation costs are expected to outweigh construction costs

LLOYD'S

Moving to a 'distributed' electricity transmission model will enable the grid to support all renewables solutions, but solutions such as BESS are needed for surety of supply

Transformation to distributed generation

Wide-scale transformation of electricity systems to a distributed generation model, has several advantages:

- Enables climate adapted technology to remain effective under the fluctuating weather circumstances, facilitating evolution away from fossil fuels in the transportation, industry and building sectors
- Improves resilience and efficiency of the electricity grid
- Facilitates connection of low-carbon industrial buildings providing embedded, local, renewable generation
- Supports transition towards electrified alternatives in transport and heating, empowering end-customers to be part of the journey through "green-homes" and other energy efficiency initiatives
- Supports reduction in emissions aligned with reduction in back-up capacity

Success relies on management of fluctuating generation and demand profiles and the associated engineering challenges

Additional opportunities presented by distributed and renewable generation

Interconnectors – Global electricity networks are increasingly interconnected, enabling more flexible supply and demand management, access to additional supply and offshore connection

Energy storage – Storage in the form of BESS and mechanical systems, such as pumped hydro are in demand for system balancing and frequency control

Hydrogen – Oversupply of renewables can be directly used to produce green hydrogen

Smart grids – Enables advanced metering, demand and supply management along with access to small-scale generation that might otherwise be lost

Headwinds and key challenges posed to delivery

Grid instability – Moving to a decentralised system, with additional low-voltage and intermittent/fluctuating sources increases the risk of wider system instability. This in turn drives a need for reactive compensation equipment increasing the cost of system management

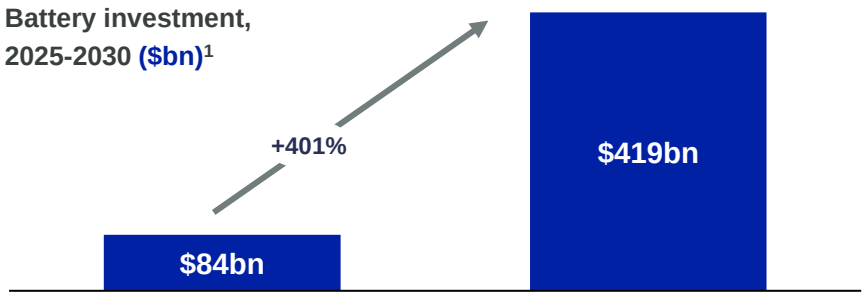
Aging infrastructure - A 50-year lifespan is common for transmission lines and associated equipment. Globally, most power grids are aged and already require significant investment. In the US, for example, power transformers with an average age of more >40 years, currently manage 90% of all electricity flow

Political pressure - Local government policies may overrule interconnector demands creating engineering challenge and construction imperative

LLOYD'S

Supply chain challenges and natural resource concerns have limited BESS to date, but policy changes, recycling solutions and advances in technology are unlocking future growth

Global investment breakdown



Current market trends

- **US: Inflation reduction act** allows battery developer easier claim of investment tax credits; plan to install 22GW more capacity by 2026
- **UK:** Has more than 16GW of battery storage currently operating, under construction or in the pipeline across 496 projects
- **Australia:** Constructing 8 large batteries and 58 community batteries across 4 states to increase capacity and provide grid stability
- **India:** Developing 7 key grid scale battery projects to help store power during low demand periods
- **South Africa:** Developing 5 new storage batteries in the Northern Cape; building battery storage to improve grid reliability

Growth drivers

Government regulation - Governments, such as the US, are incentivising investment in battery energy storage projects. In the US, the Inflation Reduction Act provides Investment Tax Credits for energy storage systems

National renewable energy policy – In the UK, Ofgem has funded several projects to support energy storage and China's "National Demonstration Power Project Management Measures", included support for Energy Storage in demonstration projects

Technology advances - Improvements to battery technology are seeing cheaper, more durable and lightweight solutions enter the market, including NIB and Redox batteries, alongside Graphene in Li-ion batteries

Headwinds

High cost of production - Prices have been declining, primarily due to technological advancements, but the cost remains high relative to traditional energy storage options. The upfront investment required can often act as a deterrent to investment and adoption

Geopolitical uncertainty – The conflict in Ukraine has pushed up the price of rare Earth materials. Continued or new conflicts may pose further challenges to the industry

Infrastructure costs - Integrating battery storage into existing energy systems and infrastructure is costly and requires significant investment to ensure safety and compatibility

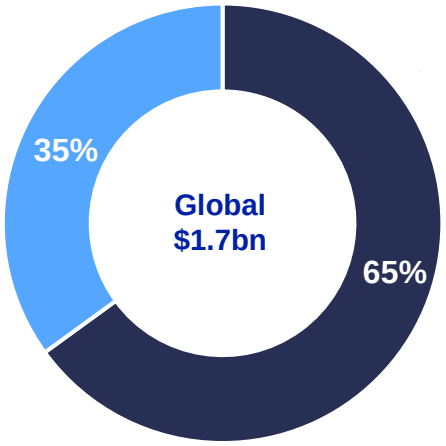
Supply chain dependencies - Existing supply chains are highly vulnerable. Countries including the US are seeking to establish more resilient supply chains and reduce its reliance on China, which currently provides the majority of mineral required

LLOYD'S

Globally $1.7bn is expected to be invested in grid infrastructure between 2021-2025, with most investment focused on new lines in Europe and APAC

