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Unlocking Private Investment for Greenhouse Gas Removal

Public-private collaboration and a technology-specific policy approach

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Summary

Coordinated mobilisation of public and private investment in greenhouse gas removal (GGR)[1] technologies is key to developing the GGR capacity required for the UK to achieve its 2050 net-zero greenhouse gas emissions target. It is also vital to meeting the interim targets for engineered removals of 21.3 $MtCO_2$ by 2040 (CCC, 2025). However, current GGR market conditions are not yet conducive to attracting private capital into GGR deployment. Technological uncertainty, revenue uncertainty and the presence of an unstable market-led environment limit investor confidence and hinder the establishment of a GGR market. The policy interventions being developed by the UK government – namely the integration of GGR into the UK Emissions Trading Scheme (UK ETS) and the introduction of carbon contracts for difference (CCfDs) – are welcome. However, based on our analysis, they are insufficient to kick-start and support GGR deployment at the necessary scale and pace. New groups of policies which strategically reduce GGR investment risk and create a more stable environment are required. This policy brief assesses and outlines public-private collaborations (PPCs) as an important intervention to unlock private-sector investment as part of a wider GGR policy ecosystem. Our main messages are:

- Public-private collaborations offer a pathway to unlocking private capital as they de-risk private investment in GGR projects, allowing projects to access preferential rates of debt financing.
- Public-private collaborations establish clear and predictable rules for investments shaped through the discussion between public- and private-sector actors, lowering the perceived risk of policy reversal or market volatility, thereby enhancing investment certainty.
- Public-private collaborations lend themselves to a technology-specific approach to policymaking. We explore three technology-specific PPCs:
    1. The joint venture model, which is suitable for early-stage technologies that carry significant operational and financial risks. It is best placed to support direct air carbon capture and storage and enhanced rock weathering GGR technologies.
    2. The build-operate-transfer model, which is suitable for large-scale, capital-intensive technologies. It is most applicable to bioenergy with carbon capture and storage and direct air carbon capture and storage GGR technologies.
    3. The private finance initiative model, which is suitable for technologies that require ongoing operational support and benefit significantly from cashflow certainty. It is particularly well-suited for supporting bioenergy with carbon capture and storage and biochar GGR technologies.

The policy brief draws on mixed-methodology research into policies for attracting private capital completed in 2024.[2] The research employed a robust decision-making (RDM) approach to explore multiple possible futures for UK GGR policy and business model development. By integrating qualitative insights from semi-structured interviews with private capital investors and a quantitative vulnerability analysis of financial models, the study identified the policies best positioned to mobilise private investment at scale. This dual-method approach allowed us to test policies under a wide range of uncertain future scenarios and generate insights on the robustness of policy instruments – particularly crucial for GGR, whose future trajectory we do not know. As such, the research departed from traditional cost-optimised decision-support tools, which were viewed as ill-suited to the high levels of uncertainty that characterise the emerging GGR sector.

1 Otherwise known as carbon dioxide removal (CDR).

2 See Taricco, 2024.

1. The GGR scale-up challenge

1.1 Meeting the net-zero target will require an unprecedented scale-up of engineered removal capacity

Greenhouse gas removal (GGR) is a central pillar of global and national climate strategies, as it serves to compensate for residual emissions from hard-to-abate sectors such as cement, steel, aviation and agriculture, where emissions reductions may be technologically or economically infeasible in the short-to-medium term. To achieve its target of net-zero greenhouse gas emissions by 2050, the UK will need to remove 21.3 million tonnes of carbon dioxide ($MtCO_2$) from the atmosphere by 2040, and 35.8 $MtCO_2$ by 2050 through engineered GGR solutions (CCC, 2025; Workman et al., 2022). These include bioenergy with carbon capture and storage (BECCS) and direct air carbon capture and storage (DACCS), and potentially more novel methods such as enhanced rock weathering and biochar.

