
**ORAL PRESENTATION**

## Day 1: 7th March 2023

## Session 2: ENERGY TRANSITION - FOCUS ON CCS

**Co-Chair: Adrian Robinson, Chevron**

**Co-Chair: Nico Bianchi, RISC Advisory**

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| 10:50 | Overview of the Gorgon Carbon Capture and Storage System | Chris Stavinoha | Chevron |
| 11:15 | Unlock Offshore CO2 Storage in the APAC region with Floating CCS Development Hub | Peter Grant | DeepCStore |
| 11:40 | CCS vs HC Exploration – An Upstream Perspective | Patricia Seevam | Shell |
| 12:05 | The Seismic Route to Cost Appropriate Offshore CO2 Storage Monitoring | Will Bradbury | TGS |


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# Overview of the Gorgon Carbon Capture and Storage System

**Chris Stavinoha** [1]

[1] *Chevron*

*chris.stavinoha@chevron.com*

The Gorgon Carbon Capture and Storage (CCS) system located on Barrow Island, offshore Western Australia, is one of the world's largest integrated CCS projects.

From start-up in 2019, the project has injected 7 million tonnes of CO2e to October 2022 with more than 100 million tonnes expected to be injected over the life of the system.

The CCS system works by separating naturally occurring CO2 from produced offshore gas fields and injecting into the Dupuy sandstone formation about two kilometres beneath the facilities on Barrow Island where it is permanently trapped.

This presentation will provide an overview of the CCS system and how Chevron overcame challenges to successfully implement this critical lower carbon technology.

**SPEAKER BIOGRAPHY**

Chris Stavinoha – Chevron New Energies

GM CCUS Solutions – Asia Pacific & Middle East

Chris Stavinoha has nearly 30 years of experience in the oil and gas industry with a diverse background, including drilling, exploration and development engineering, upstream and midstream project development and execution, conventional and unconventional asset management, in both operational and business leadership roles.

Currently Chris serves as a General Manager of CCUS solutions in Chevron's New Energies Business Unit where he has accountability for the development and execution of CCUS opportunities and projects in the Asia Pacific and Middle East Regions. In his previous role with Chevron Chris served as the Project Director on a novel Biomass Energy Carbon Capture Sequestration (BECCS) Joint Venture Project located in California.

Prior to joining Chevron, Chris served as Vice President of Capital Projects for Noble Midstream Partners (NYSE: NBLX) and as a Director of Capital Projects for Noble Energy (NYSE: NBL). Prior to these roles, Chris served as an Executive Vice President for London Offshore Consultants.

Chris received a Bachelor of Science in Engineering from the University of Houston and received his Master's in Business Administration (MBA) from The University of Denver.


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# Unlock Offshore $CO_2$ Storage in the APAC region with Floating CCS Development Hub

**Peter Grant** [1]

[1] *DeepCStore*

peterdgrant@iinet.net.au

Carbon capture and storage (CCS) is central to a clean energy transition. According to the UN's IPCC and IEA, CCS needs to attain a global $CO_2$ reduction capacity of ~4 billion tonnes per annum by 2050 to achieve Paris Agreement targets (IEA, 2020). To date only 30 large scale CCS facilities are operational worldwide, totalling 42.6 million tonnes per annum of CCS capacity (Global CCS Institute, 2022). Massive number of new projects are needed.

Australia has a potential $CO_2$ storage capacity of 434 billion tonnes, with 316 billion tonnes (73%) residing in offshore oil and gas fields and aquifers (Carbon Storage Taskforce, 2009). The APAC region also provides significant additional $CO_2$ storage capacity.

A key constraint to unlock the potential $CO_2$ storage capacity in the APAC region is that the $CO_2$ storage sites and emitter sources are not necessarily located close by. Since most CCS projects considered to date use pipeline transportation, this limits the number of developments to those that have the emission sources and storage sites in proximity.

