An Introduction to Risk Transfer Solutions for Climate Projects

How insuring and hedging risks help early-stage climate technology infrastructure projects

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This document is the second of a series of introductory guides planned for publication. The series aims to familiarize readers with important elements of climate project development and to accelerate the construction of climate infrastructure. The first paper covered climate offtake agreements. Future papers will likely cover topics such as EPC contracts, government de-risking mechanisms, debt structures, and catalytic capital arrangements. If you have expertise on these topics as they relate to climate project development, please contact kweinberg@creosyndicate.org.

Introduction

The transition to a decarbonized economy has reached an inflection point. Companies and governments have begun to spend what will total trillions of dollars on infrastructure to reduce or eliminate emissions. With such huge stakes, these projects offer significant opportunities for companies, investors, debt financers, and others (not to mention for humanity).

Companies developing climate hardware that is less polluting than legacy technologies face special challenges as they implement their solutions in large-scale projects. Deploying new technologies, such as direct air capture facilities or sustainable steel plants, on the scale needed to mitigate climate change can present many risks, including those that are technology-related (e.g., the solution does not perform its intended task), project-related (e.g., the solution does not scale), and business-related (e.g., the solution is not economically viable).

To obtain the hundreds of millions or billions of dollars often needed to build a project, companies must show funders – usually debt financers – the steps they have taken to limit risks. One such method is securing risk transfer solutions, particularly insurance and hedges. These solutions are critical to efforts to mobilize private industry to decarbonize.

While risk transfer solutions are sometimes critical pre-requisites to receiving debt financing, they are frequently left out of "fit-for-purpose capital" discussions. Fit-for-purpose capital, when used in project finance discussions for climate technology and infrastructure efforts, refers to capital that is most appropriate for a company's objectives. For example, loans may be better for financing specific projects or purchases, such as inventory or equipment, while venture capital may be better for financing technology development and operations at earlier-stage enterprises. The discussion is typically limited to investment capital and does not include contingent capital, which is made available only in specific circumstances.[1] Insurance and hedges facilitate fit-for-purpose contingent capital formation and accelerate the construction of infrastructure by reducing the impact of risks that disqualify a project for debt finance.

Risk transfer solutions can be difficult to obtain. Because few emerging climate technologies have been scaled into large, repeatable projects, limited performance data exists for risk transfer solution providers to evaluate the risk of these projects.[2] Risk transfer providers also have finite climate-specific capacity and inadequate incentives to underwrite new technologies. Risk transfer markets need better data, more human and financial resources, and greater appetite to better serve emerging climate technologies seeking to build infrastructure projects.

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[1] Contingent capital is paid once or over time in exchange for stability and compensation when something goes wrong. It can take various forms, such as insurance or hedges, but the function is the leading consideration for buyers.

[2] Emerging climate hardware companies include those in hydrogen, sustainable aviation fuel, cement, steel, carbon dioxide removal, and select other fields.

This paper describes how insurance and hedges limit risk, including the types of risks they can mitigate and issues with each solution. The paper also discusses factors to consider when evaluating a risk transfer solution. By better understanding these solutions, climate technology companies, governments, and investors increase the chances that climate infrastructure projects will be funded and completed.

What kinds of project risks do climate infrastructure technology companies face?

An emerging climate technology company is one that has developed a new emissions-reducing innovation and seeks to implement it at infrastructure-scale. These solutions are diverse and include facilities for carbon removal, green hydrogen and sustainable aviation fuel production, sustainable cement and steel manufacturing, among others.

The technology innovator and the project developer can be different companies. Sometimes, the company that developed the technology licenses its intellectual property to a project developer that will build, own, and operate the scaled facility. This paper refers to the company as the project builder, but the same principles apply to a builder that has licensed the technology. Whichever entity builds the project will face similar project risks and financing challenges.

Larger projects often involve building expensive plants and distribution networks. An offshore windfarm can cost $1-$2 billion, while a green hydrogen plant can cost $0.5-$8+ billion.[3,4,5] Many projects are government-subsidized through methods such as construction assistance (e.g., investment tax credits) and guaranteed output purchases (e.g., offtake agreements). Public funding, however, can be slow or difficult to obtain, and rarely covers all costs. To expedite the testing and deployment of these projects, companies look more to private lenders.

Companies developing climate technology face various risks when pursuing large-scale deployments. These risks can be technical, physical, geopolitical, constructional, volumetric, price-related, regulatory, or counterparty, among others, and contribute to broader project- and business-related risks that regularly concern companies. For example, a carbon removal company might be at risk from falling carbon credit prices or reduced CO_2 extraction due to faulty fans - limiting its revenue and jeopardizing its ability to make monthly loan payments. These concerns make a project less attractive to potential lenders.

To evaluate risks where performance data is scarce, risk transfer solution providers sometimes use proxy datasets containing information about projects with similar risk exposures. For example, financial institutions might quote general electricity price hedges using natural gas commodity prices as a proxy, even though the two are only partially correlated.[6] Insurers might price liquidated damage protection premiums for green hydrogen facilities, where there is little data, using loss history data from utility-scale batteries, where there is considerable information.

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3 "Offshore Wind Energy: A Very, Very Expensive Electricity Source" (Institute for Energy Research)
4 "Plants For Nearly $500m Green Hydrogen Facility Unveiled in Louisiana, Back with State Government Cash" (Hydrogen Insight)
5 "Saudi Arabia's $8.4bn Neom Green Hydrogen Mega-Plant Inks Deal for Chinese Equipment" (Hydrogen Insight)
6 "Hedging Electricity in the Irish Market" (KPMG)

What are risk transfer solutions?

Companies pursue various strategies to limit risk. For example, they can *avoid* risks (e.g., by not building a plant in a hurricane-prone region) or *mitigate* risks (e.g., by limiting the project's scope, extending the construction timetable, or building a seawall). The time and cost of these approaches can vary significantly. They might also choose to *accept* a risk.

Sometimes, though, limiting a risk operationally is unachievable or undesirable. In these cases, a company might seek a third party that will accept some or full responsibility for the risk. Such "risk transfer solutions" are legally-binding contracts, primarily insurance policies and derivative agreements (or "hedges"), that transfer risk from the company to a third party.[7] These instruments do not eliminate or mitigate the underlying risk. Rather, they are financial shock absorbers, reducing a company's potential financial loss if a risk manifests and smoothing its experience in volatile conditions.[8] In this paper, "risk" refers to the expected loss due to a negative event.[9]

By building financial resilience, risk transfer solutions free companies to take risks they might otherwise forego. For example, they might operate in a new geography or use a new contractor. Risk transfer solutions can make it easier for companies to obtain project financing by limiting financial liabilities and freeing capital they would have had to set aside as reserve to cover service risks. Ultimately, the better risk profile should lead to more reliable projected cash flows for repaying a loan. These solutions improve a project's "bankability," or its ability to attract financing from banks, investors, and other financial institutions.[10]

The two primary places where companies transfer risks are insurance markets and financial markets.[11] As an example of an insurance solution, consider the case of Bloom Energy, which manufactures and markets solid oxide fuel cells that produce electricity on-site. After raising hundreds of millions of dollars in venture funding and operating for 12 years, Bloom Energy's technology was still new to the market and unfamiliar to debt financiers. However, to deploy its technology at-scale, the company needed large loans. Between 2013-2015, Bloom Energy worked with New Energy Risk, an insurance product structurer, to secure technology

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[7] Derivatives are financial instruments that transfer risks from one party to another without changing ownership of the underlying right or interest. They *derive* their worth from the value of the underlying asset or interest, which commonly are stocks, bonds, commodities, currencies, interest rates, and indexes. A "derivative" can be used for many types of trading (e.g., betting on price changes or gaining exposure to a particular asset). A "hedge" is a strategy or particular financial transaction that is used to offset or mitigate the risk of adverse price movements. While a hedge is a derivative, a derivative is not always a hedge.

[8] "Risk transfer solutions," "financial products," "protection," and "coverage" are used synonymously throughout the paper to refer to insurance and derivative products.

[9] The textbook definition of risk is a "condition in which there is a possibility of an adverse deviation from a desired outcome that is expected or hoped for" based on the *Fundamentals of Risk and Insurance* or "variability that can be quantified in terms of probabilities" based on The Essentials of Risk Management.

[10] "Bankability" refers to a project that has guaranteed cash flow and likely meets the requirements of financiers to provide a loan. A "bankable" project has three key features: [1] offtaker(s) with investment-grade credit-rating; [2] revenue stream(s) with known quantities and timing; and [3] insulation from cashflow interruption due to uncontrollable circumstances.

[11] With credit risk, a company can transfer risk to both insurance and financial markets.

performance insurance with AXA XL.[12] This solution helped Bloom Energy obtain debt financing faster and with better rates.

As an example of a hedge solution, consider the 228 MW Lal Lal wind farm project in Victoria, Australia. It generates clean electrons for the Australian grid. To secure debt financing, the developer worked with the insurance-linked securities firm Nephila Climate and financial services provider Allianz. The project secured a "proxy revenue swap" that protected it from losses related to production volume, timing of energy generation, and future energy price risk in exchange for upside revenue sharing.[13] This product helped Lal Lal attract project investors like Macquarie Capital, Infrared Capital Partners, and Northleaf Capital.

A company typically seeks a risk transfer solution when external protection is obligatory (e.g., to get debt financing or to access rental equipment) or operational approaches are too costly. Cost is a common driver of these decisions. In a cost-benefit analysis of a risk transfer solution, a company considers factors such as the likelihood the risk will occur (5% vs. 50% probability); the time over which the risk could occur (daily vs. yearly); the projected size of the loss caused by the risk ($1 vs. $1 million); and the impact of the of the project loss relative to the company's size (3% vs. 30% of company value).

