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Risk revealed by Lloyd's

Clean technologies and hard-to-abate sectors

Lloyd's Futureset

AON

Geothermal

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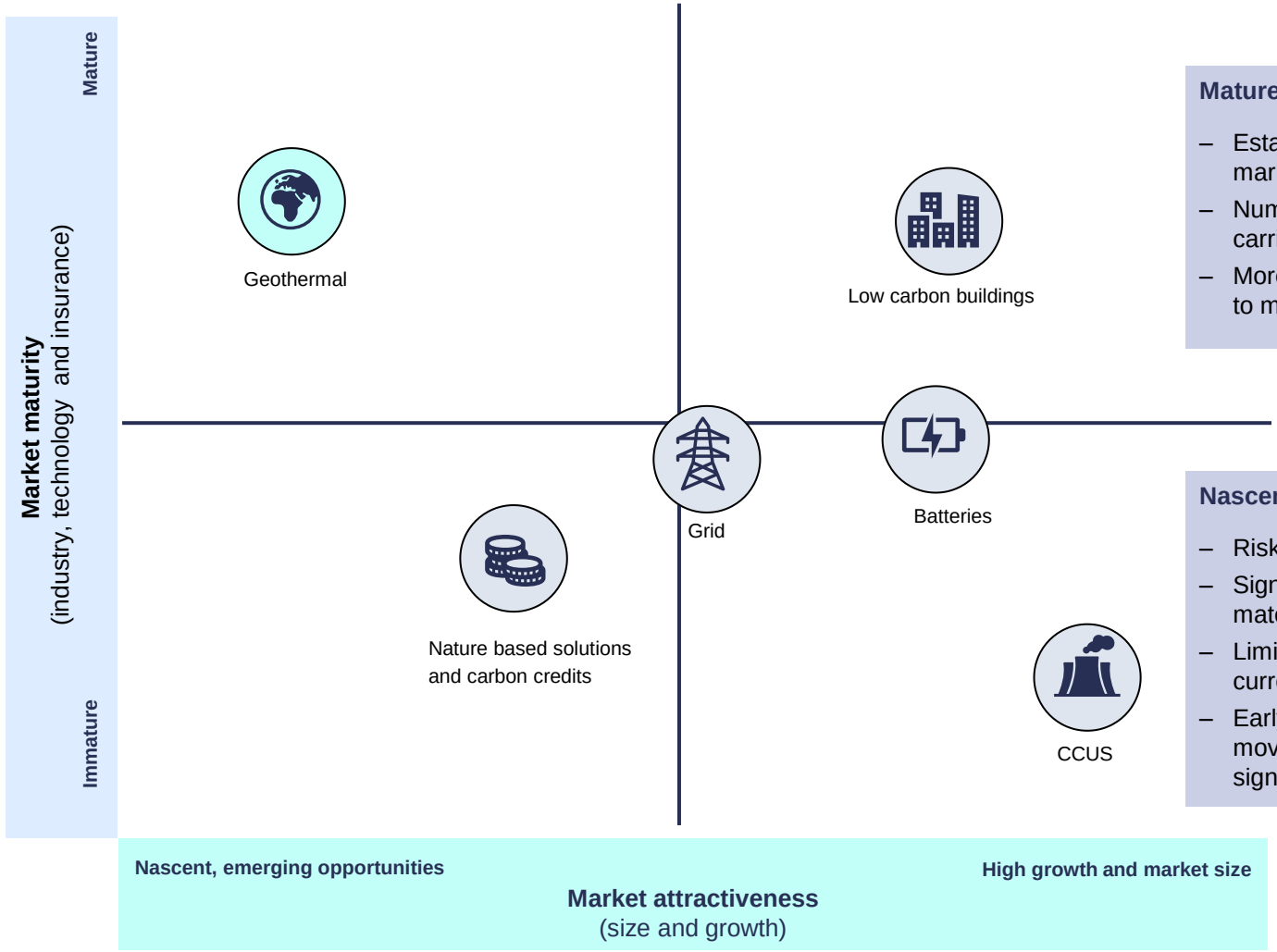
Building a larger presence in emerging 'transition' technologies could help the insurance industry to lead innovation and grow sustainably

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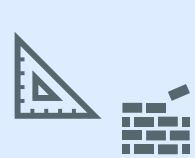
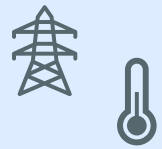
Geothermal energy is generally thought to be limited to regions sitting on tectonic plate boundaries, but growth in ground-sourced heat pumps has demonstrated wider opportunities

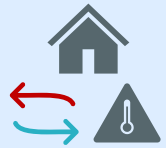
Industry and insurance market dynamics

- 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

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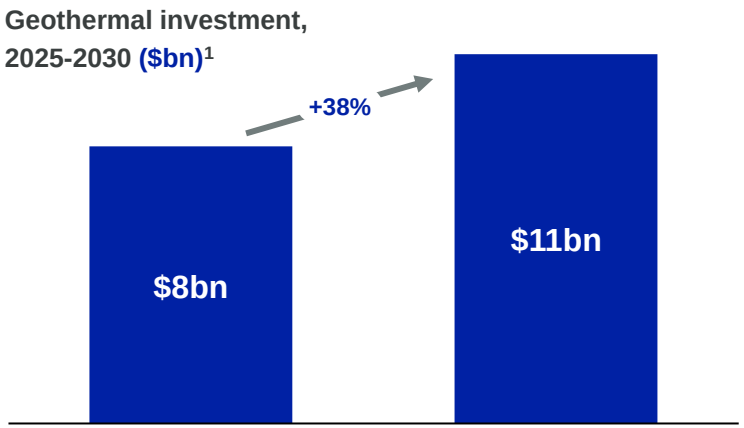
While district heating systems are a mature technology, there has been a lag in development of the geothermal solutions due to the costs of accessing heat for power generation

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

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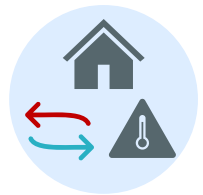
The value chain for extracting heat from below the Earth's surface for heat, power or combined (CHP) has less complexity than many other green technologies and fewer stakeholders

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

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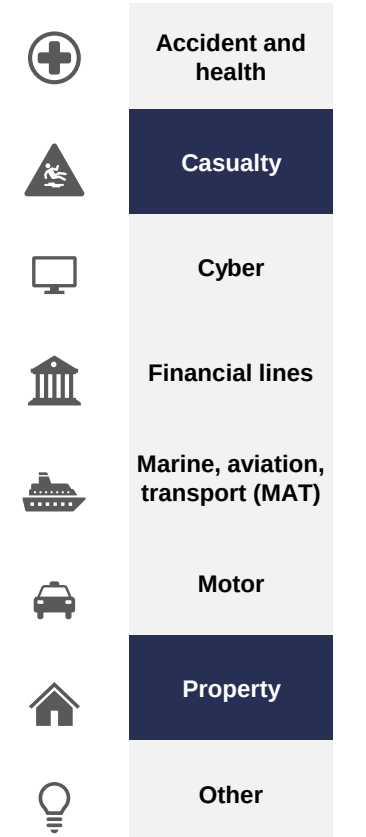
The exploratory phases of geothermal projects can present the most material risks and potential cost increases

(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

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Notes & Sources (2/3)

Page number	Source	Notes
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

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