By utilizing the Floating CCS Hub development concept, which includes liquefied $CO_2$ carriers and floating CCS hub facilities, CCS can be provided to a broader range of emission sources (deepC Store Limited, 2021). The transportation cost using liquefied $CO_2$ carriers is not as sensitive to transport distance as pipelines, which have a linear relationship between distance and cost. Liquefied $CO_2$ carriers and floating CCS hub facilities also minimise development constraints related to pipeline distances and land use, and enable replicability and scalability to unlock multiple offshore $CO_2$ storage sites for CCS in the APAC region.

## SPEAKER BIOGRAPHY

Peter has over 45 years of experience in the upstream oil and gas industry specialising in, exploration and international E&P business development.

He has extensive work experience in Africa, South East Asia, Middle East, South America and Australasia, and has led successful teams that have made discoveries in the UK, Australia, Algeria, Libya, Sierra Leone and Mauritania. Peter's experience base is founded in geoscience but has extensively augmented his expertise in corporate strategy, business development, commercial negotiations and portfolio management through his roles such as Exploration Manager for Africa and Middle East for BHP Petroleum, and through senior roles in Woodside Energy as International Exploration Manager, General Manager International, and General Manager International Ventures.

Peter established International Energy Solutions, a strategic advisory company for the energy industry and has recently advised clients on growth projects in sub Saharan Africa, China and South East Asia, both petroleum and coal seam methane related. He also provides commercial and political risk advice and has conducted numerous oil and gas training seminars.

He has a BSc (Hnrs) in Geology from Nottingham University (UK).

He is currently a non-executive Director for ASX listed Botala Energy Ltd and is technical advisor to both Transborders Energy Pty Ltd and deepCstore Pty Ltd.

He was AAPG President for the Asia Pacific region from 2015 to 2017 and a member of the AAPG Advisory Board for the same period. He is currently vice president for the Asia Pacific region. In 2021 he was awarded the prestigious AAPG Vladsimila Dvorakova International Service award for work undertaken for the AAPG in the Asia Pacific region.


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# CCS vs HC Exploration – An Upstream Perspective

**Dr. Patricia Seevam** [1]

[1] *Shell*

patricia.seevam@shell.com

Carbon Capture and Storage (CCS) is a key part of a portfolio of solutions for $CO_2$ emission reduction, estimated to account for 6-20% of $CO_2$ reduction needed by 2050 (IEA, 2014; IPCC, 2018). The Oil & Gas industry plays a key role in the evaluation, exploration and appraisal, and subsequent development of subsurface $CO_2$ storage site, especially given the many commonalities in subsurface characteristics and development technology. However, there are some key fundamental differences between CCS and Hydrocarbon (HC) development projects.

CCS projects underpin industrial value chains and are "downstream". The projects "serve" industrial customers and as such need to be able to take and securely store $CO_2$ at the rates needed by the customers and for the duration of the customers' projects – that is, there is only "plateau" rate storage. The CCS projects also underpin a very different value chain compared to HCs where the customer base could originate from outside the oil and gas sector (power and industrial products) and where currently economic feasibility relies on government incentives, regulatory and policy aspects such as tax, subsidies and liability transfer.

This storage would need to be de-risked (seismic, appraisal etc.) similar to HCs, but the ability to guarantee the sustained injectivity for the duration of the customer contractual commitment is the key "target". For saline storage this means appraising for regional pressure connectivity (ability to dissipate) as well as local containment of the $CO_2$ injected, or alternatively developing a network of stores with redundancy – often a mix of depleted fields and saline formations. One challenge is that the appetite for taking risk is somewhat lower compared to HC exploration simply because the 'reward' is much lower than discovery of HC in the current landscape where carbon policies are less mature and inconsistent around the world. This results in a smaller acceptable margin of uncertainty.

As $CO_2$ storage is done with the aim of separating $CO_2$ from the linked ocean/atmosphere system the regulatory authorities naturally ask for assurance that the stores are operating as expected: this leads for a requirement for Monitoring, measurement and verification (MMV). MMV has three aims, or the three "Cs": provide evidence in support of Containment, demonstrate expectation of Conformance, and give stakeholders Confidence in storage safety. Before receiving a storage permit the developer has to demonstrate monitorability of $CO_2$ plume location in the subsurface. The conformance monitoring helps to demonstrate that $CO_2$ is securely stored to facilitate post injection transfer of the store back to the state authorities.

In HC project, subsurface is the "producer", and the resource has been discovered at the start of a development project. Generally, HC development is a standalone project, and the resource has clear market value through direct sales. MMV is not critical and not required for project regulatory approval.

CCS will play an important role in decarbonization of industries, and the sustainability of jobs through the energy transition, and hence, as an industry we must develop new ways of thinking to unlock value in these emerging value chains.

## SPEAKER BIOGRAPHY

Patricia started her career in the upstream with BP UK, and then moved on to take various projects and operations leadership roles in the UK, Azerbaijan, North Sea, Egypt and Angola, prior to joining Shell Sabah as Production Manager in 2021. She is currently the GM for Transformation and Energy Transition for Malaysia. She holds a PhD. in CCS and MSc from Newcastle University, UK. She is a Fellow of the Institute of Mech. Engineers (FIMechE) and has several publications on CCS including a book published by American Society of Mechanical Engineers (ASME).


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# The Seismic Route to Cost Appropriate Offshore $CO_2$ Storage Monitoring

**Will Bradbury** [1], Bent Kjølhamar [1], Adriana Citlali Ramirez [1], Tone Holm-Trudeng [1], Paul West [1]

[1] *TGS*

*will.bradbury@tgs.com*

After more than 100 years of existence, the oil & gas industry has developed highly sophisticated 3D technology for subsurface characterization. The traditional focus has been on hydrocarbon exploration and production targets buried a few kilometres down. A secondary focus has been on the shallow section, and shallow hazard investigations to aid drilling and engineering work. CCS needs are somewhere in the middle. All three target zones have seismic fit for the frequencies the targets yield. Stable storage requires the right pressure and temperature mix to maintain carbon dioxide in a super critical state (for many current stores), for which a typical burial depth of more than 800m below the sea surface is required. Because of the latter and combined with economic constraints (cost of wells and injection), the ideal depth zone for storage sites should be in the range 800-1500m below the sea surface.

The cost of storing $CO_2$ is changing rapidly as market and governmental support grows and while the value of stored $CO_2$ in the subsurface is under scrutiny and expected to raise, lifetime monitoring costs could be a determining factor for the success of a given CCS project.

Even if the subsurface of the planned carbon storage hubs are de-risked properly, a geophysical monitoring plan is required (4D) for the decades to come to demonstrate the sealing integrity of the overburden while injecting $CO_2$ into the reservoirs. Different to 4D seismic used for oil and gas fields where a successful use represents increased value, 4D data for carbon storage is a cost-only entity in a loss-bearing business for the majority of current cases (outside of public funding).

There are two important factors for sustainable 4D seismic programs for CCS; that is cost efficiency and small acquisition footprints. The marine CCS storage sites planned today are near the coast and typically reuse existing oil and gas infrastructure or hubs. Many areas see high activity levels with multiple stakeholders such as shipping, wind parks and fisheries. In traditional 4D monitoring, large streamer 3D vessels with an acquisition footprint of 6-8 km2 have been used. This large footprint may not be possible to operate safely and cost-efficiently in dense shipping lanes or around wind farm developments. Even if no wind parks exist in these areas today, the CCS operator may be required to plan monitoring activities for 25 years or more ahead. Ideally the same type of technology should be used from the first base line throughout the monitoring period for the highest confidence in demonstrating containment and conformance.

Therefore, the search for more cost-efficient, small footprint measurements is ongoing and here we present three seismic alternatives: In-Well-DAS-VSP (Distributed Acoustic Sensing – Vertical Seismic Profiling), Ocean Bottom Nodes (OBN) and a repurposed light weight, small-footprint 3D system (XHR) the use of which has been well established by academia and the O&G industry. These technologies can deliver lower cost fit for purpose imaging demonstrating containment and conformance for carbon storage reservoirs through their full lifecycles.

## SPEAKER BIOGRAPHY

Will has 20 years of subsurface, commercial and leadership experience within service companies such as VP Europe and AME. He has worked with governments, regulators and energy companies developing geophysical projects. Today Will is continuing his work in TGS to develop new data offerings for the energy transition.