Risk transfer solutions are generally desirable – depending upon the price – for risks with lower probabilities, shorter time horizons, and larger financial impacts relative to a company's size. For example, an insurance policy with a $30,000 premium is valuable to a company if the risk being transferred has a small but material probability of happening every month (e.g., 1-5%) and could cause $5 million in losses – which is 80% of the company's value. While potentially counterintuitive, the reason companies will likely seek insurance for a risk with a lower probability is because higher probability risks are less likely to be insured. Companies are also comforted and can be less cash constrained by paying an insurer a premium to hold a risk instead of reserving funds should a risk manifest. In other words, contingent capital can be more efficient for risk management than reserving dilutive equity capital.

In addition to being critical for project development and management, risk transfer solutions can provide investment opportunities and sources of market insight. As investors allocate more capital to emerging climate technologies, investing in providers of climate-related risk transfer solutions can diversify their portfolios as well as make projects financeable.[14] Investments in insurance companies can deliver long-term returns and resilience during economic downturns. Because events in financial markets do not cause physical damage and trigger policies, insurance investments are relatively uncorrelated with broader public and private financial markets. Investors also watch for price signals (i.e., premium costs) from insurers and underwriters.[15] An asset is likely not financeable if it cannot be insured affordably, if at all, or otherwise protected through risk transfer products.

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[12] "New Energy Risk Partners with Bloom Energy on its Capital Raise with Performance Insurance" (New Energy Risk)

[13] "Nephila Climate and Allianz Complete Proxy Revenue Swap for Australian Wind Farm" (Reinsurance News)

[14] "Climate Tech Investments Rise to $16.6 Billion in Third Quarter" (Bloomberg)

[15] An insurance underwriter is responsible for determining whether an insurer can provide coverage for a risk and for pricing the policy (i.e., using data to establish the amount of premium needed to transfer the risk). A derivative underwriter or structurer similarly evaluates and assumes another party's risk. However, the fee can be a premium *or* a commission, spread, and interest. (Corporate Finance Institute, Société Générale)

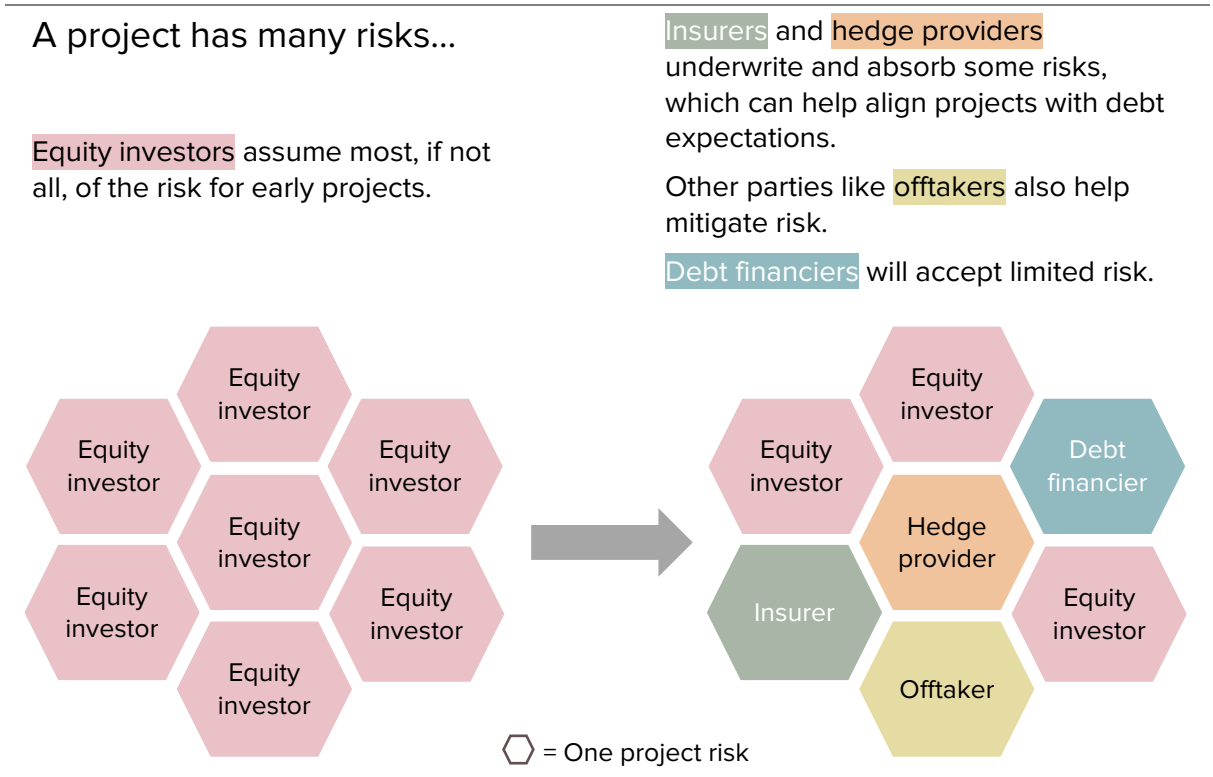
Why are risk transfer solutions important for emerging climate infrastructure projects?

In addition to reducing financial risk, securing a risk transfer solution can improve, and be a positive indicator of, a project's bankability. These solutions help align companies and projects with debt finance requirements by underwriting and absorbing risks that lenders will not accept. Insurance and hedges can affirm a project will be able to repay its debt.

The likeliest funding sources shift from equity to debt for emerging climate hardware companies pursuing large-scale infrastructure projects. Entrepreneurs and investors prefer debt for these projects because it is non-dilutive and enables them to keep a bigger share of the profits. In addition, only a limited number of equity investors can write the large checks that these projects need. However, securing loans or other forms of non-dilutive finance for initial facilities can be challenging, as projects might not generate revenue for some time or at all.[16]

Debt providers are usually conservative and want to limit the risk associated with their commitments. Risk transfer solutions absorb risk from projects to make them more appealing to debt providers. Rather than securing additional equity investment and diluting ownership or paying high interest payments on loans to build projects, developers seek risk transfer solutions and pay more capital-efficient premiums.

Figure 1: This diagram illustrates how risk transfer providers help companies meet debt expectations or requirements for their projects.



[16] The financing gap that results from lack of debt and equity investment appetite is called the "second valley of death" or the "missing middle." (Information Technology and Innovation Foundation, S2G Ventures)

Investors allocate capital based upon return on capital expectations and risk tolerances (i.e., risk-return profiles). A venture investor will allocate capital for an equity stake in a company with an expected 30%+ return on investment.[17] In contrast, a lender might fund a project for a 12%+ return. Risk transfer solutions can help companies shift their financing sources from higher risk-return profile technology development to lower risk-return profile technology deployment.

Emerging climate technology companies must attract, time, and structure fit-for-purpose capital for project development. Corporate investors typically make equity investments in the parent company ("TopCo") that created the technology, with the hope of an eventual liquidity event, such as an initial public offering, a merger, or an acquisition.[18] Investors can deploy capital early in a company's history and underwrite the *general* execution risk of an enterprise, as well as the technology risk. The success of an emerging climate technology TopCo, though, relies on the deployment of projects at scale (unless it sells the technology to another party).[19]

Building large projects requires attracting more risk-averse investors. Debt providers typically offer loans to a subsidiary entity ("ProjectCo") that houses the specific company project for customizing the technology. In return, the financier expects interest payments from the project's cashflow. These funders underwrite the *idiosyncratic* execution risk of a particular project and provide loans secured by collateral. Emerging technology project developers with limited capital might use the project or the intellectual property rights of the technology as collateral. Some TopCos with significant risk use venture capital funds to build demonstration or first-of-a-kind commercial facilities to prove technological viability and ease non-dilutive fundraising for future projects.[20] Risk transfer solutions can also help bridge the risk appetite gap between corporate investors and debt financiers.

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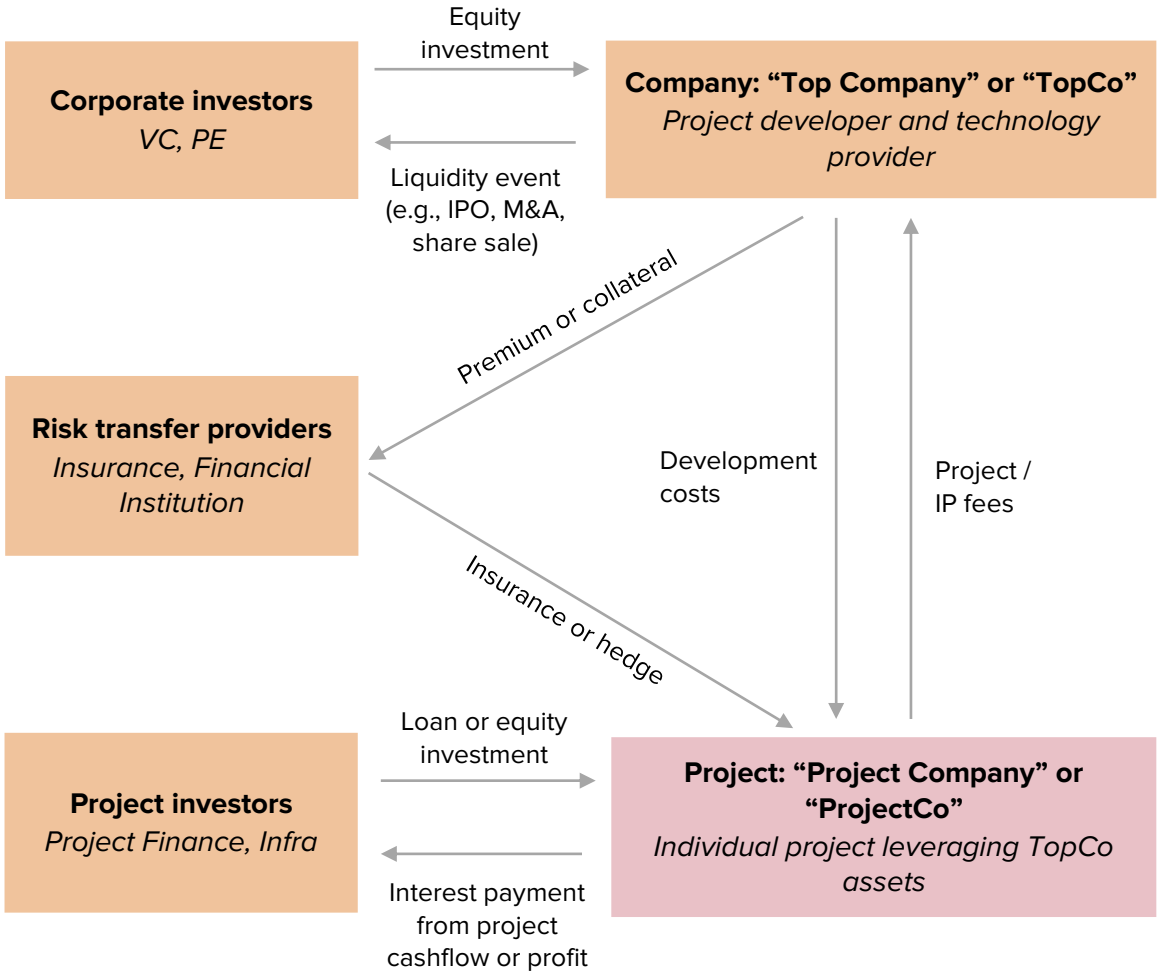
[17] "Internal Rate of Return: What You Need to Know" (AngelList)