Achieving this level of engineered GGR capacity in the UK will require a significant scale-up from the nearly negligible level it is at today, equating to below 1 kilotonne of carbon dioxide ($ktCO_2$) per year. This gap represents an unprecedented scale-up challenge, requiring not only rapid technological development but also a coordinated mobilisation of public and private investment.

1.2 Missing policy incentives and a nascent sector are limiting private investment

Given the scale of the task, it is increasingly clear that public finance alone will be insufficient to fund the required GGR expansion. For example, the National Infrastructure Commission estimates that the GGR sector could require investment in the tens of billions (Hope, 2022), and while public finance will play an essential role, it is expected that billions of pounds in private capital must be leveraged to reach climate-aligned removal targets.

Current market conditions are not conducive to attracting this investment. While private-sector actors are beginning to assess the GGR sector, investment remains marginal. Our ongoing research shows how the GGR sector has potential to generate significant investment opportunities; nevertheless, stakeholders recognise that this is not feasible under current conditions (Taricco, 2024). This is primarily because significant capital investment in GGR remains unattractive given the large risks associated with the return on investment under current GGR business models.

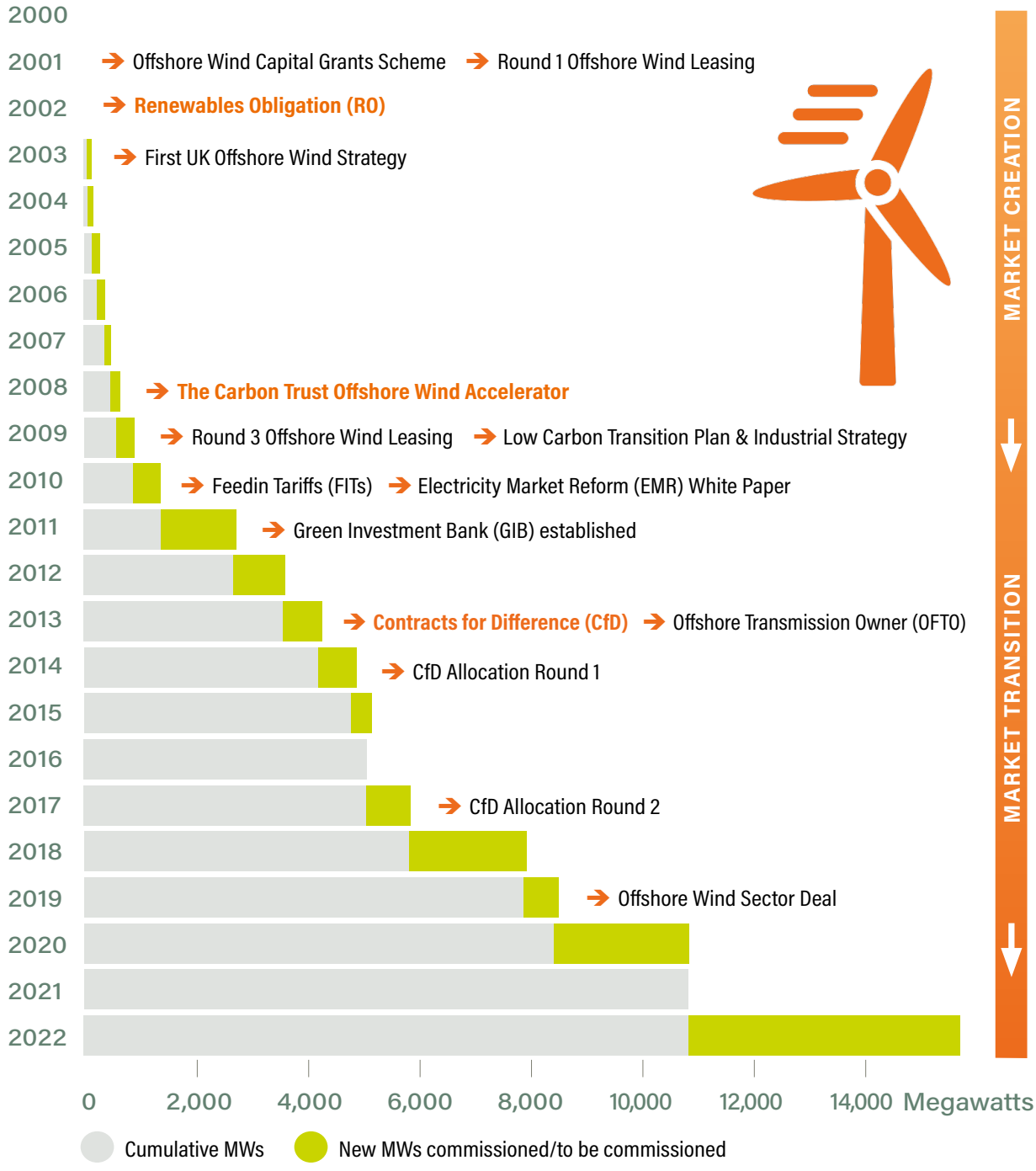
Put simply, there is a pressing need for private-sector investment in GGR, but it is not taking place at the required scale. This disconnect is difficult to resolve due to wider market failures associated with the complexity of the GGR sector. First, technological uncertainty remains high, as many GGR approaches are still in the early stages of development, and key questions about their cost, environmental impacts and technological readiness persist. Second, revenue uncertainty is acute, given that most of the current GGR revenue streams rely on voluntary carbon markets, which are volatile and lack regulatory oversight. These markets have yet to deliver sustained demand signals or price stability, making long-term investment risky. Third, the sector is currently market-led. This creates an unstable environment, as there is no assurance offered by the government on the direction of travel for the sector. The unpredictable nature of the market-led approach can lead to rapid shifts in the economic viability of GGR business models, which makes investment less feasible.

To scale up private capital investment in engineered GGR in the UK, the government is developing two policy interventions in tandem: the integration of engineered GGR into the UK Emissions Trading Scheme (UK ETS) and the introduction of carbon contracts for difference (CCfDs) (DESNZ, 2024; DESNZ, 2023b). The government announced its intent to integrate GGR into the UK ETS in 2023, conditional on the development of rigorous monitoring, reporting and verification (MRV) standards. The government is also planning the introduction of CCfDs for GGR, under which a fixed strike price would be agreed for each verified tonne of CO_2 removed (DESNZ, 2023b). If the prevailing market price for carbon falls below the strike price, the government pays the shortfall; if it exceeds the strike price, the provider returns the surplus.

Box 1: Comparison of GGR with the development of the offshore wind sector and technology

The UK offshore wind sector's successful scale-up was driven by over two decades of consistent government support and a strong policy framework that attracted private investment, making the UK a global leader (Mercure et al., 2021). Between 2001 and 2013, a combination of early-stage capital grants, the Renewables Obligation Certificates, strategic planning reforms and institutional innovations created a foundation that reduced first-mover risks and encouraged sector growth. The introduction of contracts for difference (CfDs) in 2013, alongside the Offshore Transmission Owners (OFTOs) regime, transitioned the sector from subsidy-dependent to a competitive, investor-ready market. In contrast, the UK government's current approach to GGR skips these foundational stages and moves directly to awarding CfD contracts. This leap risks neglecting the early-stage support and institutional infrastructure needed to de-risk investment and build a stable GGR market, especially because GGR has no inherent demand and is even more complex, both technologically and as a sector, than offshore wind.

Figure 1: Timeline of programme and policies for offshore wind sector along with cumulative megawatts (MWs)



While these initiatives represent a good starting point toward establishing a long-term market for GGR in the UK, additional policies which take into account GGR technological readiness must be included for a GGR policy to be well-rounded (Feng et al., 2025). Box 1 illustrates that offshore wind's scale-up was underpinned by years of early-stage support and reforms that steadily reduced investment risk before CfDs were introduced – foundations that GGR currently lacks, despite being more complex as a sector and having no inherent demand.

To test how anticipated policy designs might influence investment viability,[3] we conducted a vulnerability analysis of GGR technologies using a financial model (Taricco, 2024). Vulnerability analysis involves identifying and characterising the combinations of parameters in which a solution performs poorly with respect to others, providing an understanding of the drivers of performance of an investment. We evaluated a wide range of potential combinations of policy and financial conditions, referred to as "possible futures", based on uncertainties and risks identified through investor interviews to assess which GGR technologies meet minimum investment criteria.

Results in Figure 2 show that the introduction of UK ETS integration and CCfDs improves investment prospects compared to a no-policy baseline, with more possible futures resulting in investments that meet minimum viability thresholds (Taricco, 2024). However, even with these policy improvements, investments remain unattractive under most tested possible futures, as none of the investor–technology combinations consistently reach minimum thresholds. For instance, BECCS power (Baseline 4), the most optimistic technology in our analysis, meets strategic investor minimum investment criteria in only 54% of possible futures. This means that in nearly half of the possible futures, uncertainties remain unresolved even with the introduction of these anticipated policy supports (Taricco, 2024). Investment conditions will largely remain unattractive; market risks remain high, policy timelines are uncertain, and financial returns from engineered removals are weak. In short, the UK's anticipated policy instruments are likely to fall short in mobilising private capital at the scale and pace needed for the country to meet its climate commitments.

Figure 2: Results from the analysis of baseline policy support scenarios

	Baseline 1: No policy support					Baseline 4: Integration on UK ETS + CfD mechanism				
Market actor	BECCS power	BECCS hydrogen	DACCS	ERW	Biochar	BECCS power	BECCS hydrogen	DACCS	ERW	Biochar
Strategic investors	33.3%	0.0%	0.0%	11.1%	18.5%	54.7%	44.9%	0.0%	19.8%	40.7%
Infrastructure funds	3.7%	0.0%	0.0%	0.0%	14.8%	19.8%	32.1%	0.0%	3.7%	32.5%
Private equity	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.4%	0.0%	0.0%	6.2%

Note: the percentages in this figure represent the possible futures tested in the vulnerability analysis, in which investment in five GGR business models meets the minimum investment requirements for different private market actors under the presently proposed policy interventions.

3 Investment viability is determined by three criteria: (1) the expected internal rate of return (IRR) meets or exceeds the investor's minimum required IRR; (2) the expected IRR exceeds the weighted average cost of capital (WACC); and (3) the net present value (NPV) is positive.

2. Public-private collaboration as a strategic policy puzzle piece

To address these issues and unlock greater private investment, a new set of policies is required. These policies should focus on strategically reducing GGR investment risk and creating a business environment with more predictable returns. Based on interviews with strategic investors, four such policy scenarios were identified and three of them included types of public-private collaborations (PPCs) (Taricco, 2024). The benefits of each PPC are outlined in detail in this next section.

Using the same method, Figure 3 shows how the introduction of diverse PPC frameworks can significantly enhance investment performance, thereby boosting investor confidence and drawing private investment into GGR. Compared to the baseline scenario with no policy support in Figure 2, the PPC scenarios result in more possible futures meeting minimum investment thresholds. Some strategic investor and technology combinations become investible in over 90% of simulated possible futures, meaning these investments met minimum thresholds under nearly all tested market and policy conditions (Taricco, 2024). Infrastructure funds also show substantial improvement, with many technologies meeting investment thresholds in significantly more possible futures under the improved PPC scenarios compared to the baseline scenario. However, private equity continues to perform poorly, indicating that even with stronger PPC mechanisms, its investment model is not well aligned with the high-capital, long-horizon nature of the sector.

Figure 3: Results from the analysis of public-private collaboration scenarios

	Improved 1: Joint venture (PPP)					Improved 2: Build-operate-transfer (PPP)					Improved 3: Private finance initiative (PPP)				
Market actor	BECCS power	BECCS hydrogen	DACCS	ERW	Biochar	BECCS power	BECCS hydrogen	DACCS	ERW	Biochar	BECCS power	BECCS hydrogen	DACCS	ERW	Biochar
Strategic investors	93.8%	62.6%	41.6%	94.7%	97.1%	89.7%	29.6%	33.7%	77.8%	97.5%	99.2%	58.8%	34.6%	94.7%	100%
Infrastructure funds	44.0%	23.5%	21.0%	62.1%	69.1%	47.7%	0.0%	33.3%	40.7%	69.5%	63.8%	22.2%	7.0%	51.0%	94.2%
Private equity	0.4%	1.2%	10.3%	11.5%	13.6%	11.9%	0.0%	9.5%	7.4%	34.2%	2.9%	0.0%	0.0%	0.0%	47.3%

Note: the percentages in this figure represent the possible futures tested in the vulnerability analysis, in which investment in five GGR business models meets the minimum investment requirements for different private market actors under the presently proposed policy interventions.

PPCs offer a promising approach to attracting private capital investment. By combining public-sector support with private capital and expertise, PPCs can create tailored investment environments that target different GGR technologies, improve access to finance, accelerate project development, and make it likelier they will scale. PPCs are one approach which can be implemented within a wider policy ecosystem as a way of addressing the lack of private capital GGR investment in the UK. Based on exploratory interviews, PPCs emerged as an essential part of incentivising the required investment because they provide investor certainty, which is currently not given through other types of policies. While additional policy support will also be required, PPCs could play a crucial role in scaling up GGR.[4]

2.1 Public-private collaboration policy advantages

One of the key advantages of PPCs is their ability to de-risk investment in GGR projects. Most GGR ventures currently rely almost entirely on equity financing, grants or concessionary capital, as the high-risk and nascent nature of the sector deters a broader range of lenders. Project financing requires regular interest payments and is seen as too risky given the lack of stable revenue streams in the GGR sector. As a result, projects face high capital costs and fewer pools of capital, which in turn limits scalability. Government participation through a PPC reduces perceived risk as it shows that the project relies on the government's stable stream of funding and support. This, in turn, lowers the weighted average cost of capital (WACC), a crucial metric for determining the financial viability of a project. Because the WACC is lower, this financing structure allows projects to be more attractive to investors. By improving investor confidence to the point where project finance becomes viable, PPCs help unlock new pools of capital.

In addition to financial de-risking, PPCs provide clear and predictable rules for investments shaped through the discussion between public- and private-sector actors. Investors consistently identify long-term policy commitment as one of the most important factors in making GGR investable. PPCs reduce the perceived risk of future policy reversals or market collapse, thereby enhancing market credibility.

Moreover, PPCs allow for technology-specific policy design. Unlike generic market-based instruments, collaborative models can be tailored to the needs of specific GGR pathways. For example, a DACCS project might benefit from a joint venture structure that provides access to public capital and shared operational control. A BECCS facility might be better suited to a build-operate-transfer (BOT) model, in which private developers finance and operate the plant for a fixed period before transferring ownership to the public sector. Alternatively, a private finance initiative (PFI) structure might enable the government to pay for GGR services over time, spreading cost and improving predictability.

2.2 Public-private collaboration as a technology-specific approach

This section presents the findings of the vulnerability analysis of financial models of GGR technologies with the new policy supports, and highlights three distinct PPC models to illustrate how different technological pathways within the GGR landscape benefit from tailored policy approaches (Taricco, 2024). These models demonstrate the critical importance of designing technology-specific policies, particularly when new policy instruments are being introduced.

The first model is the **joint venture.** In this arrangement, a public entity and a private actor jointly develop, finance and operate a project. The government may provide low-interest loans or other forms of financial support, while both parties share risks, responsibilities and any resulting profits. This collaborative structure is particularly well-suited to technologies like DACCS and enhanced rock weathering, which are still in the early stages of development and carry significant operational and financial risks. The joint venture structure provides flexibility and shared oversight, which helps mitigate those risks and increases investor confidence. However, joint ventures are not without drawbacks. The potential for misaligned objectives between public and private partners can create friction and slow decision-making.

4 The UK has a number of PPCs for technology development. Examples of these are support through the Aerospace Technologies Institute, support through the Faraday Institute and the Offshore Wind Accelerator. The Offshore Wind Accelerator was vital in bringing down the UK's offshore wind wholesale costs.

The second model is the **build-operate-transfer (BOT**) approach. Under this model, a private-sector actor finances, constructs and operates a facility for a designated period, after which ownership is transferred to the public sector. BOT structures are commonly used in large-scale infrastructure and energy projects and are especially applicable to BECCS and DACCS technologies. These technologies are capital-intensive and require substantial upfront investment, but their centralised and infrastructure-like nature aligns well with public-sector management in the long term. By transferring ownership to the government after the operational phase, BOTs ensure that these strategically important assets are maintained with long-term public interest in mind. However, the extended timeline of BOT arrangements can create uncertainty. With the buyback period often years or decades into the future, investors face risks related to evolving market dynamics, regulatory shifts and technological change, all of which can complicate the project's financial outlook.

The third model is the **private finance initiative (PFI**), where a private entity is responsible for financing, designing, building and operating a public asset, and the government repays the private partner over time based on the performance or availability of the service. PFIs are particularly well suited to BECCS and biochar technologies, which require ongoing operational support and can benefit from a predictable cash flow mechanism. Unlike BOTs or joint ventures, PFIs align the government's financial support with the lifecycle needs of the project, providing a more stable investment environment. This makes PFIs attractive to investors, as they reduce reliance on unpredictable market revenues. Nevertheless, PFIs can involve complex legal structures and are susceptible to political risk, especially if future governments alter their priorities or withdraw support. Private-sector partners can also collapse, leaving governments with all of the financial liability.

Figure 4: Public-private collaboration applicability to greenhouse gas removal technologies

Policy	Joint venture	Build-operate-transfer	Private finance initiative
BECCS power		✓	✓
DACCS	✓	✓	
ERW	✓		
Biochar			✓

The findings presented here show how different PPCs are applicable to different technologies and underscore the necessity of technology-specific policymaking. One-size-fits-all approaches are unlikely to address the nuanced financial and operational realities of different GGR technologies. On the contrary, tailored PPC models, aligned with each technology's risk profile, capital structure and operational demands, are essential to unlocking investment and delivering on net-zero commitments.

3. Conclusion: scaling up private-sector investment in GGR requires new and tailored policy solutions

For the UK to deploy engineered removals in line with its climate commitments, large-scale private investment will be required, but current market conditions are insufficient. The main policy options under consideration by the UK government, such as the ETS and CCfDs, risk falling short in addressing all the risks and uncertainties associated with the early stages of the deployment of these technologies. To bridge this gap, the government must do more than build carbon markets, learning from previous successful technology scale-ups such as offshore wind and creating the conditions for investment through smart policy design and strategic collaboration.

Public-private collaborations provide a promising path forward. By directly reducing investment risk, improving access to affordable finance and providing long-term policy clarity, these types of collaborations can help to create a thriving, competitive GGR sector in the UK. As such, they should be considered an important part of a toolkit for a flexible, responsive and technology-specific approach to policymaking. In a sector as diverse as GGR, this flexibility is essential. The UK must embrace innovative policy models that reflect the complexities of climate investment and the urgency of the net-zero transition.

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This paper is part of a series of briefings presenting findings and recommendations from different areas of CO2RE's research. Read more at **co2re.org/publications/key-reports-briefings.**

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