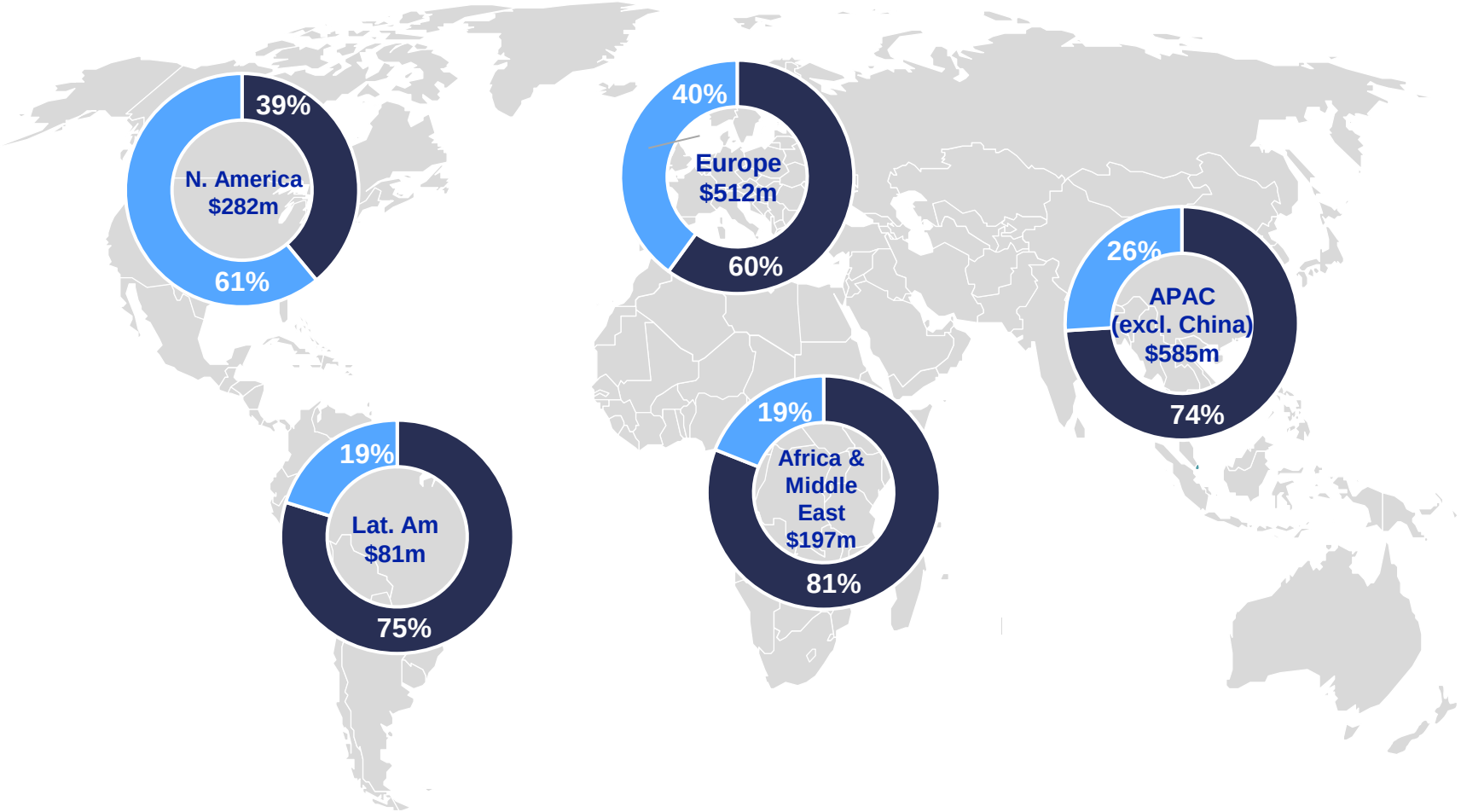
Global investment 2021-2025

Total grid infrastructure investment (Capex on new lines and replacement), 2021-2025 ($bn)[1]



Regional investment breakdown 2021-2025

Regional breakdown of total grid infrastructure (Capex on new lines and replacement), $m 2021-2025

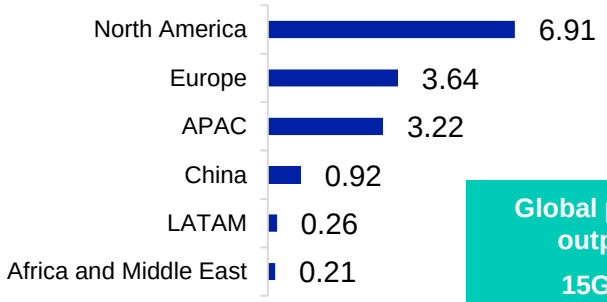


LLOYD'S

Planned electrochemical BESS plants will more than double those currently active across all geographies