[18] TopCo can also apply to project developers that license technology from the company that created it.

[19] See the prior paper on offtake agreements for more information.

[20] Demonstration facilities can prove that a technology works at scale and quell concerns about scale, yield, availability, cost predictability, serviceability, and customer satisfaction. First-of-a-kind facilities are intended to be profitable, prove a technology's commercial performance, and establish a track record for future projects.

Figure 2: The relationship and value exchange among corporate investors, risk transfer providers, and project and infrastructure financers with TopCo and ProjectCo.[21,22]



[21] In Figure 2, venture capital (VC) and private equity (PE) are shown separately. While VC is technically a form of PE, in investor circles, the terms have different meanings. VC investors commonly seek minority ownership of early-stage companies with significant growth potential, while PE investors usually pursue majority ownership of later-stage companies. Some private equity investors seek returns from a company's cash flow as opposed to a liquidity event.

[22] While the line from risk transfer providers is directed at the ProjectCo, insurers and financial institutions also provide insurance and hedges to the TopCo.

How do insurance markets operate?

The history. Insurance has a long history. Management of commercial risk can be traced to Babylonian and Chinese traders who divided goods among several ships before embarking on treacherous voyages.[23] Modern insurance practice — underwriting risk in exchange for premium — began to emerge in the late 1600s. After the Great Fire of London in 1666 destroyed thousands of buildings, primary insurance policies arose to provide fire protection for wooden homes and shops.[24] In the late 1680s, at Edward Lloyd's coffee shop on Tower Street in London, sailors, merchants, and shipowners gathered to hear reliable shipping news and maritime auction prices. Bankers joined the crowd to accept shipping risks in exchange for premiums.[25] More than a century later, modern reinsurance developed. Around 1846, Cologne Re was established to cover increasingly frequent and severe loss events (e.g., natural catastrophes such as the Hamburg fire in 1842). These events demonstrate that diversification – of buildings in a city in this example – can be eclipsed by severe and concentrated events, like a city-wide fire. Reinsurance companies were created to overcome risk severity and concentration problems by diversifying risk globally. Today, insurance is a multi-trillion-dollar industry.

The players. To understand how insurance markets operate, it helps to understand the key players and their roles. Six primary actors are involved in transferring risk in insurance markets:

- The *insured* wants affordable protection from a specific risk from a reputable insurer.
- Insurers (*primary insurers* and *reinsurers*) sell risk protection in exchange for a premium. This group is sometimes referred to as "protection providers" or "capacity providers."
- Intermediaries (*brokers, managing general agents* or *"MGAs,"* and *managing general underwriters* or *"MGUs"*) help place and administer policies, usually for commissions, and may receive success fees.

The figure below shows the relationship among these actors.

[23] "How Insurance Began: 3000 Years of History" (W S R, INC.)
[24] "How the Great Fire of London Created Insurance" (Museum of London)
[25] "Our history" (Lloyd's of London)

Figure 3: The relationships among insurance market actors.[26]

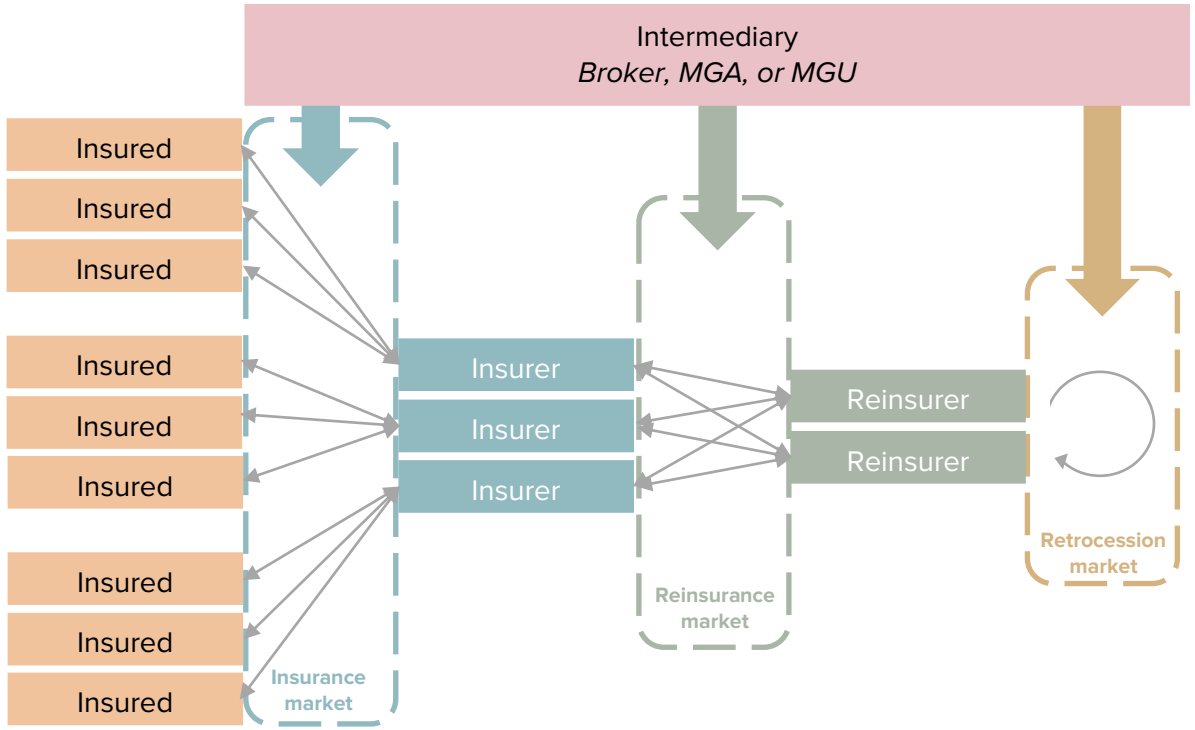


Table 1: Insurance market actors.

Actor		Category	Description
Insured / Policyholder		Protection buyer	Individual or company seeking indemnification (i.e., protection) if a loss occurs
Primary insurer		Protection provider	Company directly providing protection to organizations or assets
Reinsurer		Protection provider	Company that insures primary insurers, limiting their potential losses on claims
Retrocessionaire		Protection provider	Company that insures reinsurers, limiting their potential losses on claims. No company specializes solely in retrocession. Rather, reinsurers cede risk to other reinsurers in retrocession transactions.
Inter-mediary	Broker	Protection negotiator	Intermediary between the insured and (re)insurer, helping the insured secure a policy matching its needs
	Managing general agent (MGA) / managing general underwriter (MGU)	Protection structurer	Intermediary between the insured and (re)insurer, performing underwriting and other administrative functions on behalf of the protection providers

[26] This diagram was adapted from Figure 2 in "Risk Transfer Solutions for the Insurance Industry" by Vladimir Njegomir and Rado Maksimovic.

Primary insurers focus on distribution to sell policies at volume. To manage their own risks, they seek a certain level of risk retention – the amount of risk they hold instead of transferring it to a reinsurer. Primary insurers can transfer (or "cede") some or all of their risks, policies, and premiums to a reinsurer.[27] *Reinsurers* assess the risk of the policy bundles offered by primary insurers. Based on their underwriting expertise, balance sheet capacity, market relationships, and other factors, reinsurers will identify policy bundles with the lowest projected claims and highest premiums and choose to which insurers they offer capacity. Some reinsurers specialize in certain types of risk or coverage, such as energy or space. Sometimes reinsurers function like primary insurers, offering policies directly to the insured. ***Retrocessionaires*** are similar to reinsurers, but instead of backstopping insurers, they insure reinsurers. No company specializes solely in retrocession. Rather, reinsurers cede risk to other reinsurers in retrocession transactions.

Reinsurers can be the most innovative protection providers. Their sophisticated risk modelling and analytical tools, combined with large balance sheets, enable them to evaluate and underwrite large, complex risks. The technical capabilities of reinsurers enable them to play a significant role in creating new products for emerging risks, assets, and geographies. These new products are then tested with a group of protection buyers. If the products perform well, they can be introduced to primary insurers and brokers for wider market reach.

