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The Storing '20s: Can the UK realise its offshore CCS ambitions?

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The UK government recently announced it would create a 'treasure map' of potential carbon capture and storage resources beneath the North Sea. You may find it a curious name, but the ambition is serious: the UK aims to capture 10Mt of carbon dioxide a year by 2030 – "the equivalent of 4 million cars' worth of annual emissions".

It is already mid-2023. That leaves 6.5 years to reach that target from a standing start. How can that be done? Is it even possible? What needs to happen if we really are to mark this decade as 'the Storing '20s'?

Innovation will be needed across a variety of spheres, with unresolved questions regarding the economics, contractual models, reputational challenges, and engineering of North Sea CCS.

Economics: who pays and how much?

The climate case for CCS is clear: the Paris Agreement itself emphasises the need for carbon removals alongside emissions avoidance and reductions in Clause 1 of Article 4.

It is essential to deploy CCS, at scale, as soon as possible while other essential but earlier-stage decarbonisation technologies mature. What's more, even if we can reach a point of net zero new emissions as a society, there will remain a vital role for CCS to remove legacy emissions from the air and redress emissions 'overshoots'.

So, the question of whether CCS is necessary is a settled one. However, the questions of who pays and how much are less clear cut.

Most commentators seem to agree that the near-term economic case for CCS will come from coupling it with hard-to-abate industrial sectors such as cement production, plus a nascent blue hydrogen sector. Later, as technologies such as direct air capture mature, location may become less restrictive, but in the short-term, geographic concentration will be vital to make project economics work.

We can then imagine a near-future where such companies pay a CCS operator to store their CO2 rather than simply release it into the atmosphere as per the status quo. However, it's worth noting there are a lot of steps along the value chain before that can happen. It will cost to capture the CO2 at the flue (or from the atmosphere), and it will cost to transport it via pipeline (and cost to set up that infrastructure) – all before the CO2 even gets offshore.

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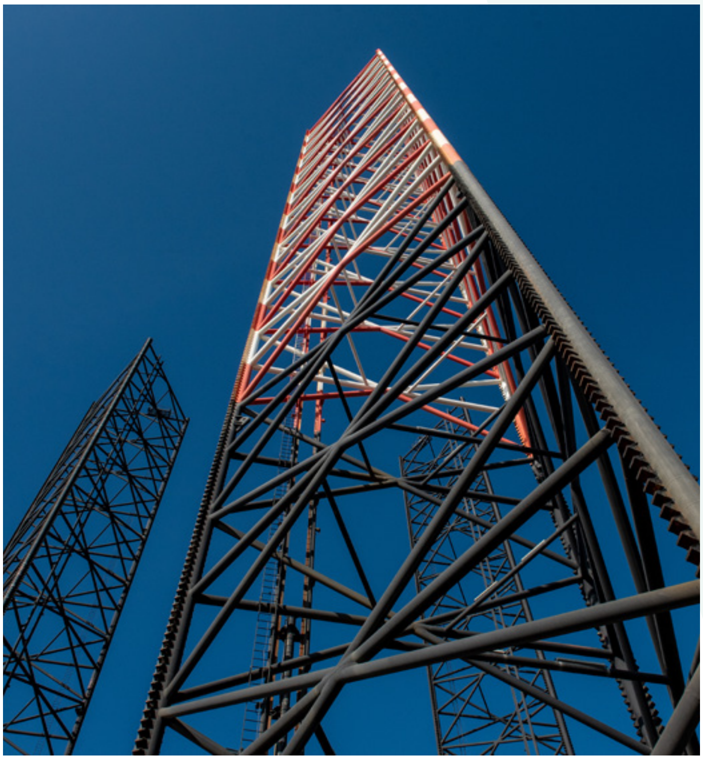
So, to the question of 'how much' – the answer is potentially quite a bit. Though there may be niche markets for products such as 'green cement' where the CO2 has been stored as opposed to released, we can't expect companies to do this out of the goodness of their own hearts. One potential method is a carbon price, either through a tax or an emissions trading scheme. However, the price would need to be sufficiently high that it makes financial sense for companies to pay for CCS instead.



Contractual conundrums: human responsibility on a geological timescale

Even if we can set a price that effectively incentivises changing corporate behaviour, we have another conundrum: who is responsible for that CO2 that is stored under the North Sea? Who keeps an eye on it and ensures it stays put? Of course, the CCS operator will take that role in the short-term. But when talking about climate change and carbon storage, we are discussing geological timeframes, not human ones. We want, and need, to ensure that carbon stays stored for thousands, if not tens of thousands of years.

You can almost certainly bet that the operator won't be around by then. Depending on how you measure, the oldest operating company in the world today is Japanese construction company Kongō Gumi, which was founded in 578. That's nearly 1,500 years – still an insignificance on a geological timescale, and most companies last nowhere near so long.

The implication is that, like it or not, the responsibilities will eventually pass back to the state. There is no practical way to hold the private sector accountable over that timeframe. Therefore, a stakeholder relationship needs to be established where the government clearly sets out the operator's responsibilities and the timeframe it is expected to hold them for - plus provisions for ongoing risk mitigation when responsibility is passed on.

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This is no mean feat. The nuclear industry has been grappling with similar issues for decades. The vast majority of our nuclear waste is held at ground or near-ground level (mainly at Sellafield), which scientists don't view as a long-term feasible plan. Consensus now seems to point to geological disposal facilities as the way forward, but it has taken decades to reach this point.

Of course, CO2 does not carry the same acute risks of radiation if it leaks, but it illustrates the difficulty of making geological timescale decisions with human timescale brains and institutions.

Public perception: waste not wanted

Another parallel to the nuclear sector – no one wants the waste in their back garden. Onshore CCS is probably unrealistic as a concept for that reason. The failed attempts to develop projects at Barendrecht in the Netherlands are illustrative in this respect.

Here, we're talking about storage beneath the North Sea, far from the vociferous objections of local communities. But that doesn't mean North Sea CCS is free of public perception challenges. Research shows mixed public feelings about CCS. Though people seem to understand the benefits and agree that 'CCS should be implemented in my country', they also worry that CO2 will leak back into the atmosphere, that it will be used to prolong the use of fossil fuels, and that science is underestimating the risks involved.

Subsurface repeat seismic monitoring, or spotlight seismic imaging, offers a proactive early warning system

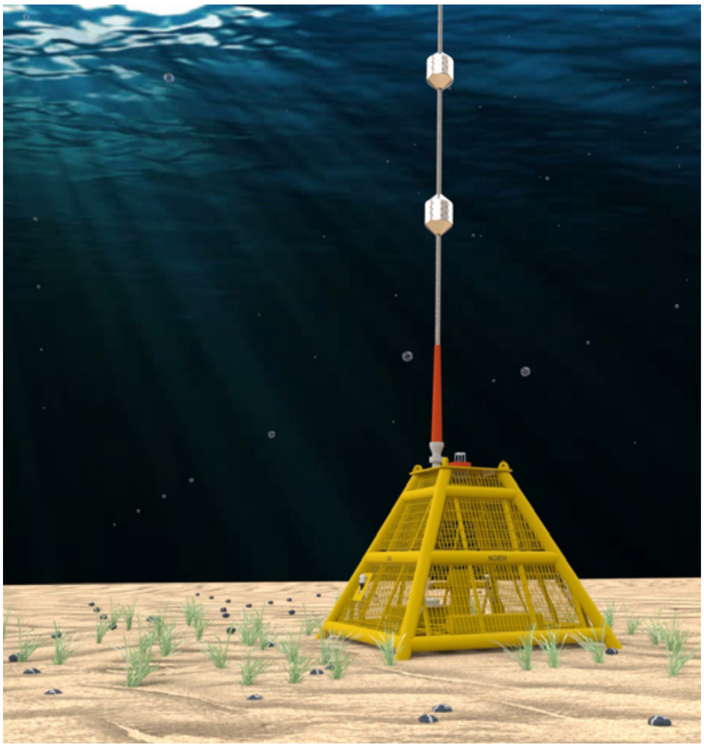
Engineering: establishing excellence

I argue that – at least partially – these issues of public perception could be solved via an engineering solution. Consider monitoring: whether we are talking about utilising depleted hydrocarbon formations or saline aquifers, it is vital that we specify the highest standards. As the CO2 is injected, the operator needs to be able to demonstrate the CO2 plume is migrating within and filling the formation as expected by the reservoir engineering, and not entering areas it should not such as faults or previously abandoned legacy well locations. If it does so, this will demonstrate accurate knowledge of the formation and competence, therefore providing proactive reassurance in that an engineered plan is being executed. If it doesn't, injection can be paused to investigate and rectify any issues. Subsurface repeat seismic monitoring, or spotlight seismic imaging, offers a proactive early warning system as well as reassurance that the injection process is going to the agreed plan. This can be coupled with water column monitoring – deploying reactive sensors to detect whether there has been a breach of CO2 – for additional reassurance.

However, it is essential that this monitoring continues after the field has been fully injected and resealed. This cannot continue indefinitely, however there will likely be a required monitoring period for injection operators post-sealing for a certain number of years, at which point the government will take over for a further defined stretch or until it is satisfied that the site is stable (e.g. by solidifying).

The catch with reactive monitoring is that these sensors are theoretically redundant – their inclusion is gold-plating in a sense. If the engineering has been done well to this point, and the proactive sensors confirm the injection has gone as planned, then they will never be used. If they are, something has gone very wrong indeed. Therefore, their inclusion is a tacit acceptance that something could go wrong – yet, it is vital to reassure the public and regulators that the asset is safely contained. Much like a fire alarm – you design so that you'll never need them, but people would rightly call you reckless if you tried to omit them.

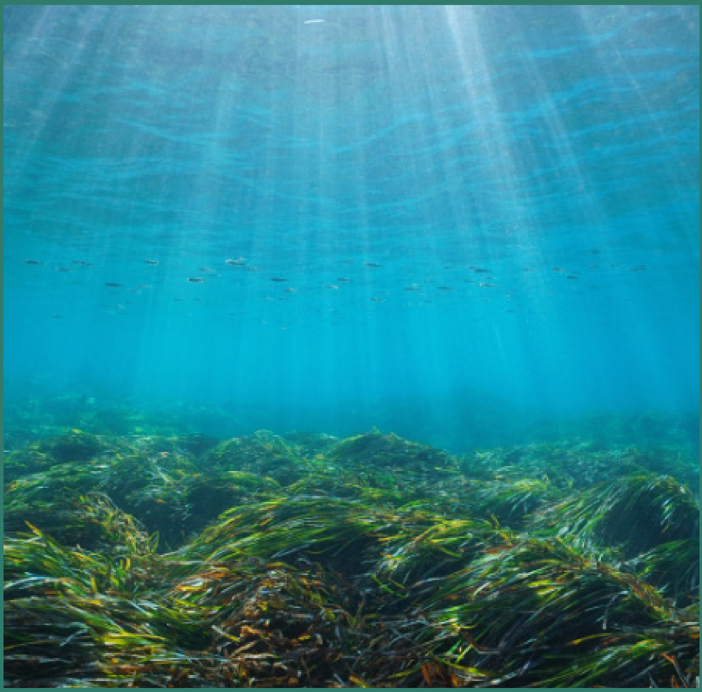
There are other engineering challenges to solve of course. For example, a key point of difference for handling CO2 versus oil and gas, is temperature. High flow-rates of CO2 can produce a super cooling effect, which by and large, oil and gas equipment has not been designed for – steel can become brittle at low temperatures and would no longer perform to the standards expected. Equipment, such as riser systems, will need to be fabricated using special alloys to protect the areas that will be most exposed to these extreme low temperatures. Consideration will also be needed when it comes to managing the effects of heightened sweet corrosion on pipelines if they are to be redeployed as CO2 infrastructure.



From challenges to reality

However, from my perspective, these challenges are not the real hurdle. We have the knowledge and technology to tackle all of these engineering challenges quite quickly, and at Aquaterra Energy, we are already working with operators on a number of feasibility studies for North Sea CCS from vertical re-entry of legacy wells and their potential re-abandonment, as well as subsurface and water column monitoring.

Nevertheless, as engineers, we are downstream of the real blockers on the UK's CCS ambitions – we need our policymakers and regulators to address the small herd of elephants in the room, which are the unresolved economic and contractual questions – and we must keep one eye on perception issues too. If, and when, that happens – we're ready and waiting to do our part in making the Storing '20s a reality.



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