Global electrochemical BESS operational capacity

Global electrochemical battery storage power output (GW), operational 2023



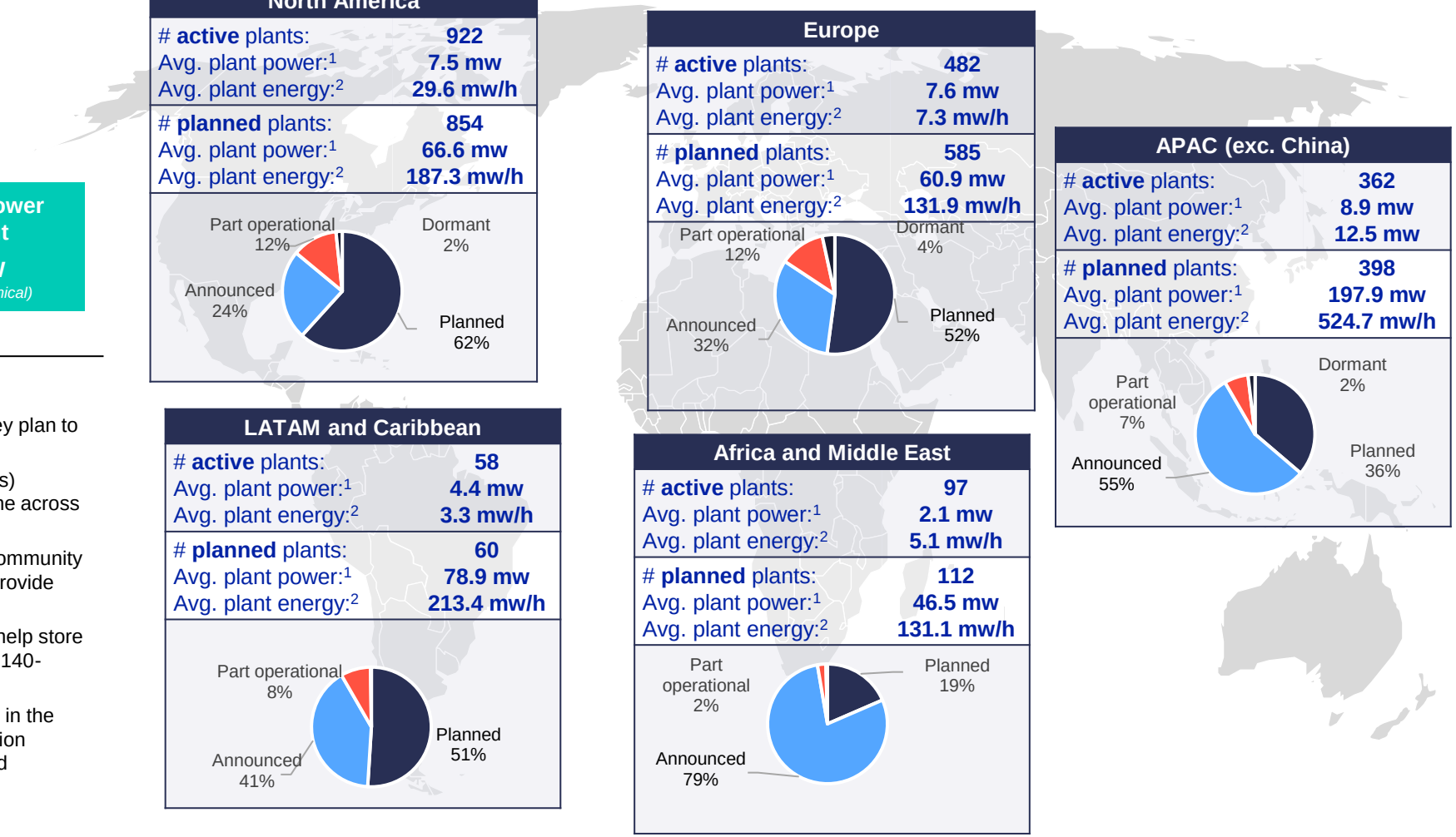
Global power output
15GW
(electrochemical)

Regional considerations

- **US:** The Inflation reduction act has allowed for battery developer to claim investment tax credits easier as they plan to install 22GW more capacity by 2026
- **UK:** Has more than 16GW of battery storage (all types) currently operating, under construction or in the pipeline across 496 projects
- **Australia:** Are constructing 8 large batteries and 58 community batteries across four states to increase capacity and provide grid stability
- **India:** Developing 7 key grid scale battery projects to help store power during low demand periods. India aims to have 140-200GW storage capacity by 2040
- **South Africa:** Are developing 5 new storage batteries in the Northern Cape, they are not able to build new generation capacity so are building battery storage to improve grid reliability

Regional electrochemical BESS plant size and status

Regional breakdown of current and planned electrochemical battery storage plants and current status of known plants



LLOYD'S

There is a mature global value chain for BESS for end-user self-generation and self-storage, while large-scale installations are dependent on upgrade and evolution of power grids

Energy storage system manufacture | Generation | Electricity transmission, distribution & storage | Uses/markets | Second life/recycling

Material mining & processing → Battery cell manufacturing → Battery cell assembly

Electrochemical

73% of global storage power output

1. Lead acid
2. Li-ion
3. NaS
4. Flow

Mechanical

9% of global storage power output

1. Flywheel
2. Compressed Air Storage
3. Hydro – pumped storage

Thermal

18% of global storage power output

1. Molten salt
2. Ice thermal storage
3. Chilled water storage

Applications

Utilities use electric storage technologies (for power generated from fossil fuels and renewables) in a range of applications such as time-shifts and supply capacity to meet the demand-supply gap efficiently

1. **Fossil fuel**
2. **Renewable energy**
3. **Distributed generation**

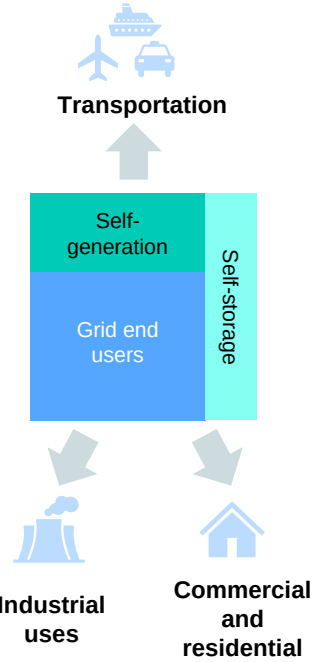
Grid side applications

End-to-end solution providers for deployment and operations of BESS's could potentially disrupt the market and are accelerating future opportunities

- **Hardware**
- **Software**
- **Services**

Applications

End-users benefit from the efficiencies energy storage systems offer in time-of-use energy tariff cost management, demand charge management, and uninterruptible power supplies



Applications

Batteries used in storage systems have **more secondary life applications** than in EVs, as overall performance is more variable, resulting in longer lifetimes

How this could be used is still unclear, as the technology continues to develop, and most systems are **10-20 years away from expected degradation** – given the nascency of their application

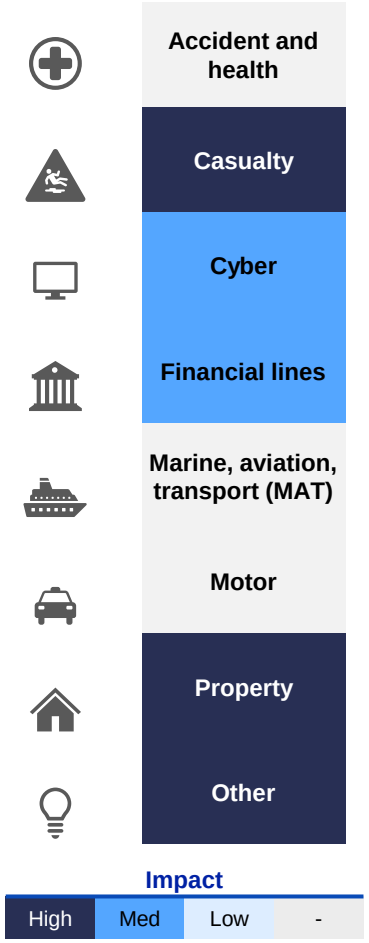
Recycling

The recycling market is **critical to reducing the environmental impacts** of producing battery material, using heavy mining processes and **toxic chemicals.** However**, fewer than 5%** of lithium-ion batteries are currently recycled

LLOYD'S

Insurers have developed standalone products for energy storage or integrated them into existing power policies, but BESS operators will seek increased capacity as more projects commence

(Re)insurance class of business impact



Key coverage sought for projects

Property/casualty (operational): operational all risks (OAR), public liability, employers liability with biggest increased risk from fire including from:

- **Thermal runaway** – the result of a chain reaction where misused or damaged battery being to release heat energy, leading to further damage in a negative feedback loop which can cause build-up of explosive atmosphere and fire
- **Failure of BESS control systems** - If one or more control component fails, for instance a battery management system, it can lead to overheating and fire
- **BESS and hydrogen evolution** - In lead-acid batteries, excess hydrogen can create a risk of explosion unless proper ventilation methods are in place

Other (construction): construction all risks (CAR), delay in start up (DSU), supply chain insurance, terrorism, public liability, political and regulatory risks

Other (extended warranties): Warranty offered in addition to a standard warranty typically offered by the manufacturer, providing protection in case of battery failure

Other (performance guarantee cover): Cover purchased in conjunction with an extended warranty product that guarantees at least 70% retention of battery capacity for a given period

Gaps in coverage currently offered

- Coverage is mostly provided under pre-existing power policies as a **property and liability component**, if the plant building an energy storage is already in operation however high-profile fire incidents in the BESS sector, have impacted insurer's appetite to provide energy storage cover
- The current **construction** market has been hesitant in establishing risk profiles given the diversity of technologies employed within the battery storage space. Minimum global standards on construction and increased loss data is needed to assist the industry in pricing
- For standalone energy storage industrial scale developments, standalone **warranty and liability products** have been developed however the market is currently immature
- Reasons for this include potential insurability challenges, losses associated with the unproven nature of the technology and the limited availability of battery performance data from original equipment manufacturer (OEMs)

The insurance industry is adapting existing warranty and business interruption offerings to BESS solutions

Example market offerings

Provider	Product description
AIG	– AIG offers coverage for "**traditional renewable energy**" which includes coverage for onshore wind, solar, hydro, battery storage – These coverages span property, casualty, D&O, and other lines of business
AXIS	– **BESS CAR and OAR solutions** provide specialised P&C coverage for every stage of a battery energy storage project from development through operation – Axis work with independent power producers, project developers, operators EPCs and utility companies
Munich RE	– **E-mobility insurance** means manufacturers and fleet owners are shielded from excessive costs resulting from warranty claims for their long-term battery warranties by Munich Rr's coverage for e-mobility applications
Munich RE	– **Stationary energy storage solution** provides strong protection against excessive repair and replacement expenses brought on by component failure or unanticipated capacity deterioration – Directed at participants along the entire value chain
Munich RE	– Munich Re uses monitoring by TWAICE software to offer performance warranty insurance for Li-ion batteries – Munich Re's **performance warranty** insurance policy covers repair and maintenance of battery storage systems and can be extended to cover lost revenue from downtime. The customer is also protected against insolvency and non-payment on the battery supplier's side
AXA XL Insurance Reinsurance	– AXA XL support Paragon Insurance Holdings, a **specialist MGA**, in offering technology performance and battery revenue insurance
Altelium MS amlin	– Initially launched in 2022, **MS Amlin** partnered with **Altelium** to offer a BESS construction all risk and operational all risk solution, which has subsequently closed

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- **Geothermal**

3 Hard-to-abate sectors

LLOYD'S

Geothermal energy is generally thought to be limited to regions sitting on tectonic plate boundaries, but growth in ground-sourced heat pumps has demonstrated wider opportunities

Industry and insurance market dynamics

- Geothermal energy originates from the heat below the Earth's surface, using wells to access and extract heat from one of two sources; radio-active decay of geological elements and heat seeping from the mantle of the Earth's core
- Modern geothermal systems are often integrated to provide combined heat and power (CHP), using hot steam to generate electricity, while simultaneously supplying hot water through underground pipes
- Geothermal energy is thought to be limited to regions sitting on tectonic plate boundaries, but at shallow depths, ground heat derived from the sun can be accessed by ground-sourced heat pumps
- Typically resilient to extreme climate events, geothermal as an energy source provides supply reliability and generates negligible emissions whilst requiring low water use and low land occupancy

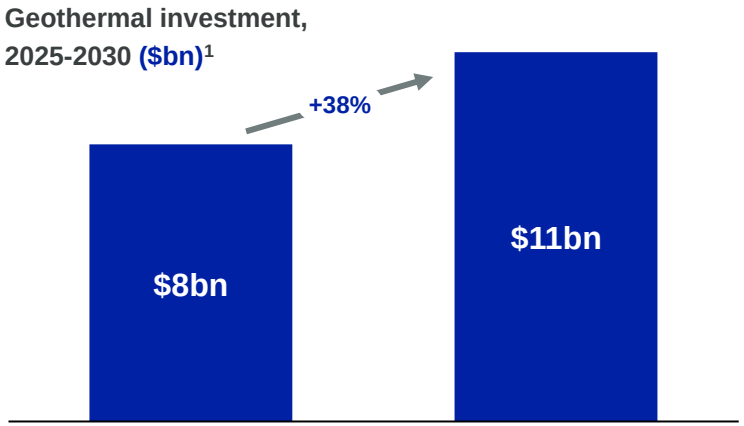
Energy sourcing and conversion	Transmission and storage	Uses
– Engineers – Construction firms – Multinational manufacturers – Plant operators	– Grid network – Heat pump vendors	– Community and national energy companies – Private energy companies

Key growth drivers	Headwinds
Government support	Expensive raw metals
Innovation	Location specific
	Sustainability

LLOYD'S

While district heating systems are a mature technology, there has been a lag in development of the geothermal solutions due to the costs of accessing heat for power generation

Global investment breakdown



Current market trends

- Since 1960, the Geysers Geothermal Field, north of San Francisco, has continuously generated commercial geothermal power and is the largest geothermal plant in the world, with 18 geothermal plants generating ~835MW of electricity
- In 2020, generation increased by just 2%, falling below average growth of the previous five years, with the lag in further development of the sector largely due to development risks and associated costs
- Globally, generation has grown slowly, at an average of 3.5% CAGR since 2015. A gap in global policies to help reduce costs and mitigate predevelopment risks has limited generation growth
- In APAC, the Philippines and Indonesia are driving investment, with most projects focusing on flash system power plants

Growth drivers

Government support - Geothermal plants act as a good base level electricity and heat generator to a diversified energy portfolio as they produce a constant fuel through subterranean high-pressure steam. In leading countries like Indonesia, Turkey and USA, there are various government incentives promoting investment in geothermal data gathering, plant setup and distribution and for geothermal heat pumps in the USA

Innovation - Enhanced geothermal systems (EGS) is an emerging technology where underground reservoirs are accessed through pumping water through impermeable rock. If the method is reproducible, it could significantly increase the accessibility of geothermal power. US investment syndicates are exploring methods of retrofitting oil and gas wells to become productive geothermal sources. Similar research is placed into unproductive geothermal plants

Headwinds

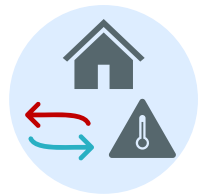
Expensive raw metals - Each geothermal construction project requires a customised turbine design to fully leverage the amount of steam generated by the underground reservoir. The plant is then shaped around the turbine, so geothermal power stations aren't reproducible at commercial scale. Rare earth metals are required in system manufacture, making geothermal more expensive than traditional power plants. As geothermal powerplants are highly location dependent, there is limited availability

Location specific - Geothermal plants need to be built in specific areas where geothermal energy within underground reservoirs are accessible, which means that some areas are not able to exploit this resource

Sustainability - To maintain the sustainability of geothermal plants, fluid needs to be pumped back into the underground reservoirs faster than it is extracted, otherwise risk depletion

LLOYD'S

The value chain for extracting heat from below the Earth's surface for heat, power or combined (CHP) has less complexity than many other green technologies and fewer stakeholders

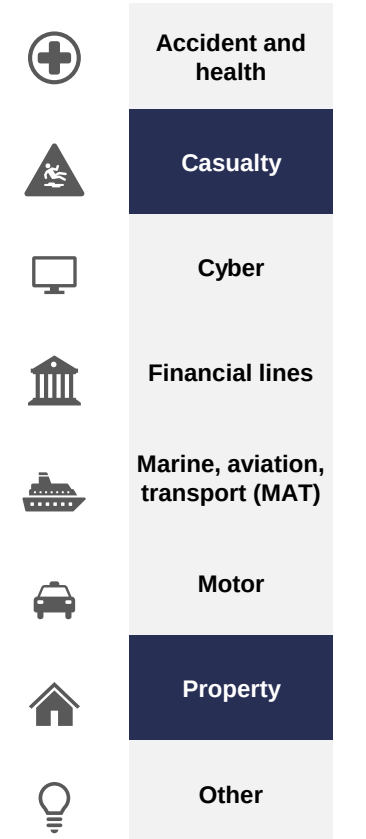
Energy source	Conversion (to heat and/or power)	Transmission and storage	Uses/markets
Deep underground reservoirs  **Ground heat derived from the sun**	1 **Binary cycle (Power)** Uses hot water to boil a working fluid with a low boiling point. The working fluid is vaporized in a heat exchanger and used to turn a turbine. 2 **Double flash (Power)** Hot water, ~180°, flows up through pipes under its own pressure, as the pressure decreases it turns to steam to drive a turbine. 3 **Dry steam (Power)** Steam is piped from underground wells to the plant where it is directed into a turbine. 4 **Ground heat pumps (Heat)** Uses hot water to boil a working fluid with a low boiling point. The working fluid is heating the building through radiation.	**Transfer to local grid through step up transformer at plant**  	**End-use is primarily electricity generation, ground heat pumps are used for heating**  Geothermal energy can be used to heat buildings all year round, used in 70 countries. However, a more popular air source heat pump has emerged which accounts for 80% of sales 

Key example stakeholders			
– Engineers – Construction firms – Multinational manufacturers	– Plant operators – both private and government owned	– Grid network – Heat pump vendors	– Community and national energy companies – Private energy companies

LLOYD'S

The exploratory phases of geothermal projects can present the most material risks and potential cost increases

(Re)insurance class of business impact



Key coverage sought for projects

Property: Traditional property cover, machinery breakdown and business interruption are important. High machine break down exposure, given the site locations being in fault zones prone to seismic activity and maintenance-related issues such as the corrosion of wellheads, casings, and pipelines, hydrogen-related embrittlement, and out-of-production wells which could also impact operations

Property/Casualty: (Drilling and geological hazards): Due to unknown conditions underground, during drilling and construction a site may be subject to well instability, risk of casing collapse, damage to the bottom hole assembly, blowout, and contamination of adjacent ground water resources. When equipment is damaged or unrecoverable, financial risks increase for project principals since drilling equipment rental agreements always include a "new-for-old" stipulation, regardless of the cause of the loss.

Additionally, "**finder's risk" insurance, or "exploration risk**" covers the risk of not finding a geothermal energy source at a given site

Casualty (environmental): Various natural gases stored under the Earth's surface are released into the atmosphere during the operational drilling. The rate at which the gas is emitted increases near geothermal plants, therefore emissions need to be monitored and maintained

Gaps in coverage currently offered

- **Property damage and business interruption** cover exists for machine breakdown and site related risks
- **Enhanced geothermal systems,** is an emerging technology where underground reservoirs are accessed through pumping water through impermeable. Despite its potential advantages, risks related to this technology are out of insurers' appetite as the method could increase the chance of earthquakes. More research is needed in this area
- Government backed insurance schemes and the World Bank initiative, GeoFund, offered coverage to most countries in Europe, but all have now expired
- There is insurance coverage that exists in the market to **mitigate financial loss** due to **failure of exploratory drilling** however, due to the small number of projects, financing and insurance solutions are limited
- **Damage to third party** property, **environmental risks** such as chemical spills during operation and coverage for bodily injury resulting from these exist
- There are tailored and comprehensive solutions available however the number of carriers and products are limited due to small number of geothermal projects

Products already exist to support geothermal projects, and the insurance industry is well placed to enable the transition of assets through retrofitting as the technology becomes proven

Example market offerings

Provider	Product description
Allianz	– **Renewable energy insurance solutions** provide coverage for renewable technologies who have risks ranging from mechanical breakdowns to natural hazards – Solutions include construction and erection all risk, operational all risk and third-party liability – These solutions include delayed start up and business interruption
Parhelion	– **Geothermal resource risk insurance** covers a pre-determined number of wells with a pre-agreed drilling and testing schedule, removing reservoir output risk during the initial development drilling phase – As a result, it provides protection for project developers' and third parties' equity and encourages the influx of private equity and other third-party capital to finance the development stages of reservoirs
Munich RE	– Munich Re has provided geothermal exploration risk insurance in Kenya, making the project's financing easier to schedule and more reliable – In early drilling phases, if the targeted reservoir is unable to produce enough output in steam or heat, project is usually discontinued so **multi-well exploration risk insurance** covers such resource risks to help ambitious projects be realised
TOKIO MARINE	– Insurance policy covers the **cost of surveys** for hot spring operators to determine if geothermal power stations are altering the quality and composition of hot spring water

LLOYD'S

The insurance industry currently provides climate resilience to the agri-business sector, but incentivising production changes could accelerate 25% of identified carbon abatement opportunities

Line of business	Number of solutions[1]
FL, incl. credit and surety	29
Property	27
Liability (incl. D&O and BI)	22
Energy	19
Construction and engineering	15
Agri-business	6
Motor (fleet and personal)	4
Alternative Soln. e.g. advisory	4
Cargo and logistics	1
Marine (hull, P&I)	0
Aviation	0

20+ solutions | 10-20 solutions | <10 solutions | 0 solutions

Agribusiness: Agriculture significantly contributes to global emissions with practices differing greatly by geography. Identified abatement measures range from consumer dietary changes to supply-side efficiencies including production practices. Combining production changes and electrifying farming vehicles could unlock 25%of abatement options

Abatement measure	Net-Zero emissions[2]	Development outlook
Diet shifts	-39%	– Consumption of carbon intensive ruminant animal proteins (namely lamb and beef) would have to fall by 45% in the Net-Zero pathway
Animal protein production	-13%	– Animals' GHG emissions could be reduced through selective breeding, feed-mix optimization and methane/nitrification inhibiting additives in feed
Crop production	-9%	– Less pollutive crop production practices would include low/no-tillage production, improved fertilization practices and better water & irrigation management
Reduction in food waste	-8%	– Food waste and loss would need to fall 13% to a 20% global average by 2050
Electrification	-3%	– Electric farm vehicles fully replace internal combustion vehicles by 2050 under the Net-Zero pathway as they are predicted to not only abate carbon but also save costs

Insurers have an opportunity to form sector-based partnerships which encourage behavioural change to better support the EU objectives and other sustainable goals

Market groups tackling the issue…

- To establish the SMI's Agribusiness Task Force (ATF), the former Prince of Wales gathered executives from some of the biggest agricultural corporations
- Its goal is to expedite the adoption of regenerative agriculture as the world's primary agricultural system
- The members worked together last year to determine what steps the business sector might take to create scalable value chain blueprints to accelerate the deployment of regenerative technologies
- The European Carbon+ Farming Coalition will employ a farmer-centric approach with partners focusing on promoting the adoption of regenerative and climate-smart agriculture practises, identifying the barriers to adoption, and devising solutions with advantages for farmers in terms of economics, practicality, and the environment
- Additionally, it will seek to provide financial instruments that farmers may use to manage transition risk and suggest the best combination of farmer incentives

Working with market groups..

- The insurance industry could look for opportunities to **form sector-based partnerships which encourage behavioural change to better support the EU objectives**, or other sustainable goals such as the UN SDGs
- Through insurance solutions that minimise risk and actively promote adoption, there is a chance to enable investment and **incentivise regenerative farming**
  - There is a longer-term/future opportunity to offer farmers insurance on conditions that lessen the cost of converting to and sustaining a regenerative system
- The insurance industry can also support on wider actions:
  - Encouraging the deployment of enabling technology, where these new technologies can promote regenerative farming practices and, in some situations, act as a crucial enabler, through the provision of insurance solutions for these technologies or strategic partnerships with tech companies
  - Ensure everyone working in the value chain is aligned to promoting regenerative farming over conventional farming practices, performance measurements could be linked to environmental objectives
- Additionally, the industry should prioritise working with Agricultural clients on protection of biodiversity and ecosystems and water use

LLOYD'S

Efficiency retrofits and the development of new propulsion methods such as biofuels and hydrogen will require continued support from the insurance industry

Line of business	Number of solutions[1]
FL, incl. credit and surety	29
Property	27
Liability (incl. D&O & BI)	22
Energy	19
Construction and engineering	15
Agri-business	6
Motor (fleet & personal)	4
Alternative Soln. e.g. advisory	4
Cargo and logistics	1
Marine (hull, P&I)	0
Aviation	0

20+ solutions | 10-20 solutions | <10 solutions | 0 solutions

Shipping: In 2021 international shipping accounts for ~90% of global trade volumes ($14tn). Reaching net zero by 2050 will require ~15% reduction in emissions by 2030, for which an estimated $5bn is required in the immediate term to advance alternative technologies

Abatement measure	Net-Zero emissions[2]	Development outlook
Hydrogen	-19%	– Low-carbon fuels account for ~45% of fuel intake by 2050, with hydrogen constituting a large portion of this but long vessel lifetimes may delay adaptation
Bioenergy	-19%	– Design and implementation of engines powered by ammonia and other biofuels – First hydrogen and ammonia powered vessels due to come into operation in 2023
Energy efficiency	-14%	– Energy efficiency must improve from 30 to 35% by 2050 to reach Net-Zero – Shipping has had limited investment in zero-emission technologies to date, however retrofitting to meet regulations and improve fuel efficiency/costs is a mainstream activity
Electrification	-4%	– From 2030, ferries and other vessels for short-sea shipping would be electrified – Technologies to decarbonise shipping are at early stages of maturity with R&D ongoing in alternative fuels, electrification and hydrogen
Shipping demand reduction	-4%	– Slowing demand growth driven by a 40% reduction of oil tankers as oil usage decreases

The insurance industry has a unique opportunity to work with marine market groups to learn and evolve existing offerings

Market groups tackling the issue…

- The 'Maritime Just Transition Task Force' was set up by the ICS, the ITF, the UNGC, the ILO4 and the IMO5 during COP 26
- First sectoral task force devoted to solving the climate emergency in a way that is as fair and inclusive as possible, whilst creating good work opportunities
- Seeks to increase and coordinate cooperation in order to move the shipping industry towards decarbonization in a safe, equitable, and people-centred manner between governments, business, labour, academia, etc.
- Allianz has partnered with Sea Shepherd, who fight to defend, conserve and protect the ocean. Last year, they collected 12 cubic metres of garbage made of plastic and polypro
- By deploying its fleet of ships to follow, monitor, and actively obstruct the activity of fishing vessels suspected of engaging in illegal and unreported activities that lead to the unsustainable exploitation of marine life, Sea Shepherd is perhaps most known for adopting direct action techniques to achieve its aims

Maritime Just Transition TASK FORCE

SEA SHEPHERD

Working with market groups..

- The insurance industry has an opportunity to focus investments or partner with innovators to facilitate the 4th propulsion revolution
- This includes opportunities to form sector-based partnerships which encourage behavioural change to better support the EU objectives, or other sustainable goals such as the UN SDGs
- With decarbonisation for shipping focused on purchasing offsets to compensate emissions, growth in carbon market offerings could increase coverage in hard-to-abate sectors
- Opportunities arising for insurance companies:
  - Liability coverage for failing carbon offsets
  - Coverage of risks related to the use and stock of hydrogen and ammonia in shipping
  - Liability insurance against increasingly demanding energy efficiency standards
- There is a short-to-medium term opportunity to adapt Marine insurance products to cover retrofits for current regulations and fuel efficiencies, for example asset performance products covering performance shortfall
- Given the nascent nature of the market, learnings are limited, leaving opportunity for profitable products specific to those technologies mentioned earlier (e.g. hydrogen, bioenergy and electrification) as a longer-term opportunity
- Increasing carrier propositions as limited carrier propositions have been observed so far e.g. Gard providing P&I and Hull & Machinery cover to Yara Birkeland, the world's first autonomous and zero-emission vessel, in 2021

The insurance sector is well placed to support the aviation transition pathway through innovative solutions and partnerships

Market groups tackling the issue…

- The SMI's Aviation Task Force (ATF) is coordinating efforts to ensure that aviation reaches net zero emissions by 2050
- While it is feasible to fly without using fossil fuels, effort is needed to make alternatives like SAFs a reality
- The ATF launched a SAF pocket guide at COP27 to promote adoption within the business community and support the goal of using 30% SAF in corporate travel by 2030
- The International Air Transport Association (IATA) members have committed to achieving net-zero emissions from their operations by 2050
- This comprises of coordinated efforts of the entire industry and significant government support, enabled by CORSIA
- To address emissions from international aviation, the International Civil Aviation Organisation (ICAO) adopted the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), marking the first time a single industry agreed to a global-market based measure in the field of climate change

Opportunities for the sector..

- The insurance industry could explore opportunities to form sector-based partnerships which encourage behavioural change to better support the EU taxonomy objectives, or other sustainable goals such as the UN SDGs
- Funding and financial de-risking for the promotion of continued innovation and research into Sustainable Aviation Fuels (SAF) is required
- Improving efficiencies requires joint efforts from a large group of stakeholders but an opportunity exists for the ITF to collaborate with the Aviation Task Force (ATF) to accelerate fuel efficiencies
- Potential opportunities for insurance companies:
  - Traditional coverage for SAF producers (e.g., biofuels distributors)
  - Insurance for SAF supply chain disruptions for airlines
  - Liability coverage for failing carbon offsets
- Similarly, by having insurance solutions in other areas such as coverage for alternatives such as high-speed railways, can reduce the demand on aviation, further reducing emissions
- Decarbonisation for aviation is for now focused on purchasing offsets to compensate emissions so growth in carbon market offerings could increase coverage in hard-to-abate sectors

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Notes & Sources (1/3)

Page number	Source	Notes
7	IEA; International Council on Clean Transportation; McKinsey Insights: Scaling the CCUS industry to achieve net-zero emissions; Global Data; McKinsey; UN PRI	1. The total 2025 global market size estimates for both operational and capital expenditure were obtained from IEA Net Zero and UN PRI Forecast Policy Scenarios
8	Carbon Offset Guide; California Air Resources Board; EY; EU ETS; Center for Climate and Energy Solutions: Secondary Carbon Markets; ISDA: Role of Derivatives in Carbon Markets	1. Subject to product designs adhering to regulatory guidance and requirements
9	Carbon Offset Guide; California Air Resources Board; EY; ISDA	1. OTC – "Over the counter" direct trading, 2. Emissions Trading System, 3. Regional Greenhouse Gas Initiative – "Cap-and-invest" scheme, 4. California allows 4% carbon offset credits, rising to 6% in 2026;
10	IEA	1. According to the Net Zero Scenario
11	Carrier websites; company websites	1. Subject to product designs adhering to regulatory guidance and requirements
12	Carrier websites; SMI ITF 2022 products and services showcase; IEA; UN PRI	1. Product not yet launched
14	IEA; International Council on Clean Transportation; McKinsey Insights: Scaling the CCUS industry to achieve net-zero emissions; Global Data; McKinsey; UN PRI	1. The total 2025 global market size estimates for both operational and capital expenditure were obtained from IEA Net Zero and UN PRI Forecast Policy Scenarios
15	IEA	1. According to the Base Case – Forecast Policy Scenario (UN PRI)
16	TFM Data; Global Data; IEA; IRENA	Investment figures shown are based on Base Case – Forecast Policy Scenario (UN PRI) only
17	GlobalData; US Department of Energy	Pipeline figures are based on projects completed but not currently in use, currently under construction and future projects that have been announced
18	Global Data; IEA; Company websites	
19	Global Data; IEA; Carrier websites	1. Subject to product designs adhering to regulatory guidance and requirements
20	Carrier websites; SMI ITF 2022 products and services showcase; Climeworks; UN PRI; IEA	1. SPILLS – Site Pollution Incident Legal Liability Select; 2. CELL – Contractors Environmental Legal Liability
21	IEA; UN PRI; GlobalData	1. Heating includes heat pumps, solar thermal and biomass
22	IEA; International Council on Clean Transportation; PwC	**1.** Another key element to building retrofits and green buildings is use of green materials which is not included in our model **2**. According to the Base Case – Forecast Policy Scenario (UN PRI)
23	The Building System Carbon Framework; McKinsey: Climate risk and the opportunity for real estate	
24	McKinsey; IEA; UN PRI	

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Notes & Sources (2/3)

Page number	Source	Notes
25	McKinsey; IEA; UN PRI	
26	IEA; UN PRI; Carrier websites; SMI ITF 2022 products and services showcase	1. Percentage split according to the Base Case – Forecast Policy Scenario (UN PRI)
28	IEA; International Council on Clean Transportation; IEA; UN PRI; GlobalData	1. Batteries includes grid, EV charging and EV battery manufacturing; 2. Grid includes replacement only and excludes new lines
29	IEA	
30	IEA; Energypost; S&P Global; Financial Times; U.S Department of Energy; Reuters	
31	IEA; International Council on Clean Transportation; GlobalData	1. According to the Base Case – Forecast Policy Scenario (UN PRI) with battery here including grid, EV charging and EV battery manufacturing
32	IEA; GlobalData	1. Expected Capex investment is based on the Net Zero Scenario (IEA). Excludes China.
33	GlobalData	1. Power rating (measured in megawatts) indicates how much power can flow into or out of the battery in any given instant; 2. The energy rating (measured in kilowatt-hours) is the amount of energy that can be delivered or absorbed over the course of an hour
34	IEA; International Council on Clean Transportation; S&P Global; EVGO; Manufacturer websites	1. The Group Rating Panel, administered by Thatcham Research, assigns new car models to an insurance group from 1 (cheapest to insure) to 50 (the most expensive).
35	Aon analysis	
36	SMI ITF 2022 products and services showcase; Carrier websites	1. Percentage split according to the Base Case – Forecast Policy Scenario (UN PRI)
38	Global Geothermal Alliance; Global Data; IRENA; International Energy Agency; World Energy Investment; Bloomberg	
39	IEA, Global Data; TFM Data; IRENA; DECC; USGS	1. According to the Base Case – Forecast Policy Scenario (UN PRI)
40	Global Data; IEA; IRENA; Company websites	
41	Aon analysis	
42	ITF 2022 products and services showcase; Carrier websites	1. Based on a Net Zero Scenario
44	McKinsey; IEA; Princeton University; Global Business Travel Association; SMI	1. Numbers in the heatmap refer to number of solutions from SMI Insurance Task Force members, with some solutions in multiple pillars or lines of business; 2. Change Vs. reference case in 2050

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Notes & Sources (3/3)

Page number	Source	Notes
45	SMI: Agribusiness Task Force; European Institute of Innovation and Technology	
46	McKinsey; IEA; Princeton University; Global Business Travel Association; SMI; IMO; UN Global Compact; ICS	1. Numbers in the heatmap refer to number of solutions from SMI Insurance Task Force members, with some solutions in multiple pillars or lines of business; 2. Change Vs. reference case in 2050
47	McKinsey; IEA; Princeton University; Global Business Travel Association; SMI; IMO; UN Global Compact; ICS	1. International Chamber of Shipping; 2. International Transport Workers' Federation; 3. United Nations Global Compact; 4. International Labour Organization; 5. International Maritime Organization
48	McKinsey; IEA; Princeton University; Global Business Travel Association; International Air Transport Association (IATA); SMI	

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