Emerging climate technology companies with multi-million or billion-dollar projects and longer-duration risk transfer needs require reinsurers and retrocessionaires to accept excess risk that primary insurers cannot bear. As these parties cover more climate infrastructure projects and more performance data becomes available, policies can start to become standardized, likely making it easier for future projects to get coverage.

- For more information about the types of reinsurance coverages and structures, see Appendix I.

Brokers tend to be the first stop for companies seeking insurance. They do not provide insurance and do not underwrite risks. Rather, brokers connect other insurance industry players to one another. They maintain relationships with protection buyers (e.g., governments, corporates, and startups) and protection sellers (primary insurers and reinsurers). Brokers earn commissions by matching an insured with an insurer, an insurer with a reinsurer, a reinsurer with another reinsurer (a retrocessionaire), or some other combination of parties. To create more matches and ease back-office burden, brokers can also negotiate on behalf of the insured and insurer; handle policy filing and insurance regulatory requirements; hold certifications required to file and place insurance products; and sometimes pay required taxes.

Managing general agents (MGAs) and *managing general underwriters (MGUs)* are intermediaries like brokers. However, unlike brokers, their insurance partners can grant them policy-binding authority. This means they can price, quote, and bind policies that fit within specific risk parameters. MGAs differ from MGUs in that, they typically have broader authority, including claims management, and focus on administrative and operational aspects as opposed to technical underwriting details.[28]

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[27] Similar to how primary insurance is not always available to those who seek it, reinsurance and retrocession are not always available to primary insurers who seek it.

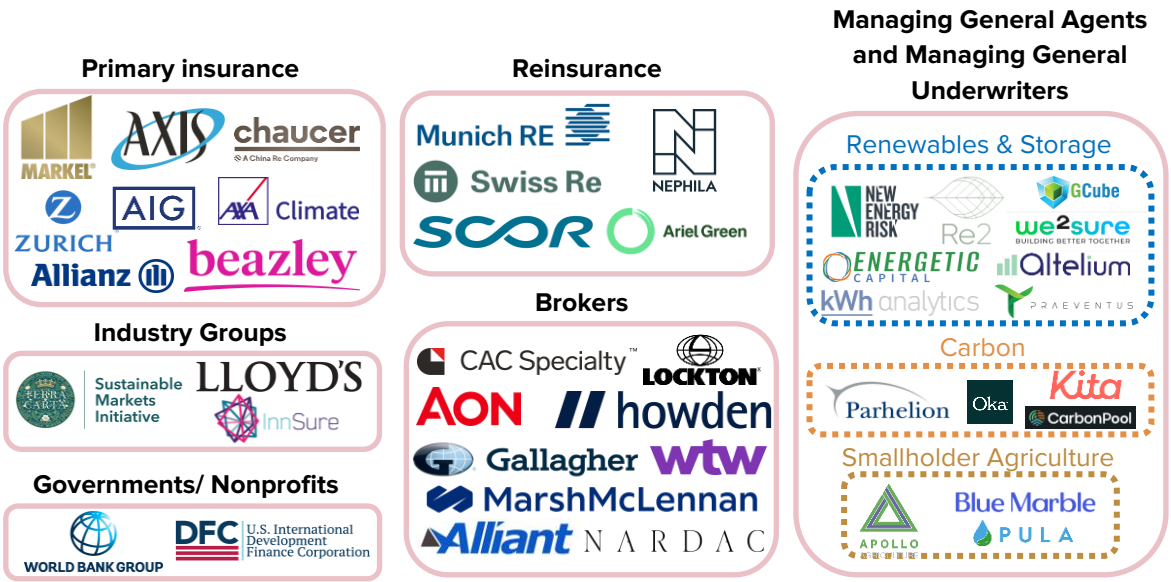
[28] "MGA vs. MGU in Insurance: Understanding the Key Differences" (Insly)

MGAs and MGUs are underwriters that large capacity providers can easily hire (or fire) to gain diversified risk exposures. Similar to fund managers, they (particularly MGUs) differentiate themselves by having either expertise in nonstandard, niche, or specialty lines of insurance or access to specific customer segments. When insurers lack the experience or data to price certain risks, intermediaries like MGAs and MGUs can supply needed insight. They thus allow insurers to enter new markets without building new internal infrastructure and capabilities. In addition, primary insurers can be so big that they cannot adapt rapidly to emerging client needs.[29] MGAs and MGUs can function like personal risk shoppers for insurers and reinsurers, finding new underwriting opportunities for their clients. MGAs and MGUs are sometimes backed by venture capital and commonly market themselves as technology companies.

The relationship between intermediaries (brokers, MGAs, and MGUs) and capacity providers (insurers and reinsurers) can change quickly. Policy performance, market reputation, and personal rapport can play a significant role in how insurers evaluate intermediaries. After a policy has a year of bad performance (i.e., claims exceed the premium), the capacity provider is unlikely to renew the policy. Capacity providers reevaluate not only their policies but also their relationships with intermediaries. Intermediary reputation matters to capacity providers. For example, some intermediaries are known to provide limited added value during negotiations, while others push leading edge technology and policy innovation.

As insurance for climate infrastructure projects is still an emerging market, finding brokers with knowledge of emerging climate technologies can increase the likelihood of securing a risk transfer solution.

Figure 4: Leading actors for emerging climate infrastructure insurance.[30]



[29] "A Hot Market: Insurers Launch Climate-Related Business as Green Tech Grows" (Best's Review)

[30] This figure is not comprehensive.

Are emerging climate infrastructure insurance policies available?

McKinsey cites a "once-in-a-generation opportunity" for insurers to address new climate change-induced volatility and to catalyze decarbonization with adapted or new products.[31] The imperative for adopting emerging climate products is strong, but since most insurers do not feel the same pressure (yet), they have been slow to innovate. While some insurers embrace ambiguity and product innovation, many still have a wait-and-see approach for emerging climate infrastructure projects. As a result, a limited number of products and capacity providers is available for emerging climate infrastructure companies and projects.

Two primary reasons for limited industry movement, beyond lack of awareness of the opportunity, are data gaps and limited incentives.

Data gaps. Risk transfer solutions for climate infrastructure projects are not standardized like those for life insurance. Evaluating the risk of a project frequently requires significant modelling with specific data. Insurers prefer years of technology and project performance data to price policies. Without sufficient valid data on technology and project performance for emerging climate technology, insurers might struggle to model risks. If they do offer a policy, they will likely pad the premium to account for uncertainty. Some insurers partner with infrastructure funds and institutional investors to access data and technical expertise.

Limited incentive. The primary insurer business model relies on scale through policy distribution and sales. Insurers are less inclined to pursue a new type of policy until its terms and evaluation become standardized and market demand is sufficiently large. Insurers may be satisfied with premiums from legacy industries, whose standardized policies are large, reliable, and profitable. With limited incentive to hire new talent and find new revenue streams, the traditional insurance industry could impede the transition to a decarbonized economy.

Within the climate technology risk transfer sector, insurance innovation is driven primarily by MGAs and MGUs for policy guidance and reinsurers for both product innovation *and* risk capacity. However, since MGAs and MGUs lack balance sheets or capacity to hold the risk, the reinsurance market becomes the ultimate arbiter of whether a new risk transfer product will be "placed."[32] MGAs and MGUs are also limited in their ability to develop new products. Each typically focuses on a single or a few products.

Some traditional insurers choose to start underwriting climate infrastructure policies but limit their exposure. For example, policies might provide annual coverage, even though the company or project needs multi-year coverage. Policies might also restrict the amount of risk insurers accept or include claim exclusions.

With time, data, and adoption, insurance policies for climate technologies should become more common and standard, and premiums should decline. Insurance used to be much

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[31] "Capturing the climate opportunity in insurance" (McKinsey)

[32] Primary insurers and reinsurers have the most influence over which risk is underwritten. These two actors have "capacity" or "risk capital" to provide insurance. Insurers must maintain enough capital to carry risks they underwrite and therefore have limited capacity.

costlier for electric vehicles (EVs) than for gas-powered vehicles. The gap narrowed over the past 15 years as EVs became more common. Further premium decreases are expected as EV popularity increases, battery technology evolves, and more data becomes available.[33,34] Before 2019, when outsized natural catastrophe losses drove up premiums and reduced risk capacity, insurance for renewable energy assets was easily attainable.[35] Insurance premiums for renewable energy assets aligned with those of power, oil, and gas assets. As risk capacity providers gained experience, insurance coverage for wind, battery, and solar was regularly underwritten and became more prevalent in the market, sometimes with generous terms for the insureds.[36] As technologies mature, insurers can provide competitive risk capacity to climate projects.

Once new policies are in place, a few years of losses could ruin short-term coverage for the underlying risk or asset. After 2019, following years of recurring losses to solar panels, wind farms, and battery facilities from hailstorms, natural disasters, and fires, there is some evidence the insurance industry is turning away from covering many risks in the renewable energy sector.[37,38,39,40] Emerging climate technologies can and will likely face similar obstacles.

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33 "Insuring an electric car? Here's what you need to know before buying coverage" (CNBC)

34 While EV demand slowed in 2023, based on an increase in the amount of time needed to sell them compared to the year prior, many say the shift toward EVs is inexorable. Analysts also say that uneven growth is not surprising as EVs move from niche products to mass market offerings. (CNBC, NYT)

35 In 2019, one hailstorm in Texas alone caused $75 million in damage to a solar farm. (Best's Review)

36 "From Niche to Necessity: Insuring Renewable Energy" (PV-Tech)

37 "Storm Season has the US Solar Industry Looking to Protect Assets from Costly Hail Damage" (PV Magazine)

38 "Evolving Extreme Weather Risk Posing Unprecedented Insurance Woes for Renewables" (Power Mag)

39 "Battery Storage Fire in Arizona is Under Investigation" (Power Engineering)

40 "Of, the Irony: Climate Change-Related Catastrophes Put Green Energy Infrastructure in Peril" (Risk & Insurance)

What factors should be considered when evaluating an insurance policy?

