



CCUS at S&P Global

S&P Global

Commodity Insights

S&P Global is being asked a range of questions regarding CCUS

Where is CCUS activity happening? What fields are involved?

What depleted fields could be potential storage candidates? Which basins have known saline aquifers?

Where are the trends for technology and innovation in CCUS?

Who are the participants in this project? What does the project comprise of?

What dry structures are nearby? What is the seal & how extensive is it?

How is the regulatory, policy and fiscal environment evolving in key countries?

What infrastructure is in place? Where are the large industrial emitters?

How many gas processing plants are there in the region? What CO2 volumes are captured?

What are the current and forecasted costs for a varied portfolio of projects by type and size?

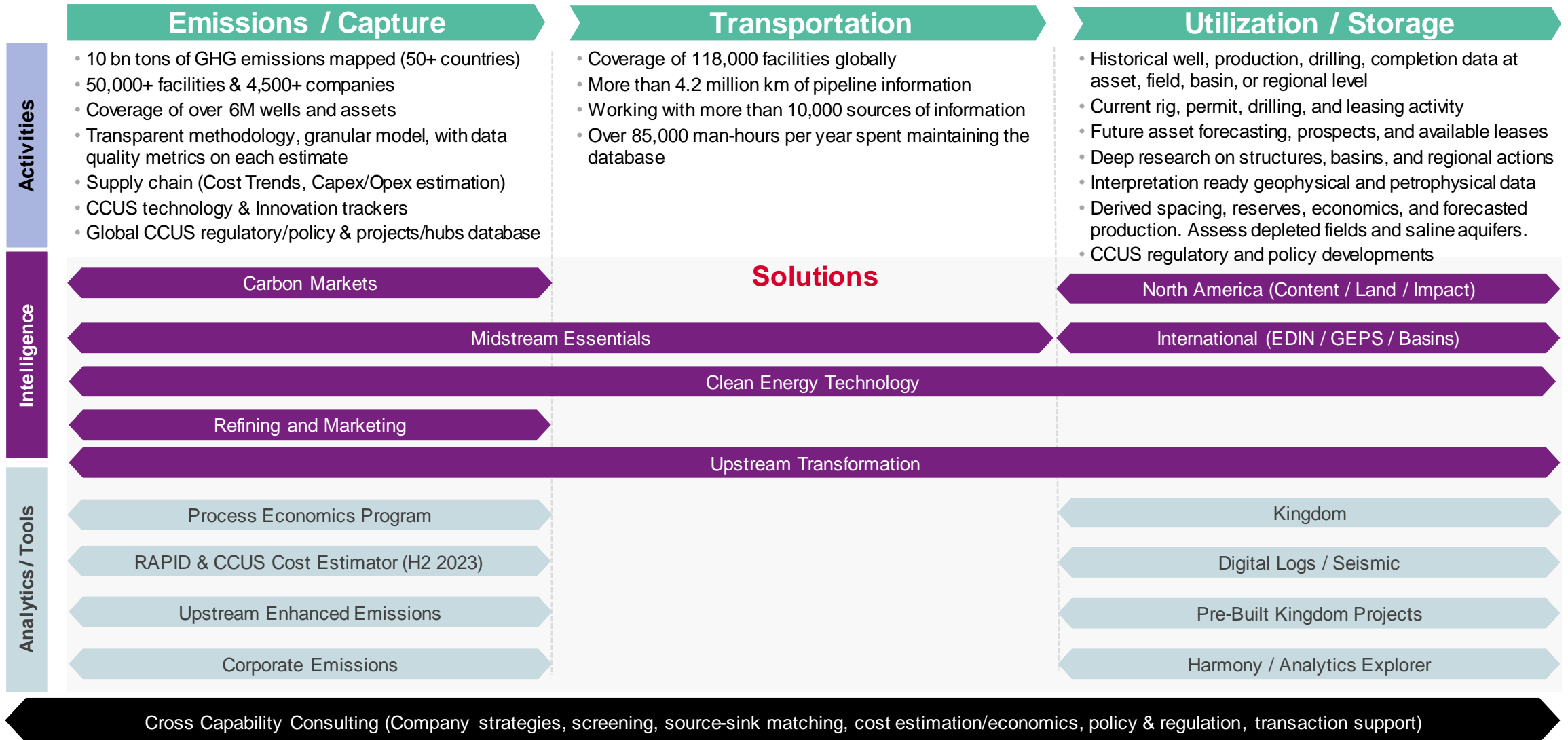
What are the subsurface properties for a given depleted reservoir? What common geological elements are required for a CCUS project?

How many EOR candidate fields fall within 50km of these plants and what's the EOR potential?

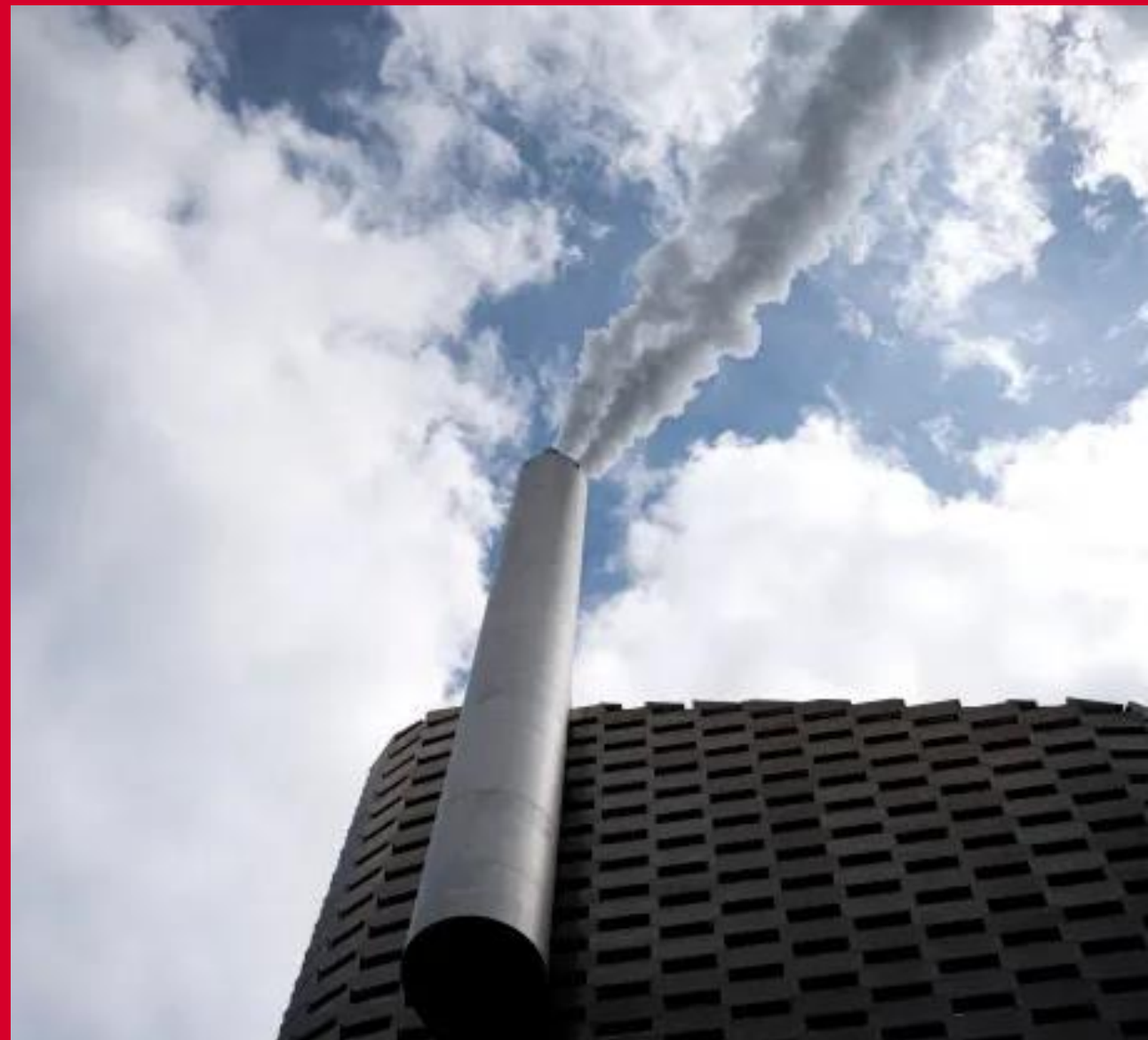
How are the CCUS strategies differing between peer groups?

S&P Global provides the most comprehensive solution to cover the entire CCS/CCUS development value chain

From source to sink



Emissions & Capture



Emissions | To build a best-in-class CCUS capability, S&P Commodity Insights have made efforts to bring together our data and expertise

Service	Description	Visualizations
<p>Upstream Enhanced Emissions</p> <p><i>Absolute and Intensity of Upstream Emissions</i></p>	<ul style="list-style-type: none"> Granular emissions at the asset and well level broken down by source and type <ul style="list-style-type: none"> Scope 1: fuel combustion, flaring, venting, fugitives, others Scope 2: electricity use Comprehensive coverage of over 6M wells and assets Transparent methodology, granular model, with data quality metrics on each estimate Integrated with SPGCI's core dataset, easily consumed through API/Cloud or visualized in our Impact or Vantage tools 	
<p>Corporate Emissions</p> <p><i>Standardized data and analytics on GHG emissions across the energy value chain and industrial sectors</i></p>	<ul style="list-style-type: none"> Research & Insights, Web platform with analytics dashboards, Data query and API capabilities 10 billion tons of GHG emissions (CO₂e) mapped in over 50+ countries 50,000+ facilities & 4,500+ companies across the energy and industrial sectors Absolute and Emissions Intensity metrics reported on an asset-level Scope 1 and 2 emissions reported on a gross operational and net equity basis Time series from 2010 to 2030 	

Upstream Enhanced Emissions

S&P Global Commodity Insights' Upstream Enhanced Emissions dataset

- provides estimated **absolute GHG emissions** and **emissions intensity** for upstream oil & gas facilities globally
- complements our **core upstream** asset/well and production datasets
- supports **upstream workflows** where detailed facility emissions are increasingly important.

Benchmark

Plan

Screen

Abate

Upstream operators: ESG, Competitive Intelligence, Upstream operations, Portfolio management, Benchmarking, Reporting

Financials: upstream investors, ESG/Decarbonization commitments

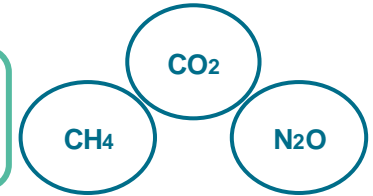
Service companies: business development, market strategy, decarbonization business

*Provides GHG emissions insights to **Upstream Transformation** and upstream facility emissions data to **Corporate Emissions Solution***

✓ Granular

Emissions estimates at the asset or well level, broken down by GHG **source** and **type**

- ☐ **Scope 1:** fuel combustion, flaring, venting, fugitives, other
- ☐ **Scope 2:** electricity use

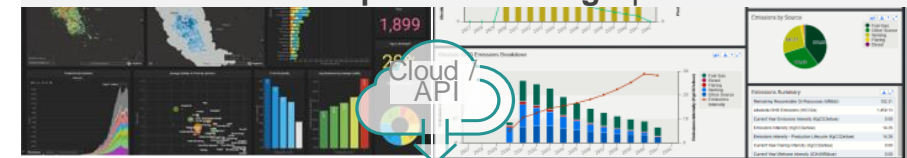


✓ Comprehensive

geographic coverage for **6m US Lower 48 & Canada** onshore wells, and **~18,000** assets/projects internationally for the rest of the world.

✓ **Transparent** public methodology, consistent system boundaries, granular engineering model, input hierarchy & recalibration, Data Quality Metric for each estimate

✓ **Integrated** with our core upstream asset/well and production datasets, with primary delivery in our Energy Studio **Impact** and **Vantage** platforms



Vantage | Upstream Asset & Portfolio Valuation

A transparent and interactive forward-looking view on asset and portfolio level oil and gas production, costs, and economics.

Vantage enables customers to **visualize** each step of the **valuation** process for **18,000+** global upstream assets at various stages of the oil and gas asset lifecycle in a powerful **online** platform. Vantage leverages the expertise of dedicated geologists, engineers and economists, proprietary Exploration and Production (E&P) data, world-class tools and the most comprehensive fiscal terms database.

- **Asset, Project & Portfolio** evaluation capability.
- **Global Coverage:** >18,000 assets comprising discoveries through to producing assets.
- **Granular** project level **production, CAPEX & OPEX** profiles.
- **Transparency:** Open accessible economic models, development concepts and underlying geological inputs.
- **Customization:** Sensitivity analysis on key parameters (oil price outlooks, costs and production).
- **Unique bottom-up approach** taken in our methodology. For non-producing projects, the Vantage research teams use the industry standard **QUESTOR** cost estimation and field development planning tool.



Portfolio Analysis



Customization & Scenario Management

- Reserves & Production
- Asset & Portfolio Valuations
- Field Development & Costs
- Economic & Fiscal Terms
- Analytics & Data Visualization

International Upstream Enhanced Emissions | Vantage 22.1 Release

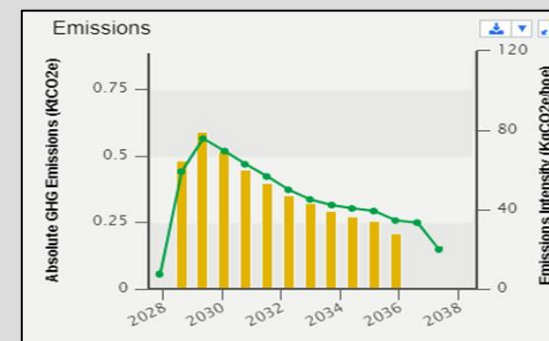
ADDED Project Level Emissions Data



- Coverage increased to all assets and projects in Vantage (worldwide outside of onshore NA).
- Initially the new emissions data will be scope 1, direct emissions only.
- **NEW** Emissions Attributes – Vantage Projects:
 - Absolute GHG Emissions (KtCO₂e)
 - Emissions Intensity (KgCO₂e/Boe)

Available as part of existing Vantage subscription

- ✓ Vantage Query Builder
- ✓ Vantage Asset Viewer
- ✓ Vantage Custom Viewer
- ✓ Vantage API



NEW Emissions by GHG Type & Source



Detailed breakdown for each project to show absolute emissions and emissions intensity by GHG type and source

GHG Type

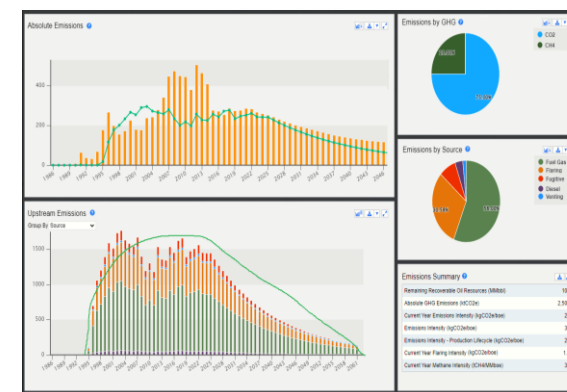
- CO₂ (Kt)
- CH₄ (KtCO₂e)
- N₂O (KtCO₂e)

Emissions Source

- Fuel Gas Combustion Emissions (KtCO₂e)
- Diesel Combustion Emissions (KtCO₂e)
- Flaring Emissions (KtCO₂e)
- Fugitive Emissions (KtCO₂e)
- Venting Emissions (KtCO₂e)
- Other Source Emissions (KtCO₂e)

Available in Vantage as part of new:
International Upstream Enhanced Emissions Data Set

- ✓ New emissions dashboard
- ✓ Additional attributes available in:
 - Vantage Asset Viewer
 - Vantage Custom Viewer
- ✓ New Intl Upstream Enhanced Emissions API



Upstream Transformation | An integrated view of CCUS market evolution

Government

Monitor regulatory changes and incentives that will impact project economics, compliance, technology deployment, market access, and policymaking in other jurisdictions

- **Government Low-Carbon Action Tracker:** Monitor emerging policies on a country and state/provincial level, and benchmark their durability and stringency
- **Research:** Detailed insights on future policy directions and developments, including for CCUS

Company

Compare company low-carbon strategies and actions, assess their ability to execute, identify emerging corporate best practices

- **Company Low-Carbon Action Tracker:** Monitor events that deliver upstream companies' transition strategies and benchmark activity, including in CCUS
- **Company Low-Carbon Strategy Profiles:** Analysis of company strategies and potential challenges
- **Research:** Detailed insights on company actions, including the role of CCUS in their emission reduction progress

Technology & Innovation

Analyze company technology development strategies and activities to meet the evolving needs of an industry in transition

- **Technology Trends:** Document and anticipate shifts in industry technology sourcing strategies, focus areas, and adoption rates, including for CCUS
- **Technology Tracker:** Monitor technology development and deployment activities in the low-carbon, digitalization and core upstream domains
- **Research:** Proprietary frameworks and data sets, company profiles, and technology deployment case studies, including for CCUS

Carbon Capture, Utilization & Storage

Explore detailed cost, technology, supply chain and incentive assessments crucial to project planning and execution

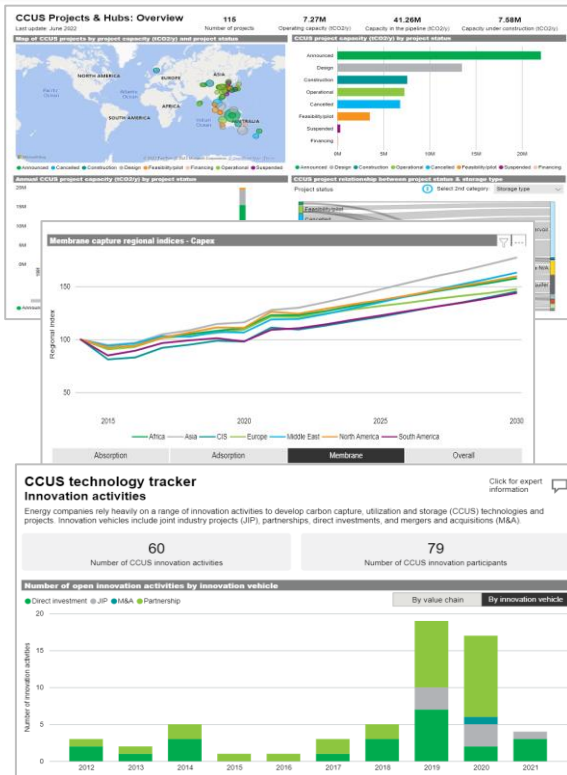
- **CCUS Project and Hub Database:** Monitor CCUS project status, technology, cost, service company and stakeholder data
- **CCUS Cost Indices:** Current and forecasted costs for a varied portfolio of CCUS projects by project type, size and region
- **CCUS Policy and Regulation Tracker:** Monitor emerging policies, regulations and incentives that shape CCUS development and deployment
- **CCUS Technology Tracker:** Assess CCUS innovation, technology development and cost reduction strategies
- **Research:** Detailed insights on CCUS developments

Upstream Transformation | Providing the full landscape, drivers and opportunities to transform CCUS from a cost to a business

Delivered via

Analytical trackers and dashboards

- **CCUS Projects and Hubs Database:** Monitor project status, technology deployment, project cost estimates, service company engagement and more
- **CCUS Cost Indices:** Gain an understanding of current and forecasted costs for a varied portfolio of projects
- **CCUS Technology Tracker:** Assess innovation, technology development and cost reduction strategies
- **CCUS Policy and Regulation Tracker:** Follow emerging policies, regulations and incentives



Insights

Malaysia's new energy policy sets out an ambitious but durable plan for upstream and low-carbon energy development

The state of CCUS technology development—Lowering costs to scale an emerging carbon management business

United Kingdom expands access to its offshore carbon storage acreage

Global carbon capture, utilization, and sequestration (CCUS) industry trends

IHS Market
now a part of
S&P Global

CCS Costs | By H2-2023, S&P Commodity Insights will have a dedicated tool for estimating costs for CCS projects

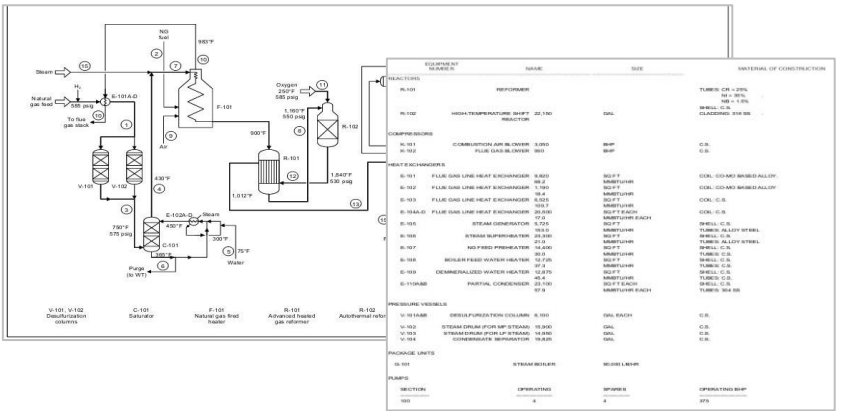
Service

Description

Visualizations

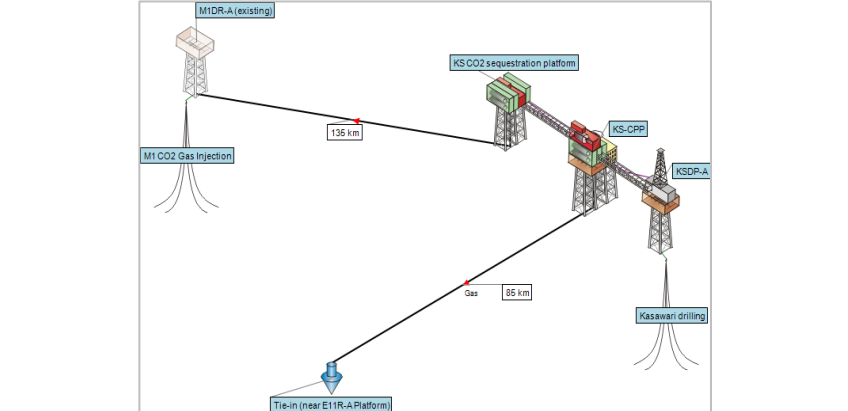
Process Economics Program
Bottoms up process analytics by chemical engineers and chemists

- Design Basis
- Process Flow Diagrams
- Heat and Material Balance
- Equipment Specs
- Detailed Capital Investment and Operating Cost



CCUS Cost Estimator / RAPID (Decarb Cost)
Releasing H2-2023

- RAPID – Detailed PEP Cost Tool for Carbon Capture to facility exit
- CCUS Cost Estimator - Detailed estimator tool taking CO2 from capture facility to sub-surface
 - The tool will build on our decades of experience with QUE\$TOR, which is used by more than 500 energy estimators and managers in 50 countries and provides concept screening, optimization and detailed oil and gas CAPEX/OPEX cost estimates.



Value Chain Coverage | S&P also brings expertise across the energy value chain in conjunction with carbon markets

Service

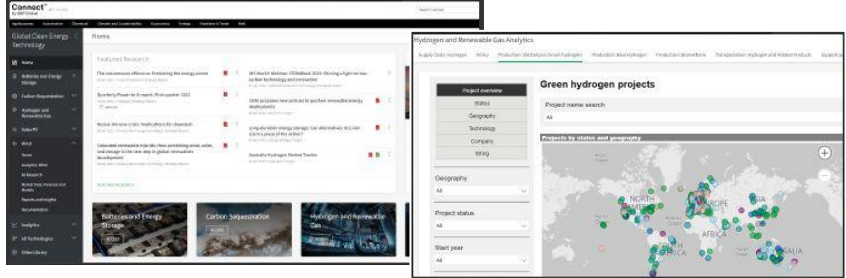
Description

Visualizations

Clean Energy Technology

In-depth global coverage of supply chain economics and outlooks for clean energy

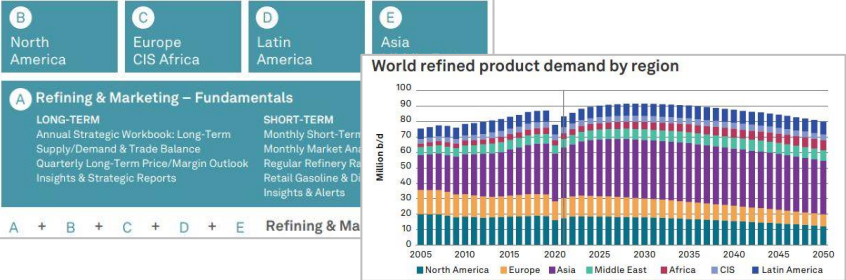
- Policy, technology, market issues and drivers
- Capex, Opex, and cost for key technologies
- LCOE for solar, wind, hydrogen, and renewable gas production
- Capacity outlooks for power generation, solar PV, onshore and offshore wind installations, storage and hydrogen production
- Emerging trends: drivers and inhibitors on the outlooks
- Corporate strategies and business models
- Global databases of projects



Refining and Marketing

Refined product supply, demand, and fundamentals

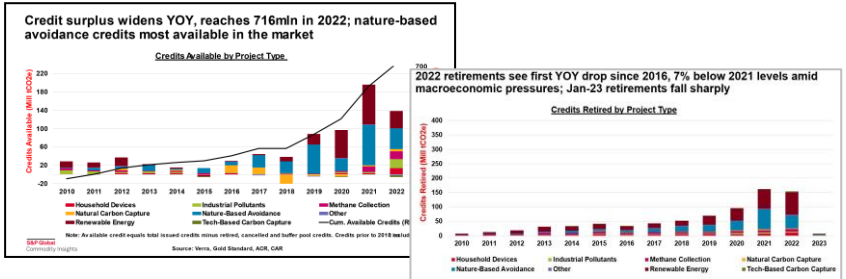
- Policy, technology, market issues and drivers
- Fundamental and structural trends (Short Term and Long Term)
- Detailed data and analysis by product (Utilization rates, refinery projects, capacity rationalization)
- Inter-regional trade by major products
- Outlook for product prices and refinery margins
- Country profiles analyzing value chain from refining through retail (Country level context that rolls up to regional and global forecast views)



Carbon Markets

Price assessments, transparent data, news, and analysis on the global carbon landscape

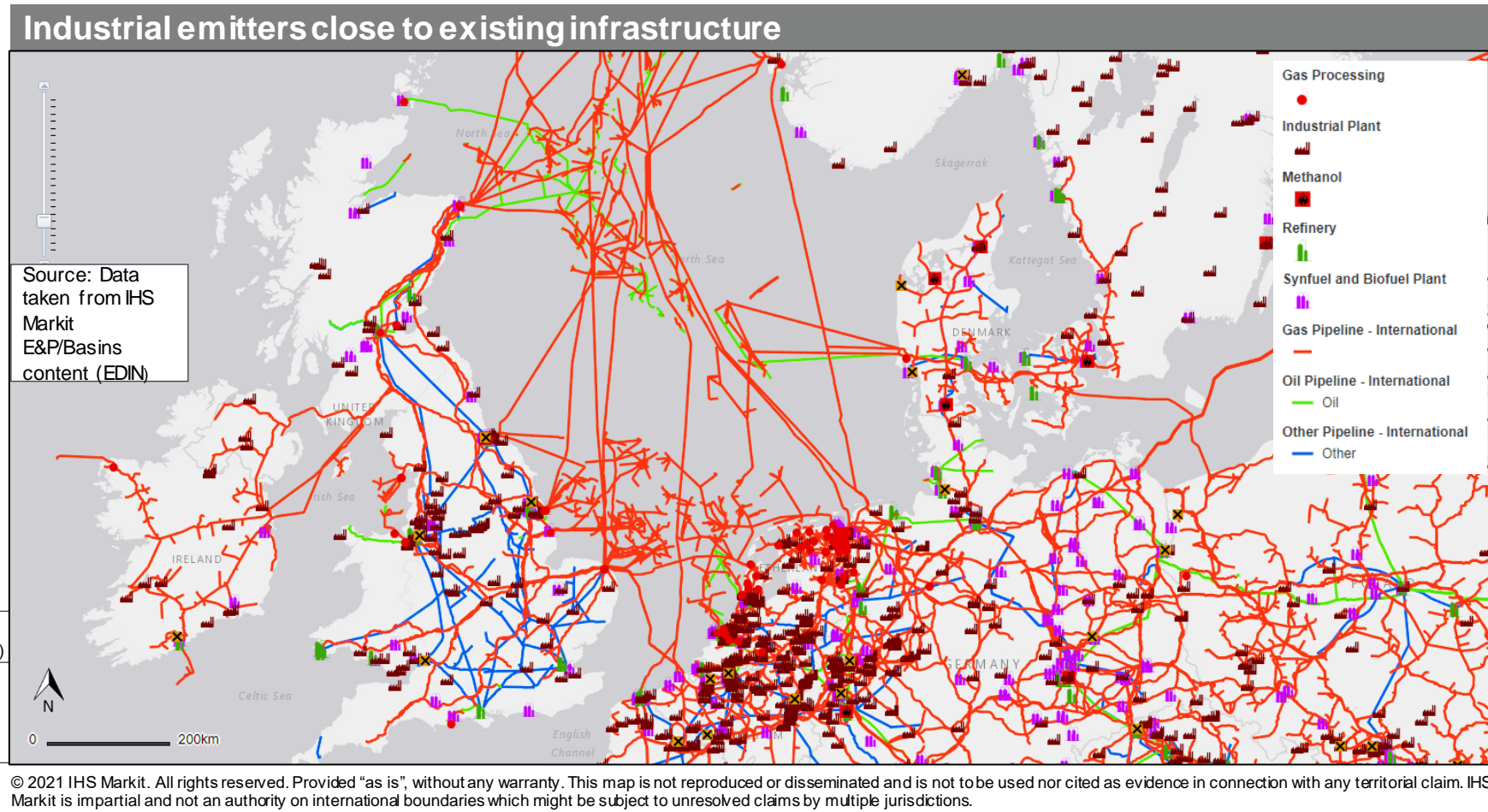
- Voluntary Carbon Markets (VCM)
- Methane Performance Certificate (MPC) markets
- Compliance Carbon Markets
- Low Carbon Fuel Standards
- 108 Carbon Credit assessments
- Real-time insights and daily reports



Transportation



Midstream Essential | The most comprehensive data and visual interface to understand sources of emissions and proximity to infrastructure



Midstream Essential | Entails geospatial energy transportation, processing and primary markets infrastructure data

- **Pipelines** (*Content: Carbon Dioxide*) / Pipelines North America (*Cmdty Des: Carbon dioxide*)
- **Ports**
- **Terminals**
- **Storage** (*Fluid Type: Carbon Dioxide*)

- **LNG**
- **Gas Processing**
- **Refining**
- **Syn-biofuels** (*Syn Fuel Type: Hydrogen, Bioethanol, Biodiesel etc.*)

- **Power Generation**
- **Olefins**
- **Methanol**
- **Ammonia**
- **Heavy Industrial** (*Plant type: Aluminum Smelters, Cement, Iron/Steel etc.*)

- ***Reported CO2 emissions (US, Europe, Australia)**

- Coverage of 118,000 facilities globally
- More than 4.2 million km of pipeline information
- Working with more than 10,000 sources of information
- Over 85,000 man-hours per year spent maintaining the database

The Midstream database offerings are accessed through the **EDIN portal**, providing ongoing data updates through a powerful online data search and mapping environment. The datasets are also delivered via **Web Services / APIs** for a range of workflows along the energy value chains enabling analytics through various business intelligence and spatial platforms.

*** Reported CO2 emissions available via the Gas & Power Database**

Utilization / Storage



GEPS (Upstream Intelligence) | Increasing CCUS Coverage

Market Intelligence on upstream linked CCUS activities; Hot Topics Dashboard – Filters & Alerts for CCUS

Upstream Intelligence
by S&P Global

Search within GEPS Reports

GEPS REPORTS | MAP | DASHBOARD | ADVANCED SEARCH | CROSS PRODUCT | MY SERVICES | OIL PRICE | RESOURCES

BREAKING NEWS LATEST FROM TODAY'S DAILY EXPLORATION ALERT

o Rio: Albacora Leste deal progress | 28 Apr 2022 | Brazil - Shell Atapu ToR right inked | 28 Apr 2022 | Belarus - Belorusneft: Discovery: Omelkovshinskaya Vostochnaya-1 nfv | 28 Apr 2022 | Slovenia - Govt. Frac ban | 28 Apr 2022 | Uni

ARTICLES BY COUNTRY

Highlights Only | ---Worldwide--- | Last 30 Days

INDUSTRY HOT TOPICS

Current | Previous

Carbon Capture, Utilisation and Storage (CCUS)

Find information and updates relating to CCS / CCUS projects worldwide

LATEST MAPS

Title	Date
Kuwait - Kuwait and Divided ...	27 Apr 2022
Middle East - Middle East 2 ...	27 Apr 2022
Turkey - Turkey General	27 Apr 2022
Turkey - Turkey Black	
Turkey - Turkey Diya	

MONTHLY/QUARTERLY REPORTS

Title
Saharan Africa Mar 2022
Europe Mar 2022

GEPS SPECIAL REPORTS

The economic impact of carbon capture and storage (CCS) on an upstream project

A worked example app... The upstream oil and gas industry associated with the exploitation of emissions intensity and potentially... In September 2020, we released a key challenges to developing the n both carbon dioxide (CO₂) and hyd capture and storage (CCS) will be... The Kasawari field is one of the lar to MLNG and contains about 22% capture, utilization, and storage (C final investment decision (FID) to b

CO₂ Sequestration in South East Asia: Screening Methodology for Potential Storage Sites in Depleted Gas Fields

Zafrah Razali, Sr. Technical Research Analyst, Hong Shien Lee, Technical Research Associate Director, Emilio Intieri, Technical Research Associate Director, Mei Ching Koway, Technical Research Principal, Norishah Hashim, Technical Research Principal, Kian Chong Tan, Sr. Technical Research Analyst, Antonio Jr. Dimabayay, Technical Research Executive Director

Carbon Capture & Storage (CCS) is one of the many technologies that have been developed to address CO₂ emissions. This technology has recently attracted a lot of interest from the oil and gas community due to global concerns around CO₂ levels. Secured underground storage for CO₂ has been part of CCS project studies since the 1990s. When considering prospects for CO₂ storage, it is important to gain a full understanding of the area in question, through available data on field status, geological characteristics, geometry, and proximity to the CO₂ source.

Subsurface storage of CO₂ can be undertaken in a variety of geological settings such as basins, oil fields, depleted oil and gas fields, deep coal seams and saline aquifers (Bachu 2003; Metz et al. 2005; Akintunde et al. 2013; al. 2011; Raza et al. 2017). As each basin has unique features, a deep understanding of depleted reservoirs, either carbonate or clastic, is vital.

This paper showcases how the evaluation of target areas has been developed by incorporating risk identification as part of the integral process for CO₂ storage prospects, targeting depleted gas fields in South East Asia (SEA). The focus of this study is to recognize potential CO₂ sources from developed and undeveloped fields and identify potential future storage candidates based on operators' priorities.

The novelty of this study comes from the fact that site selection is the most crucial, time-consuming, and costly process at the initial stage of a CO₂ sequestration project. This paper highlights the regional screening approach and maturation study for South East Asia depleted gas fields.

Several focus areas have been identified for this study: Central Luconia Province, Tatau Province and the Malay Basin in Malaysia, and the East Java and South Sumatra basins in Indonesia. Geological boundaries such as faults, stratigraphy, and hydrogeology are ideal cases for site selection characterization. However, in practice, the study area is defined by the authority on the basis of block or concession boundaries and is also limited by data availability.

Introduction

The oil and gas sector in SEA contributes a reliable provision of energy, thus aiding in the region's socio-economic prosperity. However, as SEA is one of the most dynamic and fast-growing regions, this has resulted in the oil and gas sector becoming its largest emitter of greenhouse gases (GHG) (Sillitonga, A.S. et al., 2013; Sillitonga A.S. et al., 2018; Ong, H.C. et al., 2014; Sandu, M. et al., 2019; Mofjur, M. et al., 2019).

The ASEAN POST reported in January 2019 that the ASEAN-5 countries (Indonesia, Malaysia, Philippines, Thailand and Vietnam) have their own national commitments to reduce their carbon footprints as part of the effort to realise the December 2015 Paris Agreement. It is of utmost importance for authorities to consider CCS projects to facilitate the imminent need for decarbonization.

Petroleum Nasional Bhd (Petronas) Phase 1 Sarawak Multi-client 3D, completed

PETRONAS has completed the Phase 1 of the Sarawak Sarawak Multi-Client 3D (Sarawak MC 3D) survey, in offshore Sarawak, around 24 April 2022. Acquisition Area The first phase of the survey, a 8,600 sq km 3D seismic was acquired by PGS "Ranform Sovereign' S/V using multi-sensor GeoStreamer...

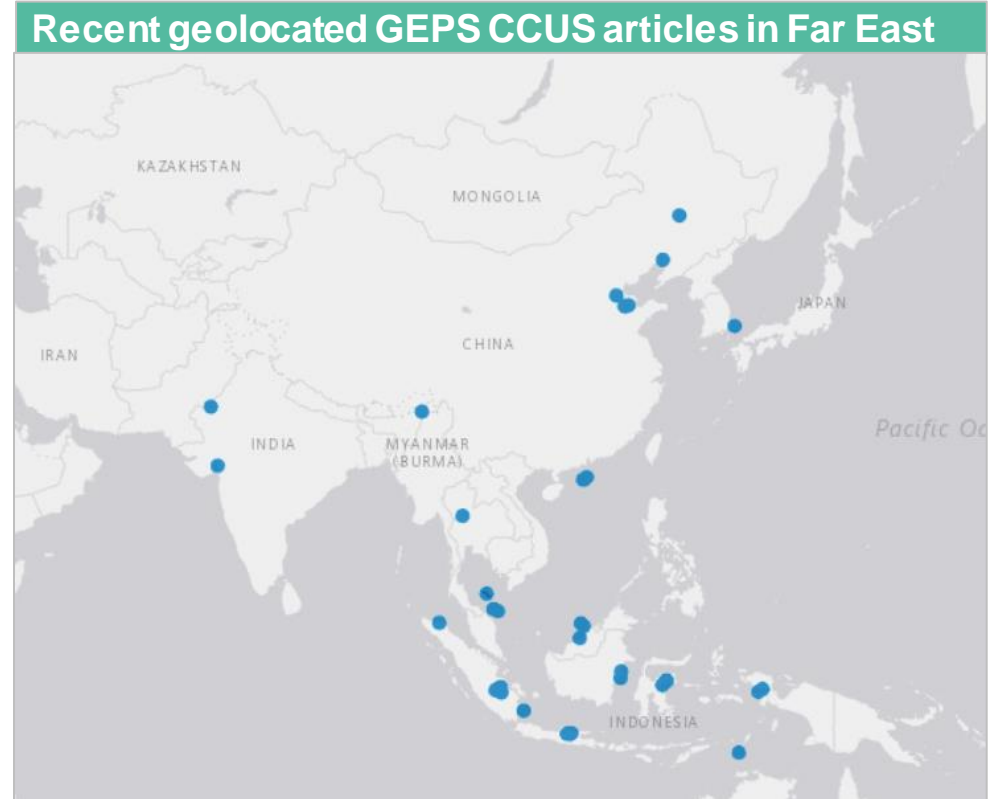
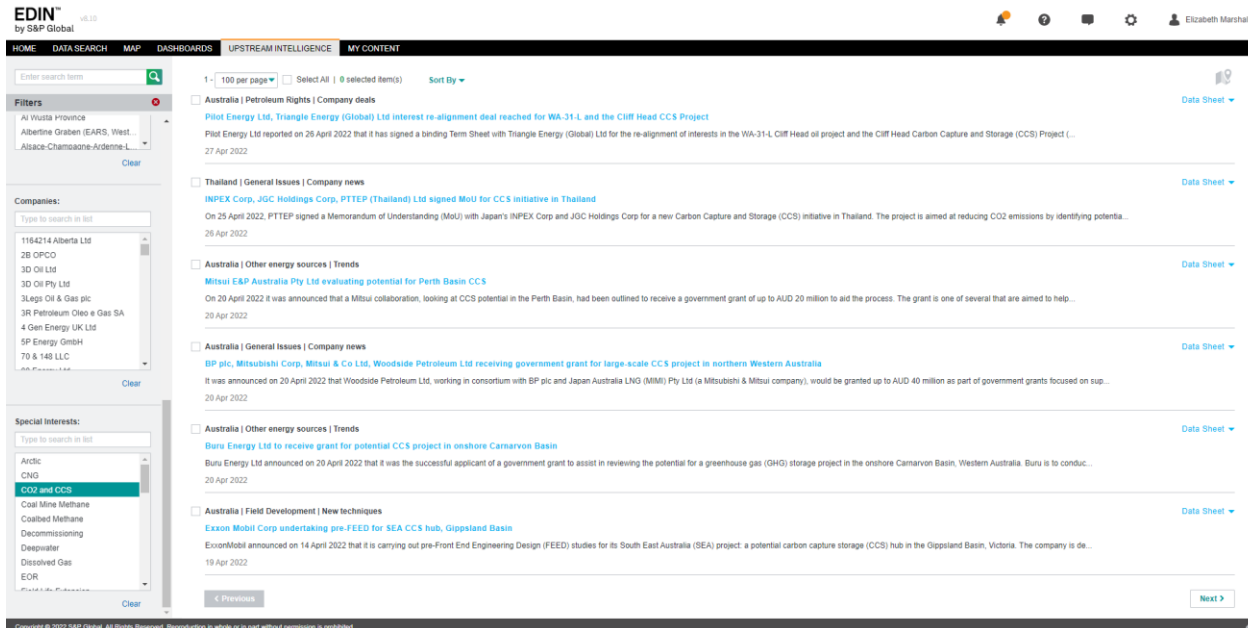
28 Apr 2022 Malaysia > Geology and Geophysics > Geophysical operations

Santos Ltd has been offered Block R from the 2019/2022 Timor Leste bidding round

- 8,000+ articles per year, by subsurface experts
- Reports – Monthly & annual by country and subject
- 500+ detailed, regularly updated high-res maps
- Unlimited direct connection to regional experts

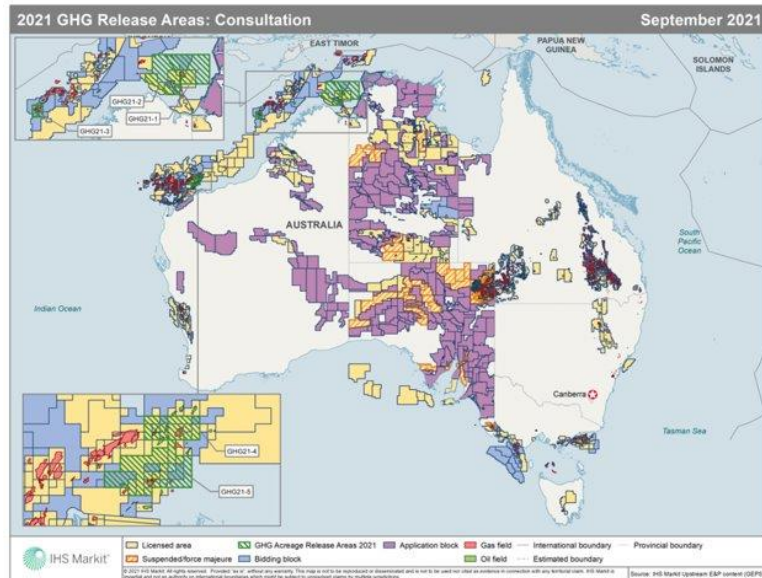
GEPS in EDIN Interface | Where are carbon storage activities taking place?

Articles can be easily filtered using the CCS Special Interest filter

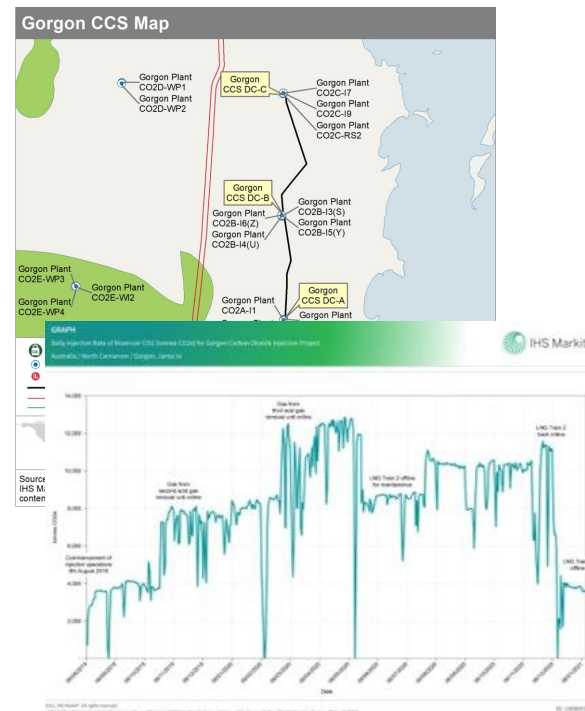


EDIN | Where are carbon storage activities taking place? Any key lessons from ongoing or previous projects?

Examples in Australia



Current CCUS licensing activity



Moonie West 1 Well | