Carbon Capture and Storage **today**

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‘We need to collaborate if we want to meet the challenges in CCS’

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Carbon Capture and Storage today: **a kaleidoscope** of challenges, passion and collaboration

A trending series on a popular streaming service features a group of criminals planning a bank heist. What is unique about this series is that the eight episodes are shuffled so that each viewer sees the story unfold in a different order. A similar thing happens when you talk to experts and professionals in carbon capture and storage policy, engineering, transport and research about the state of the sector today. As each one casts light on the industry from their perspective, changing patterns appear.

The carbon capture and storage (CCS) industry raises interesting topics that look different depending on where in the industry's value chain you view them from. Capture is the first part of the chain and is well established, as was made clear by all the interviewees.

With a background in engineering, Zoe Kapetaki earned her spurs designing carbon capture systems, but later went on to work as a Scientific Officer at the European Commission's Joint Research Centre. Zoe's gradual change of focus from engineering to the policy landscape parallels the way the main CCS challenges have shifted away from the carbon capture side. Her accomplishments in the industry date back more than a decade and in her many roles she has never lost her passion for CCS, nor her sense that this is something the world urgently needs. Together with a legion of other scientists and visionaries working behind the scenes, she has laid an important foundation that today's CCS world builds on. Porthos is a showcase CCS initiative anchored in that foundation. ▸

'OUR CCS TECHNOLOGY CAN BE SHARED WORLD WIDE'

DENIS KADITO, PARES RAMMAN

Porthos: a potential game changer

Porthos is a potential game changer in the battle against climate change. If it proves that CO_2 can be stored safely in this way, the technology and learnings can be shared worldwide to help navigate all parties in the industry through the intricacies of CCS. Large scale transport to and storage in depleted gas fields, represents an unfamiliar and challenging new territory - in contrast to storage in aquifers - which is keeping all experts on their toes. In order to showcase CCS application, the Porthos project has been initiated in the Netherlands to prove large scale CO_2 reduction can be established.

"The intention behind this kind of CO_2 storage is to gain time to further develop CO_2 abatement technologies while other parties also look at global warming through a different lens" says Eric Kerssies, previously in the role of Porthos Integration Manager.

Eric is confident that the overall project is under control, and due diligence by specialized consultancy firms confirms the robustness of the design. But with its vast scope, Porthos can be likened to the CCS industry in miniature and the challenges in this one-of-a-kind project abound. For a start, some of the participating carbon emitters in the Port of Rotterdam are still developing their carbon capture systems. Another challenge is the phased structure of the project, which means controlling subprojects that are in various different stages of engineering.

And the complexity has been further increased by a potential future connect with the Aramis CCS infrastructure project. This would offer synergies and new prospects on national and international scale, while undoubtedly adding new technical and regulatory challenges.

With Porthos facing a critical timeline, integration and permitting in this new industry are unforgiving. It is deeply frustrating to many that a lack of public acceptance blocked the development of the technology twenty years ago, leading to greatly increased pressure now. Time is running out to mitigate climate change and the sooner the Porthos project demonstrates success, the sooner potential best practices derived from it can be shared to speed up developments in other countries. ▸

'HANDS-ON MECHANICAL INTERVENTIONS HAS BEEN OVERTAKEN'

ERIK KERSSIES

CCS engineering: from oil and gas to unchartered territory

Design practices and tools evolved over time in the more traditional oil and gas industry now form the basis of CCS engineering. Decades of experience underpin the international design standards now in place, and any new well development in a brownfield asset will follow a textbook procedure. CCS engineering builds on and beyond this to develop workflows and standards for this industry's own unique space.

Traditionally, engineering companies utilize standard practices to translate subsurface wizardry into a new product design. Depending on the age of an asset – such as an oil or gas well – a newly developed high pressure system connecting into an ageing lower pressure system will require in-depth discussions in which the original design philosophy is revisited and aligned with current engineering practices. Back in the day, introducing double block and bleed valves and automated process trip, was considered overkill. Operators would know the plant by heart therefore acting from experience. Now, though, this reliance on hands-on mechanical interventions has been overtaken by a desire for leaner and meaner operations, giving rise to a new way of remote operating in CCS industry based on smart instrumentation and monitoring systems.

As the industry grows, the CCS community is working towards best practice workflows for performance and containment. The independent Dutch research organization TNO is an important player in this field, and part of the focus of its geologists is on developing workflows that ultimately lead to proven, bankable storage capacity and that supply investors with the certainties they need to make investment decisions. The two main aspects of concern for investors around carbon storage are capacity and injectivity: can the facility store sufficient volumes of carbon, and can targeted storage volumes be injected within a reasonable time and budget?

Of course, once the carbon has been stored, it is important that it is contained permanently. Containment relies on engineered barriers, such as cementing of wells, and on geological containment barriers provided by the natural characteristics of reservoirs plus side or top seals. Backed by a wealth of oil and gas experience, petroleum and exploration geologists ▶

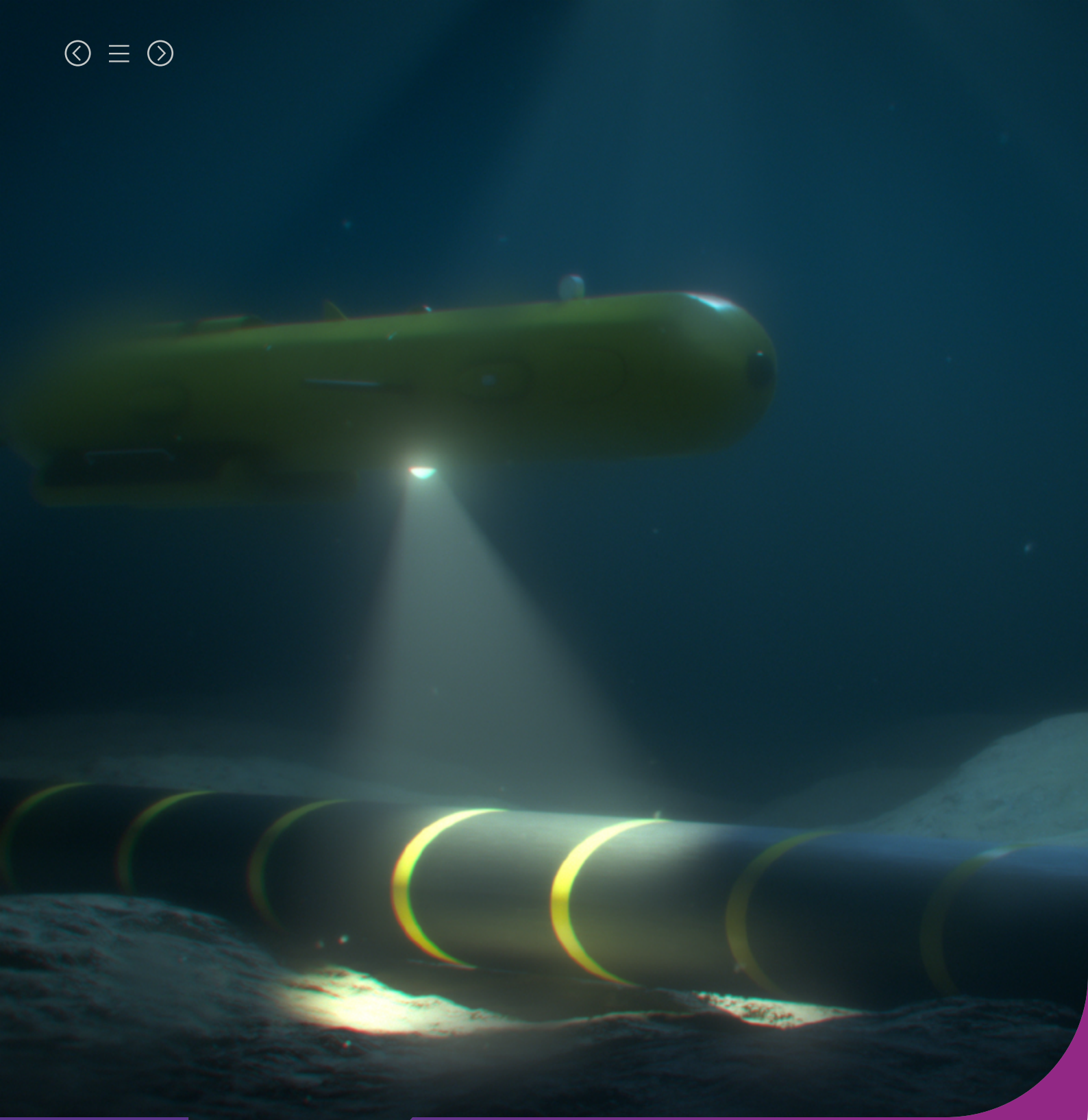
EDWIN VAN DRUNEN

‘YOUNG AND NEW ENGINEERS ARE ENCOURAGED TO ADOPT NEW WAYS OF THINKING’

are skilled at characterizing the subsurface and can make sound assessments of the effectiveness and security of storage and containment. Since public concern about the feasibility of storing CO_2 underground permanently can plague projects with delays, the industry must share these findings more widely and grow public confidence in CCS projects. The need to create a new culture supporting this was underlined by the majority of the interviewees.

At Enersea, an offshore engineering specialist that aims to meet the tremendous demand for cost-efficient energy solutions now and in the future, the focus is on what hydrogen and CO_2 related pipelines and platforms should look like. To the mind of Edwin van Drunen, owner and director of Enersea, what they are doing as a company both technically and collaboratively is pioneering work. The emphasis on partnering with clients with a combination of technical and management skills and bouncing ideas off each other as a team. Young and new engineers are encouraged to adopt new ways of thinking by focusing not only on their own specialty but interacting with other engineering disciplines to produce the best solution for a project.

It is important for engineers at Enersea to understand what happens outside their own scope of pipelines, facilities, and platforms and to know the limits of design in oil and gas wells, for example, so that they can reference this at every step of the process – from the concept phase through to the detailed design. Working at the cutting edge of a field where standards are being developed on an ongoing basis, Enersea regularly finds itself in territory where none are in place yet. When this happens, it falls back on existing standards and builds from there. ▶



'IT IS PIONEERING WORK WITH UNIQUE ADDED VALUE'

TON WILDENBORG

On the shoulders of **pioneers**

A discussion with Lydia Rycroft and Ton Wildenborg forms an interesting exchange between the new guard and the old guard at TNO. Lydia studied geology and worked over four years as a member of TNO's CO_2 Storage Team. Passionate about mitigating climate change, she chose CCS when she graduated as the direction in which to channel her drive. Ton, also a geologist by training, now engages with subsurface risk management (identification, evaluation and monitoring systems and mitigation) and regulation for safety at TNO. He is also involved in communication, particularly in dialogue with the public and sharing information in an accessible way. The practice of CSS for CO_2 abatement didn't even exist in the early days of his career, but he has worked in the CO_2 storage arena since 1994 and may now, at the end of his career, see his life's work come to fruition.

When Lydia was at university studying geology, CCS topics were already firmly on the syllabus. "Although it's still emerging as a market, I regard it as established from a technology perspective. Just look at the millions of tonnes of CO_2 already stored through various international CCS projects. This is proven technology." By contrast, government policy, markets, finances, and liability – areas she also gained experience in at TNO – do more readily fit the description of 'under development'.

Her colleague Ton, likewise, feels he came to the scene when the groundwork was already in place. "I see myself more as a transferer of the knowledge I learnt from concept pioneers in the late 80s and early 90s." He has taken that knowledge, as well as knowledge acquired from CO_2-enhanced oil recovery projects, and helped develop it further for implementation in the industry. Injecting CO_2 into a depleted gas field is not the same as storing it in aquifers, however. In that sense, it is pioneering work with unique added value that he shares with research consortia around the world working on similar storage facilities in depleted gas reservoirs. ▶

'ALIGNING COMPANIES IN THE CHAIN IS KEY TO ON-TIME DELIVERY'

GERBEN DIJKSTRA

Challenges and gaps

From Zoe's perspective, the main challenges around CCS implementation relate to stakeholder management and the need for transparency. Engineering issues can be resolved. Public perception is a bigger challenge – especially in our polarized society. There will be those who reject CCS as a deliberate choice and those who do so simply due to a lack of understanding. How can we best address this? According to Zoe: "It boils down to sharing information, reaching out to the public and speaking a common language. More than ever, the CCS community needs to have a shared goal on this front. Collaboration and a common language will be key."

A talk with Gerben Dijkstra (Head of Business Development) and Malte Dabbert (Business Development) at Anthony Veder highlights the shipping company's solid experience providing CO_2 transport for the food industry. There is nothing new about shipping CO_2, and regulations governing carbon transport are laid out in the International Gas Carrier Code. What Anthony Veder urgently needs now is for carbon emitters and carbon storage providers to establish a standard on CO_2 specification for transport and an operating window (pressure and temperature) at the loading and discharge points. With this in place, custom-made ships can be designed with materials that can handle the specific CO_2 requirements. The choices made by emitter and storage parties will have an impact on ship design and build time. It is crucial that the wider market realizes that these are not off-the-shelf vessels. Given that current yard availability for shipbuilding is 2026 and it takes two and a half years to build a vessel, there is a considerable risk of misalignment between emitters, storage parties and shippers, leading to a bottleneck in this part of the CCS chain.

While Anthony Veder aspires to transition towards a more sustainable world by reducing its own CO_2 footprint, it has limited influence on the decision-making around CO_2 specifications and operating regimes. Aligning low public profile companies like this with developments in the chain is key to on-time delivery of CO_2 shipping vessels.

The gap that Enersea foresees becoming problematic in the next couple of years, is in the supply of ▸

MALTE DABBERT

'THE CRUCIAL LAST STEP IS OPERATIONAL EXPERIENCE'

operational parts. This will not directly affect Enersea's own domain of facilities, but will present a serious challenge for wells and reservoirs. Here, transient situations such as start-ups and emergency shutdowns that can't be automated are crucial, as they determine what materials are needed based on operating temperatures. This requires operational experience which engineering companies at this stage do not have. The fact that Enersea is not involved in developing material standards, limits its role to be proactive in terms of the research it does on facility design and evaluation.

From its position in the value chain, Enersea strives to develop studies and plans that are eventually built to completion, which may take months or even years. In this developing industry and in general, Enersea knows it can control the project delivery process and provide clients with complete and correct information about the facilities it designs. The big economic and policy decisions, however, are in the hands of government.

The TNO team feels the science is comfortably covered in terms of challenges for the next five years. The crucial last step is operational experience. A lot of work is now being put into developing procedures that are as straightforward and clear as possible. During operation, it will be vital to monitor operations and containment performance and update the operating strategy continuously in real time.

Lydia observes that the issues causing delays in projects are not CCS technology issues as such, but external factors. "As I see it, the industrialization of CCS is being held back more by country-specific topics. The Porthos delay in the Netherlands can be traced to the nitrogen crisis, while problems in the UK are related to changing political will and to funding being pulled."

Another challenge lies in the area of risks and how far governments are willing to share the investment burden with industry to promote the public interest served by CCS. The industry is understandably reluctant to shoulder the financial and political risk involved in this immature market. So the question is: how much of that liability is government willing to take on to move CCS forward? Without effective government action, the industry will be left impaired to a certain extend. ▸


40
60
80
20
0
100
bar


CO_2

'FINDINGS OF JOINT PROJECTS NEED TO BE SHARED'

EDWIN VAN DRUNEN

Creating a culture of teamwork

Baselines for teamwork need to be defined in a new CCS industry comparable to those in oil and gas exploration and production. As well as collaboration between R&D and engineering, it will also take experience and common sense to tackle the unknowns in CCS operation. Given the thermodynamic complexity involved in CO_2 transport, flow assurance studies will be a strong point of focus, and tailormade simulation tools for CO_2 will be needed. The entire supplier and supporting industry will need to delve into the new requirements for a safe and operatable CO_2 system, so it is unsurprising that all the interviewees place a strong emphasis on collaboration.

With its collaborative approach to industry partners, Enersea is eager to break down walls. Edwin is clear about the way forward: "There are a lot of confidentiality issues between individual companies, which stunts progress at the industry level. In this early stage, there should be more drive in the industry for cooperation and knowledge sharing. Protecting commercial interests with NDAs puts up barriers that limit this. With the oil and gas industry for reference, we know well enough how these things work. To develop the CO_2 industry, the findings of joint projects need to be shared, but that's not happening readily at this point."

Integration across the industry can only succeed if players are willing to learn and share experiences. This requires having the right people who understand the complexity involved. The end goal of establishing a new industry with its own language and set of requirements transcends individual value drivers and company cultures.

Edwin argues that the behaviour of CO_2 is well understood, as are the engineering and technical safety requirements, which are based on processes and reviews. "A thorough risk assessment is only as good as the people who design it, so the way we work needs to change, and is changing, to ensure success. All experts should be on board and give each other space to be critical and follow through with hazard identification and operability studies. Most importantly, having experts with active experience of injecting CO_2 into wells and reservoirs will add immense value." ▸

'IT IS VITAL NOW TO FIND A WAY TO ENGAGE WITH THE PUBLIC'

LYDIA RYCROFT

Engaging with the public

Public opinion can make or break the industry's ability to accelerate development and activate political support, as we know from past experience. There are many ways to engage and educate the public on what we are doing in CSS. Activities like EBN's Carbon Storage Dialogues can play an important role, but at the moment these only target professionals within the industry. It is vital now to find a way to engage with and inform the wider public, get feedback, listen carefully and follow up. Lydia points in this context to learnings from the initial stages of the Covid pandemic: "Just look at the amount of disinformation that was easily accessible to the public. It became abundantly clear that the scientific world needs to engage and communicate better with the public."

Organizations like TNO need to play a key role in science communication moving forward. Lydia recognises this: "Given the miscommunication and disinformation there is around CCS risks, statistics and safety, it's hardly surprising the public are struggling. Governments must be clearer on climate change policy and why they are pursuing CCS. And their commitments need to endure even if governments or politicians change." She has noticed the tide of public opinion about CCS turning fast in recent years. Take Denmark, for example, where they have started assessing the potential for onshore storage in the short term. Denmark does not foresee any resistance from the public regarding onshore storage, which contrasts sharply with the pushback seen in the Netherlands in the recent past. Denmark has introduced an improved strategy of engaging early with the public on CCS topics, which shows that a huge change in public opinion can be achieved when messages are communicated well.

Eric is adamant: "Right now, the world needs CCS to help stop climate change. Not everyone realizes that hydrocarbons aren't just burned for fuel. Other products are derived from hydrocarbon production, too. That means it's impossible for our society today to stop hydrocarbon production completely. Even if we shift to renewables, we'll still need hydrocarbon for daily products. The public should be made aware how much energy is required for something like a single Google search. Lowering energy consumption is key."

The world has changed, and opinions have changed too. Climate change has increased people's understanding that we urgently need CCS. In terms of safety, the public has more faith in CCS design now than in the past. They feel more comfortable about offshore than onshore storage, and auditing by consultancy firms has bolstered confidence in this principle. Risk analysis shows that CO_2 does not pose a greater risk than media such as nitrogen, hydrocarbons or acids flowing through pipelines in the Netherlands' Botlek area. ▶

EDWIN VAN DRUNEN

'WE STILL NEED TO USE FOSSIL FUELS'

Serving a **shared goal**

Whatever their position in the chain and their perspective on the industry, the interviewees are all united by their passion and a deep belief in the need to push CCS forward. When we ask them in closing what message they feel the world needs to hear, their words reveal the higher goal behind the work they dedicate their professional lives to.

Zoe acknowledges that there are still some gaps to be filled, such as technology and business model innovations, as well as research on the CCS value chain and associated critical materials. Nevertheless, she is confident that engineers will do what it takes and will produce solutions. "What is important is to make it clear to the public and all relevant stakeholders that whatever work is done to further CCS will be for the good of all."

Gerben and Malte emphasize Anthony Veder's passionate commitment to reducing the CO_2 footprint and strong belief in working together towards a solution that works for all parties involved. Of paramount importance is a solid basis of open communication on how the choices made by each party impact others.

Lydia refuses to retire without first putting some CO_2 into the ground. She has deep faith in the ability of scientists and engineers to deploy CCS in Europe safely. "If we manage to inject CO_2 by 2030, for example in the Porthos project, I believe the industry will really take off. If we don't, I feel we will have missed the boat for CCS in Europe."

Ton is retiring from TNO in less than three months. Having seen CSS projects emerge in the past but then be cancelled for economic or political reasons, he deems it key to get these first projects rolling. "The risks around Porthos are greater than for a routine project. We have to keep these risks in perspective, mitigate them, because the project must succeed. Any other outcome would be a huge setback."

Edwin's message to the world is that we must realize that with the amount of energy our society requires, we still need to use fossil fuels. Other sources are too limited for now. "CCS can help us – if you pollute, it offers you a way to clean up the environment."

‘WHATEVER WORK IS DONE FOR FURTHER CCS WILL BE FOR THE GOOD OF ALL’

ZOE KAPETAKI

Eric wants to make it clear that CCS is part of the effort to stop climate change and should be seen as an absolute necessity. “You could draw a parallel with CFCs causing a hole in the ozone layer. Thanks to public awareness, CFCs were banned in time and the hole is now shrinking.”

Industry experts are witnessing a drive to share and collaborate that they have never seen before. The conviction is spreading that we can not afford not to join forces when there is so much at stake for humankind and life on Earth in general. Now that the science is in place, it is time for the industry to break down barriers and accelerate progress for the greater good. We need to raise public awareness and we need governments to take real, sustained action. In Lydia’s words: “When governments wanted man on the moon, they made it happen. When they decide they want to avoid climate change, with the necessary political support, CCS can be deployed quickly and at scale.” ■

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