Risk transfer solutions can be complex, especially in nascent markets. As a result, companies can have a hard time evaluating them. Moreover, because these policies are not standard, there may be more room for negotiating their terms. For example, a company might be unaware that policies do not need to start coverage at the first dollar lost. Accepting a higher deductible can lower premiums and otherwise be a useful negotiation tactic for companies seeking first-of-a-kind policies.

The following table highlights important considerations when evaluating risk transfer solutions. The indicative values are most relevant for technology performance insurance. These policies provide an output or revenue guarantee where the insured is the project owner and the sought protection covers the debt service (i.e., the cash needed to pay the required principal and interest of a loan) or other financial repayment obligation. The table is not as relevant for a manufacturer warranty backstop. (See the paragraph below Table 2.)

Table 2: Insurance policy features and guidance for emerging climate technology companies.

Features	Guidance for Buyer
Timing. When should a company start talking to an insurer or intermediary about coverage for a project?	Technology stage. Insurers typically will not cover an implementation project until the technology has shown it can scale well beyond a lab phase. Most insurers begin providing coverage when the solution reaches technology readiness level (TRL) 7 or 8, with clear momentum toward 9. The TRL reflects the maturity of a particular technology, ranging from TRL 1 (basic principles observed) to TRL 9 (fully mature and proven technology ready for commercialization). Technology with TRLs less than 7 is frequently deemed too risky. Protection size. Many reinsurers will not provide policies to customers seeking less than $10 million of protection for an individual project or less than $20 million for a portfolio of projects. These values represent the amount for which a company seeks protection or the limit (maximum payout) from the insurer, not the total value of the project.[41] The percentage of total project value a developer insures is highly dependent on its investors. A company often seeks insurance for only 20-30% of the total project value, meaning that a company seeking $10 million in protection for an individual project is likely building a $33-$50 million project. A risk-averse investor might push a company to purchase greater coverage to protect their investment and the long-term debt service. Insurers prefer individual projects or portfolios of projects with higher insured values, especially for emerging climate technology projects, so the total premiums are large enough relative to other policies (even though the insurer might be able to charge a higher rate for the coverage). For example, a

[41] Limit represents a cap on insurer's liability for covered losses. Assuming a fixed policy trigger value, companies will pay a greater premium for a higher limit.

Features	Guidance for Buyer
	$100,000-$1 million premium for a project seeking $10 million in protection is much lower than premiums for less risky legacy technologies and large projects. Structuring timeline. In general, policies for emerging climate technologies take 3-9 months to structure. The timeline largely depends on data quantity and quality, policy uniqueness, and negotiation of policy terms, among other factors.
Coverage. What type of coverage should a company get for a project?	The primary risk drivers for many emerging climate technology projects are technical, physical, financial, and geopolitical. For these risks, a company can pursue different risk transfer solutions. For an overview of different solutions, see Figure 6. Prices and availability of these options vary. Identifying the most substantial risk will help determine the best coverage option.
Deductible. What amount of risk should a company hold (vs. transfer) for a project?	A deductible is the amount a policyholder pays out-of-pocket for a claim before insurance coverage kicks in. Typically, a higher deductible means a lower premium for the policyholder because the risk held by the insurer is lower. This arrangement can benefit both the policyholder and the insurer. Usually, the insurer determines the deductible. Negotiating deductibles higher than what an insurer quotes could be a helpful strategy for decreasing premiums.
Premium. How much should a company pay in premium for an insurance policy?	The premium is an amount paid periodically to an insurer for a policy. Premiums are most frequently paid monthly or yearly. In some cases, the full premium of a multi-year insurance policy is charged upfront. Historical data, or lack thereof, is the primary determinant of a policyholder's premium. For example, a policyholder with a history of making claims or poor credit is likelier to be viewed as high-risk, resulting in higher premiums. Similarly, a policyholder lacking an insurance purchase history could have higher premiums until they build a track record.
Data. How much data does a company need for a project to get an insurance policy?	Insurers prefer having as much loss history as possible about a project. This data helps them structure and price policies. The amount of data needed varies based on the technology. For example, the data requirement will be different for 25-year solar panel warranty coverage compared to 8-year energy storage warranty coverage. Insurers often recommend that companies predict output, then compare actual output to their projections once a project is operational. A small difference between expected and actual output suggests to the insurer that production volatility and risk are limited. On the other hand, a significant difference between expected and actual output may suggest that a project's risks and volatility are too big to insure.
Length / Tenor. For what length of time should a company seek coverage?	Insurers strongly prefer annual policies, especially for first-of-a-kind policies and emerging technology projects. Shorter-term contracts allow insurers to test new risks and structures with less fear of massive claims. However, the risks that many emerging climate technology companies seek to cover are multi-year — sometimes up to 15 or 20 years — to match the length of the

Features	Guidance for Buyer
	offtake and debt.[42] Policies get more difficult to underwrite with each additional year requested. A small subset of insurers can underwrite five-year policies for emerging climate technologies, and a tinier subset can underwrite 10-year policies.

One insurance product for climate technology producers is the manufacturing warranty backstop. (This product does not apply to project developers.) The typical buyers of this product are manufacturers of solar panels, batteries, electrolyzers, or other smaller, commercially-proven technologies (TRL 9) that want to offer a warranty (i.e., a guarantee of the long-term reliability of their products). The length of the coverage usually matches the warranty period to protect against excessive warranty claims from product degradation and insolvency. For example, Munich Re provided a manufacturing warranty backstop for 25 or more years to solar module manufacturers, including Sunova Solar and Jolywood Solar in China.[43,44]

[42] Similar to offtake agreements, longer-term risk transfer contracts appeal to lenders to limit potential debt default. However, while a project might be able to secure 10+ years of offtake, securing 10+ years of protection for a risk can prove significantly more difficult and expensive.

[43] "Jolywood Solar Recognized with Munich Re Warranty" (PV Magazine)

[44] "Sunova Solar Completes Final Certification with Munich Re" (PV Tech)

How do derivatives and hedges work?

New methods to transfer risk have developed over the last 40 years. Derivatives, which are a form of hedging, have become a common method for transferring risk. Hedging allows a company to protect itself from loss on an investment by making balancing or compensating transactions. Derivatives can serve purposes besides hedging, including speculation and dealing/market making.[45] This paper focuses on their use as hedges. Most emerging climate technology developers, owners, and investors use derivatives to transfer price risk.

Derivatives are financial instruments that transfer risks from one party to another without changing ownership of the underlying right or interest. They *derive* their worth from the value of the underlying assets or interests, which commonly are stocks, bonds, commodities, currencies, interest rates, and indexes. Often the variable underlying derivatives is the price of the traded assets. A stock option, for example, is a derivative whose value depends upon the price of the stock. However, the price of derivatives can be linked to many types of variables, such as the price of steel or the amount of wind in a particular location.

Like insurance, hedges do not eliminate or lessen the chance of a risk happening. Rather, they limit its financial impact. Unlike insurance, a hedge is not guaranteed to successfully limit a risk's impact. In fact, companies have gotten into trouble by betting improperly with derivatives. In February 1995, for example, Barings Bank, Britain's oldest investment bank at the time, became insolvent after a rogue trader in Singapore bet more than $1 billion in unhedged, unauthorized speculative trades.[46] Derivatives in the mortgage market also contributed to the 2008 financial crisis.[47] For this reason, it is important to have skilled people managing hedging strategies.

There are four primary types of derivatives: forwards, futures, options (calls and puts), and swaps. These are described below (and in Table 3) with applications for emerging climate technology companies and projects. Examples used in this section were simplified for illustrative purposes.

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[45] Speculation involves taking risk from another party to profit from price changes. Dealing/market making is facilitating risk transfer by intermediating between hedgers and speculators to earn a spread between the two.

[46] "The Barings Collapse 25 Years On: What the Industry Learned After One Man Broke a Bank" (CNBC)

[47] "Over-The-Counter Derivatives" (Federal Reserve Bank of New York)

Table 3: Four primary types of derivatives. [48]

Type of Derivative	Forwards	Futures	Options		Swaps
			Call	Put	
Description	Buy or sell at a specified future date and price	Hedge against future price movement	Buy at a specified future date and price	Sell at a specified future date and price	Hedge against future price movement
Contract Type	Customized, OTC contracts	Customized, exchange-traded contracts	Standardized, exchange-traded contracts		Customized, OTC contracts
Underlying Asset	Financial asset or commodity	Financial asset or commodity	Financial asset, commodity, or index		Commodity, index, or other financial variable
Rights/ Obligations	Obligation to buy/sell at future date	Obligation to buy/sell at future date	Right (but no obligation) to buy/sell		Exchange cash flows based on financial variables
Priced Based On	Negotiation between parties	Transparent index/market	Transparent index/market		Negotiation between parties

Forwards

- Forwards lock in the price of an underlying asset at a future time. Suppose a London-based sustainable concrete company (SlabCo) sells its product to a French construction company (BuildCo). SlabCo expects a €50 million payment from BuildCo in three months, on June 19. If the exchange rate of pounds to euros falls, it could significantly reduce SlabCo's earnings. SlabCo decides to hedge its foreign exchange risk by selling €50 million in the three-month forward market at an exchange rate of 0.8702. This arrangement locks in the pounds to be realized from the euros at £43.51 million. In these situations, companies must weigh forward prices against spot prices. Here, if the exchange rate on June 19 exceeds 0.8702, SlabCo forgoes some gains through hedging because it sacrificed upside. If the exchange rate on June 19 is less than 0.8702, SlabCo made the right decision. If BuildCo considered hedging the same transaction, it would take opposite actions.

Futures

- Futures, like forwards, lock in the price of an underlying asset that a company will buy or sell in the future. Unlike forwards, though, futures trade on exchanges rather than over-the-counter (OTC). Consider a carbon removal facility that uses corn to capture CO_2 from the atmosphere (CobCo). Because of trends toward healthy diets and reduced corn-based

[48] "Swaptions" and "collars" combine various derivatives. A swaption – a combination of "swap" and "option" – gives the holder the option (but no obligation) to enter into a swap at a specified future date. Collars combine a put option to protect against falling prices and a cost-offsetting call option to limit potential gains. A purchaser limits its gains to ensure steady prices.

product consumption, CobCo worries that corn production will decrease, and prices will rise by 15% between September and October. Corn futures are projected to increase 8% between September and October. CobCo signs a futures contract to hedge against an anticipated corn price increase and to maintain its operation margins.

Options

- Puts and calls are the simplest types of options. Put options provide the right to sell an underlying right or interest at a fixed price (known as the strike price or exercise price) at a future date, while call options confer the right to buy a right or interest at a fixed price at a future date. The option holder has the right but not the obligation to exercise the option. By contrast, the seller of the option has a contingent obligation to buy or sell the underlying right or interest if the buyer exercises the option.[49] An option buyer will exercise the option to buy or sell only if the option is "in-the-money." That is, a party will exercise a put option to sell only if the actual price is below the exercise price, while a party will exercise its call option only if the underlying price is higher than the exercise price.
- *Put options* protect holders if the price of the underlying asset falls. Consider a sustainable aviation fuel (SAF) facility owner that produces 5,000 gallons each month. In January, the price per gallon is $9, but the producer worries that the price will fall by April. The owner buys 50 put option contracts that give the owner the right to sell 5,000 gallons of SAF for $8.50 in April.[50] If the quoted option price is $1, then each option contract costs $100 (100 x $1), and the total cost of hedging is $5,000 (50 x $100). If the price per gallon of SAF falls below $8.50, the holder can exercise the option and realize $42,500 in revenue. If the price stays above $8.50, the options will remain unexercised and become worthless. The owner's decision is whether the certainty of hedging the price to lock in $37,500 of net revenue ($42,500 - $5,000 put option cost) outweighs the uncertainty of leaving the price unhedged and potentially dropping below $7.50 (which would also yield $37,500 of revenue).
- *Call options* protect against price rises in the underlying asset. Suppose a sustainable steel manufacturer in Chicago needs outside temperatures to stay below 90°F for factory conditions to comply with employee safety rules. For every day that temperatures exceed 90°F, the manufacturer must close the plant and lose $250,000. Closing for more than six days could render the company insolvent. Over the past three years in Chicago, an average of 4.7 days exceeded 90°F. The company could buy a $250,000 temperature call option for May through August.[51,52] The manufacturer must decide whether to pay one day's revenue for protection from seven or more days above 90°F or remain unprotected.

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[49] Derivative transactions, like non-derivative transactions, have a long and short side. The "long" party is considered the buyer and benefits from price increases, and the "short" party is the seller and benefits if the price falls.

[50] Since there are no price indexes for *sustainable* aviation fuel and limited price indexes for *industrial* aviation fuel, most companies purchase crude oil hedges as a proxy because of its strong correlation to aviation fuel prices. Options can be purchased from commodity trading desks at big banks (e.g., Goldman Sachs, Morgan Stanley, and JPMorgan Chase).

[51] The temperature call option can be purchased from the Chicago Mercantile Exchange (CME) Group, which has an index of daily average temperatures using data from a basket of temperature-collecting sites. "Weather Products" (CME Group).

[52] Weather derivatives are more complicated than described. Technical information and practical examples about how temperature derivatives are available here.

Swaps

- Swaps allow companies to trade upside potential for downside protection. Suppose a green hydrogen producer is building a $5 billion plant with stable revenue and knows it needs to borrow more money in July. The interest rate now (its fixed-rate), in February 2024, is 10%, but the company worries that the rate might rise by the time it needs to borrow again in February 2027. Interest rates periodically adjust up or down, based on a country's federal reserve benchmark, to reflect economic or financial conditions. This oscillating interest rate (its floating-rate) could benefit or hurt the terms for the hydrogen company's loan. The company wants a predictable financial future. Another firm faces the opposite exposure. Its assets yield a return that fluctuates with market rates, but the interest payments on its loans are fixed at 7% for a longer period. The hydrogen producer and the other firm enter into a swap transaction to exchange some of their interest payments.[53]

These examples focus on solutions for developers and owners of climate technology projects, but output purchasers can also use hedging strategies. Purchasers of sustainable outputs are typically concerned about trends in the opposite direction from those concerning producers. Buyers want output prices to stay the same or fall, while producers want prices to be stable or rise. During the COVID-19 pandemic, to hedge against jet fuel price increases, Southwest Airlines purchased oil derivatives with nine commodity trading desks on Wall Street.[54,55] As jet fuel price increased from $1 per gallon in June 2020 to more than $4 per gallon in June 2022, hedging saved the company $1.2 billion.

Many sustainable outputs lack fungibility and transactable indexes. As a result, they do not trade in financial markets, so producers cannot execute output-related derivative contracts. For example, carbon dioxide removal (CDR) credits are not yet fungible. Unlike megawatts of electricity, one ton of carbon removal is not necessarily the same as another ton of carbon removal because mechanisms for sequestration and storage vary in quality. When outputs are not fungible, the markets in which they operate are not liquid. As a result, it may be difficult to replace the output if non-delivery occurs, create transparent and continuous price indexes, and structure hedges. As sustainable output markets mature, many examples above could become reasonable.[56] In fact, many OTC contracts could become exchange-traded as more price data is collected and converted into indexes. As emerging climate technologies mature, financial markets for trading are likely to emerge – as they have for renewable energy. More liquid hedging markets often originate from customized, one-off hedges that become standardized or from large aggregations of risk that could be hedged with simpler products.

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[53] Swap contracts can be difficult to structure. A more detailed example of an interest rate swap is available here.

[54] "'We will humble them': four fuel traders took on Wall Street and saved $1.2bn" (Financial Times)

[55] Because the Southwest's trading strategy is not communicated to the public, the company could have been both hedging *and* speculating.

[56] For example, the Global Carbon Trust is urging for the standardization of carbon credit contracts to create transparency, liquidity, and fungibility within market – hopefully yielding increased trust, trading, and financing. Similar efforts could emerge for sustainable fuels and materials. (Bloomberg Philanthropies)

Figure 5: Leading actors for derivatives and hedges.[57]

Companies that use derivatives to hedge their risk exposures typically invest in talented employees with years of trading experience. For an untrained employee, forwards, futures, and swaps — if mismanaged — can lead to significant financial losses. It is therefore important to compare risk management options (i.e., insurance policies vs. hedge agreements).

As Table 3 indicates, contract for derivatives can trade in two ways: on an exchange or over-the-counter:

- ***Exchange-traded contracts*** are highly standardized and "booked" with a central counterparty (CCP) or "clearinghouse." This standardization enhances liquidity.[58] Trading through an exchange also facilitates price discovery and transparency and allows trade counterparties to remain anonymous. As Table 3 shows, options and futures are standardized and exchange-traded, while forwards and swaps are customized.
- ***Over-the-counter (OTC)*** *contracts* are customized, privately-negotiated, and booked between the contracting parties. Trading parties negotiate terms that fit their risk preferences and interact with dealers. Since OTC trading parties lack an exchange, they face counterparty credit risk.[59] Forwards and swaps are custom contracts that are OTC-traded.

As the outputs of emerging climate technology projects are standardized, contracts can shift from OTC to exchange-traded.

[57] This figure is not comprehensive.

[58] Fungibility is a prerequisite for liquidity. Outputs are fungible if they can be treated as commodities and traded at a lower transaction cost, indicating a more "liquid" market. A market cannot be liquid unless the commodity traded is fungible. A market's liquidity is therefore assessed by the ability of buyers or sellers to enter and exit their positions with minimal transaction costs. A market is more liquid if it has lower price and time requirements to enter or exit.

[59] There is a growing trend of cleared OTC derivatives that do have standardized terms and are booked with a CCP, helping trading parties avoid credit risk exposure.

What is the difference between insuring against a risk and hedging a risk?

It is important to understand the differences between insurance and hedging.

The two types of risk transfer policies address different types of risks. Insurance covers unidirectional endemic risks which can *only* harm an asset.[60] Examples of endemic risks are earthquakes, fires, floods, power outages, and terrorist attacks. Hedging strategies, by contrast, reduce exposure to bidirectional systemic risks, such as currency exchange and interest rate risks, whose fluctuations can *harm or benefit* an asset.[61]

Insurance and hedging both limit financial exposure but in different ways. Insurance is a one-way transaction that transfers risk from the buyer to the insurer in exchange for a premium, while hedging is a two-way transaction that offsets risk and involves regular payments. Insurance indemnities are settled after a claim is submitted and are paid out over a certain timeline, whereas hedges are settled faster — sometimes on a daily basis. Unlike insurance, where companies must prove they suffered a loss, hedges pay based upon indexes or negotiated prices (in the case of a swap).

Here is an example of how these two solutions apply to a problem at a climate technology project:

- A wind farm owner-operator in Illinois wants to build a new facility in Indiana. The cost of debt financing for the facility is higher than expected because lenders are uncertain about how varying wind speeds will affect electricity generation and facility revenue. In the lender's experience, debtors are likelier to default on debt payments when revenue falls below the 10th percentile of outcomes. To reduce its debt cost, the wind farm owner-operator agrees to purchase protection to cover revenue losses falling below the 10th percentile.
- The owner-operator must determine whether insurance, a hedge, or neither is the best solution. A wind farm performance insurance policy would cover a revenue shortfall due to underperformance. The insurer would work with the owner-operator to model expected revenue based upon wind trends and other factors, such as energy conversion rates and electricity prices. After performing the analysis, the insurer would determine a fixed premium to cover a revenue shortfall below the 10th percentile.
- For a hedge, a weather derivative contract covers deviations of actual weather conditions (e.g., windfall) from a predefined index. Depending upon the type and structure of the derivative, which would likely be a put option or swap to protect against lower-than-predicted wind, the issuer of the derivative pays the buyer when wind conditions deviate from an agreed upon index/term.
- The owner-operator must consider whether to choose insurance, which covers an outcome-based value loss, or a hedge, which targets more specific, index-based risk factors, like price and volume. Cost is also a consideration.

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[60] Unidirectional endemic risks stem from specific events that can only create losses, without the potential for gains, and that are defined.

[61] Bidirectional system risks stem from unspecific events that can create losses or gains and that are undefined.

- The nature of a risk often influences which type of protection is most appropriate. Insurance policies are more appropriate for localized risks that are static with defined loss values. Derivatives are often better for systemic risks that constantly change with indexed prices, volumes, or values. Here, a weather-based derivative would likely be a better fit for the risk concerning the wind farm owner-operator.
- The company should also consider its staff's size and financial experience as well as the size of its balance sheet. If the wind farm owner-operator has a small staff with limited finance expertise and has a small balance sheet, an insurance policy is likely a better fit, depending on the price. If the company has financially sophisticated individuals and more capital resources, a derivative contract is likely a better fit, depending on the price.

As this example illustrates, insurers and derivative issuers handle risk differently. Insurers hoard risk and premiums. They pool policyholders and risk to increase the stability of predictions. The number and variety of policyholders and risks in insurance are purposefully large because insurers manage risk by making predictions about future events, using the law of large numbers to mitigate risk, and diversifying within or among various risks.[62,63]

Just as insurers must decide whether to hold or cede risk, derivative providers must decide whether to buy and hold, buy and hedge, or buy and trade a contract. Many companies are exposed to risks that are highly or perfectly correlated. Sometimes, these risks can be transferred to other companies exposed to the same risk but in the opposite direction. For example, a wind farm operator might buy a futures contract to sell a specific quantity of electricity at a fixed price, while a green hydrogen producer that relies heavily on electricity might enter into a futures contract to buy the same quantity of electricity at the same fixed price. This process of matching trades and finding a corresponding short position for every long position is complicated.[64] As "market makers," derivatives issuers charge transaction fees to counterparties. They also make money as bid-ask spread bettors, buying (bidding for) underlying rights or interests at a lower price and selling (asking) at a higher price. If derivative issuers confirm they can move risk (i.e., confirm a trade match) and bet on a particular indexed risk (i.e., buy an underlying right or interest for a lower price and sell at a higher price), companies will likely be able to purchase hedges for that risk.

Table 4 highlights contrasting traits — such as duration, sophistication, payment schedule, and loss type — of insurance and hedges as risk transfer solutions.

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[62] Selling policies at scale can be another challenge to insuring new climate technology projects.

[63] The law of large numbers is a statistical principle that describes the tendency for the average of a random set of variables to stabilize as the size of the sample increases. As the number of similar, independent, and identically distributed risks increases, the accuracy and reliability of predictions about the aggregate behavior of those risks increases. Applying statistical models to this large pool, insurers can estimate the average frequency and severity of claims for specific events and calculate appropriate premiums. Insurers make money by charging premiums and investing them (e.g., in public and private markets). If an insurer determines that a policy can aggregate significant risk and yield sufficient premiums, it might be willing to sell the policy widely.

[64] "Clearing Arrangements for Exchange-Traded Derivatives" (Risk Institute)

Table 4: Differences between insurance and a hedge for buyers to consider.[65]

Risk transfer type	Insurance	Hedge
Loss type	Defined; outcome-based; endemic/specific	Undefined; index-based; systemic
Possibility of gain?	No	Yes
Expected duration	≥1 year	<1 year
Risk management style	Passive; buy and move on	Active; buy and manage carefully
Needed buyer sophistication	Low	Medium (call or put) to high (swap or future)
Time to structure[66]	Weeks to months	Days to weeks
Trade execution	Bespoke; OTC	Bespoke; OTC *or* Standardized; on-exchange
Counterparty accepting risk	Insurer	Financial institution (e.g., bank)
Payment type	Premium paid monthly or annually	Collateral posted in a margin account that pays fees daily or weekly
Expected payout period	Months or years	Hours or days

Choosing between insurance and hedging. Four factors primarily influence a buyer's choice of an instrument for protection: project data accessibility; the internal risk management capabilities of the company; the appetite of a third party (e.g., insurer) to offer protection for the risk; and the cost of transferring risk.

- ***Project data accessibility***. Data quantity and quality influence protection purchasing options. Insurance markets operate based on asymmetric information. A buyer typically has more data on its risks than an insurer does. The insurer must ask questions and collect data to assess, price, and underwrite the risk. In contrast, hedge markets operate on symmetric information. The buyer has, or should have, equal access to relevant data as the financial institution or counterparty issuing the hedge. Prerequisites to structuring and issuing a hedge include publicly available, regularly captured data and a transparent, liquid market. Data is often exchanged through spreadsheets for an insurance transaction and is likely accessed through services like Bloomberg or S&P for a hedge transaction. A buyer with limited but quality data is more likely to receive risk transfer through the insurance market than the derivative market.
- ***Internal risk management capabilities***. The buyer's needs also affect the choice of risk protection. Insurance is more appropriate for companies with passive management styles seeking long-term protection (≥1 year) from endemic risk or with limited knowledge of the risk exposure. Hedging is more appropriate for companies with active management styles wanting shorter-term protection (<1 year) from systemic risk. Hedging a risk requires active management because indexes used to structure contracts fluctuate and can rapidly increase or decrease exposure to a risk. Insuring a risk, on the other hand, involves more

[65] This table is not comprehensive.
[66] Reminder: This assumes the project or portfolio of projects involve emerging climate technologies.

passive management because, once the policy is signed, the company cannot do anything to change the contract. If a company lacks expertise in or knowledge of the risk to which they are exposed, insurance is a more logical choice to cap losses.

- ***Availability of solutions***. A company might be unable to obtain affordable risk protection. The willingness of insurers and derivative issuers to offer a solution is driven by how they manage risk and make money. Insurers operate by the law of large numbers, aggregating risk and premium. Derivative issuers operate by diversification and dispersion, transferring risk for a fee and betting on future prices. These approaches to risk management and revenue generation govern how these respective markets function. See the "What factors should be considered when evaluating an insurance policy?" section below.
- ***Cost of transferring risk***. There are several factors to evaluate regarding the cost of a risk transfer solution:
  - ***Premium.*** Companies first evaluate whether the quoted price for protection (i.e., the monthly or annual premium) is affordable and reasonable in light of the protection it provides. If the premium is affordable, the company will likely evaluate the materiality of the risk for which it is seeking protection and any strategic value provided by the protection.
  - ***Risk materiality*** (described on page 6). A company will calculate the amount a potential loss could impact its portfolio of projects and determine whether it is better to hold cash in reserve or pay an insurer to manage it.
  - ***Strategic value***. Risk transfer solutions can unlock access to cheaper financing. If a company needs debt financing to build a project and a lender requires a risk transfer solution before providing a loan, the company could compare the cost of regular interest rate payments for the loan and of premiums for the risk transfer solutions price to the cost of dilutive equity (i.e., the percentage ownership dilution benchmarked to the company's valuation). Many times, the cost to the company of the former will be cheaper.
  - ***Accounting and tax***. Accounting and tax implications might also affect a company's decision about whether to purchase insurance or a derivative contract. Insurance contracts are recognized in a company's profit and loss statement as operating expenses.[67] Proceeds from insurance claims are generally not taxed, as they are offsetting an equal loss of property.[68] Derivative contracts are recognized on a company's balance sheet at fair value (i.e., the prevailing market price on recording dates), as is typical for an investment product.[69] OTC trades are typically taxed when the contract is settled, has expired, or is sold. Exchange-based contracts are taxed on a mark-to-market basis. Overall, the gains and losses for a derivative are subject to a hybrid tax rate in the US. Derivatives can cause concern for company liquidity. Companies constrained by their balance sheets likely will prefer operational risk management measures.[70]

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67 "Exploring the Place of Insurance in Final Accounts: A Comprehensive Guide" (Marg ERP Ltd)
68 "Are Insurance Proceeds for Property Damage Taxable?" (Azibo)
69 "Financial Derivatives: A Supplement to the Fifth Edition (1993) of the Balance of Payments Manual" (International Monetary Fund)
70 Other factors to consider when choosing a form of risk transfer include indemnification, regulation of pricing, the actors involved in each ecosystem, and documentation.

Figure 6: Risk transfer products and their cost and accessibility for different project risks.

Primary Risk Driver	Risk Transfer Solutions*	Financial Loss Protection For...	Risk Transfer Type(s)	Cost ($-$$$)	Accessibility
Technical	Technology development and project deployment				
Output	Product liability insurance; Product recall insurance; Defects liability insurance; Warranty insurance	Defective output	Insurance	$$	Medium
Construction	Delay in start-up insurance; Builder's / works risk insurance; Performance / completion / surety bonds; Liquidated damages insurance; Decommissioning insurance; Green endorsement/replacement coverage; EPC wrap insurance; Feedstock supply chain insurance	Project damage, delay, and cost overrun	Insurance	$	Medium
Equipment performance	Equipment breakdown insurance; Inland marine insurance; Performance warranty insurance	Mechanical or electrical malfunction	Insurance	$$	Medium
Technology performance	Technical E&O; Technology performance insurance; Energy efficiency insurance	Project underperformance	Insurance	$$$	Hard
Intellectual property	Intellectual property liability insurance; Copyright and trademark infringement insurance	Intellectual property infringement	Insurance	$$	Medium
Physical	Project exposure to and impact on environmental factors				
Weather (e.g., wind, rain, snow, hail, and irradiance/sunshine)	Weather derivative; Parametric insurance; Crop insurance	Weather relative to a pre-agreed threshold	Insurance + Derivative	$$	Easy
Catastrophe (e.g., hurricane, typhoon, flood, wildfire, and earthquake)	Catastrophe-specific insurance; Parametric insurance	Natural disaster	Insurance	$$	Easy
Environmental	Environmental liability insurance; Biodiversity loss insurance	Pollution and environmental damage	Insurance	$	Easy
Financial	Output price and market volatility or interruption				
Market (e.g., commodity price, interest rate, foreign exchange rate)	Cap and trade bid guarantee bonds; Index-based options and swaps	Price or rate changes	Derivative	$$	Easy
Revenue	Proxy revenue swap; Business interruption insurance; Equity contribution guarantee facility	Less-than-expected revenue	Insurance + Derivative	$$$	Hard
Counterparty	Credit default swap; Trade credit insurance; Trade finance insurance; Project finance insurance; Fraud and negligence insurance; Insolvency insurance; Delivery risk insurance	Counterparty default or fraud	Insurance + Derivative	$$	Medium
Geopolitical	Governmental, political, or radical event				
Terrorism	Cyber and property terrorism insurance	Act of terrorism	Insurance	$$	Easy
Political	Confiscation and expropriation insurance; Political risk liability insurance; Political violence insurance; Sovereign debt default insurance	Government intervention or adverse change	Insurance	$$$	Hard
Regulatory	Tax insurance; Business interruption insurance; Carbon credit invalidation insurance	Changes in regulation	Insurance	$$$	Hard

* The list of risk transfer solutions is not comprehensive.

Conclusion

Risk transfer solutions can help emerging climate technology companies obtain debt and equity financing for their large-scale infrastructure projects. As emerging climate companies deploy their technologies at scale, they pivot from technology development to project deployment (unless they license their technology to project builder). Companies seek debt financing for their projects to reduce the cost of capital and reach an optimal debt-to-equity ratio. Achieving these financial conditions will enhance their ability to raise additional funding due to reduced risk. Risk transfer solutions play an important role in facilitating debt and equity transactions but are frequently forgotten or ignored in project financing discussions.

Risk transfer solutions bridge the risk-return gap from dilutive equity investment to non-dilutive debt financing. These solutions are financial shock absorbers that can reduce a company's potential financial losses and financial volatility, making it more appealing to debt providers. While equity investors often accept (or even want) aggressive growth strategies that can strain finances, debt providers prefer stability that ensures reliable cash flow for making loan payments. However, debt financing can be difficult to secure for first-of-a-kind facilities among emerging climate technology projects. As project developers collect performance data, securing a risk transfer solution should become easier. Risk transfer solutions can also send a price signal on the materiality of a risk and indicate whether a perceived risk is actual or nonexistent.

Despite being risk transfer solution providers, **insurers and derivative counterparties are risk-averse and reactive to market needs**. Insurance companies and financial institutions often have many reliable revenue opportunities that involve limited risk. Recurring revenues from existing customers are the bread-and-butter of the insurance and banking industries. Current incentives are therefore limited to create and underwrite new products that de-risk emerging climate technologies. Despite the increasing demand for solutions from emerging climate technology projects, insurers lack incentive to devote financial or human capital until the market grows to match that of other assets (e.g., renewables).

While existing risk transfer products can be repurposed for emerging climate technology projects, **new products are still needed**. Creating products and underwriting their profitability requires significant data, and existing providers are reluctant to step in. Intermediaries like brokers, MGAs, and MGUs can help with product innovation, but capacity providers (i.e., primary insurers and reinsurers) are the ultimate arbiters of whether a product line grows. **Entrepreneurs can help with new product development by providing analyses comparing predicted and actual output** to demonstrate to insurers that production volatility and risk are limited. For emerging climate technology companies with multi-million- or billion-dollar projects and longer-duration risk transfer needs, reinsurance and retrocession markets are needed to take on excess risk that primary insurers cannot bear.

There is a significant financial and societal opportunity to develop the market for emerging climate technology risk transfer solutions. Equity investors, debt providers, companies, and insurers alike could benefit from increasing the capital pool, products, and talent dedicated to underwriting climate projects. Within the climate-focused ecosystem, **equity investors** can grow their portfolio companies and gain exposure to uncorrelated returns from the insurance market; **debt providers** can increase the pipeline of financeable projects; **companies** can

build projects; and **insurers** can create opportunities for premium and revenue. Without intervention (e.g., new dedicated talent and risk capital), the risk transfer market is years away from having sizable capacity and off-the-shelf products for emerging climate technology projects.

Billions of dollars are flowing into climate-focused venture capital, private equity, debt, and bonds. To work efficiently, the financial system requires risk management tools. Investing in, as opposed to seeking coverage from, a contingent capital provider (i.e., an insurer or derivatives provider) can generate significant returns across climate finance.

Appendix I - How does reinsurance work?

Reinsurance facilitates product innovation by sharing the risk from new policies with primary insurers. Innovation, in turn, enables climate companies to pursue projects. Without more reinsurance capacity, coverage options for emerging climate technology projects will remain limited.

Two factors — coverage and structure — govern how reinsurance operates and how reinsurers accept and transfer risk. These factors are summarized in Table 5.

Coverage. Reinsurers negotiate with primary insurers the type of coverage they will provide before determining the structure. The division of risk coverage between the insurer and reinsurer typically falls into one of two categories: facultative and treaty.

- ***Facultative reinsurance*** is an agreement between an insurer and a reinsurer to share losses arising from one risk only. Reinsurers retain the "faculty" to accept or reject each individual risk.
- ***Treaty reinsurance*** is an agreement between an insurer and reinsurer to share losses arising from more than one risk. Reinsurers automatically accept individual risks that fall within the category set by the treaty.

Most reinsurance is facultative because treaties require a lot of trust and data to work.

Structure. Once the insurer and reinsurer agree which risks each will cover, they typically choose one of two types of structures.

- ***Quota Share structures*** are arrangements in which the primary insurer cedes to a reinsurer a fixed percentage of the risks and premiums of a policy or bundle of policies. If multiple insurers and reinsurers want to provide capacity for a policy, the structure will likely be a quota share structure because it facilitates straightforward sharing of profits and losses among all parties.
- ***Excess of Loss (XoL)*** *structures* are arrangements in which the reinsurer covers losses that exceed a predetermined retention level set by the primary insurer, providing protection for catastrophic or high-severity events.

Table 5: Types of reinsurance coverage and structure

Industry Term	Category	Description
Coverage		
Facultative	Discretionary	• Primary insurer has option of ceding a risk • Reinsurer has option to accept or deny risk • Each risk is considered individually • Terms and conditions are negotiated individually per risk ceded
Treaty	Obligatory	• Primary insurer and reinsurer enter into an agreement for an entire portfolio of risks • Primary insurer is obligated to cede all business under terms and conditions of the treaty • Reinsurer is obligated to accept all risks ceded by the reinsured • Terms and conditions described in contract schedule and wording
Structure		
Quota Share (QS)	Proportional	• Ratio of retained liability to ceded liability is the same for every risk up to a limit • Insurer cedes a fixed percentage of liabilities, premiums and claims, irrespective of the sum insured • Treaty limit is a fixed maximum amount that can be ceded into a treaty
Excess of Loss (XoL)	Non-proportional	• Reinsured undertakes to pay losses up to pre-agreed amount • Reinsurers pay the balance of losses exceeding amount – but only up to pre-agreed limit (hence excess of loss terminology) • Reinsured and reinsurers do not share risk; they share loss on XoL basis • Loss can mean single loss or aggregation of losses • Premium is calculated and paid upfront

Appendix II - What is parametric insurance?

Parametric insurance products have emerged as a bridge between insurance and derivatives. Also called index-based insurance, parametric insurance is a non-traditional insurance product that offers pre-specified payouts based upon trigger events (e.g., windspeeds, river heights, ground shakes). Parametric insurance aims to address two big challenges that insureds experience: speed of recovery and freedom to deploy recovered capital as they see fit. These products are detached from an underlying asset and offer a level of clarity and certainty to insureds that the traditional market cannot match.

Consider the wind farm owner-operator example from before. Parametric insurance could help the owner-operator create an event trigger based upon windfall (less than M speed over N time), electricity price (less than X dollars over Y time), or both parameters with a payout that matches revenue losses below the 10th percentile outcome. Parametric insurance is often easier to understand than a derivative contract and — when designed appropriately — provides better correlated loss protection.

For insurers, parametric insurance can involve multiple triggers or input determinants on a payout. Using multiple parameters can make difficult-to-insure risks more acceptable. For example, companies operating in flood-prone areas might struggle to get flood insurance. These companies seek parametric insurance that includes parameters for rainfall, temperature, and soil moisture content to qualify a claim. Parametric insurance depends on the reliability and accuracy of the mechanism used to measure or create the input metrics/parameters.

For the insured, the most obvious downside of parametric insurance is basis risk (i.e., the potential mismatch between the insured's financial losses and the insurer's payout). The economic losses could differ from the amount of coverage, or they could experience losses without the parameter being triggered.

Acknowledgements; Further Reading

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Here is further reading on the intersection of climate projects and risk transfer solutions:

- "Climate Tech for Industrial Decarbonization: What Role for Insurers?" (The Geneva Association)
- "Insuring a Sustainable Future: Protecting Nature, People, and the Planet" (Sustainable Markets Initiative)
- "Industrial & Energy Technology Project Finance: A Startup and Developer's Guide to Scaling and Commercial Success" (New Energy Risk)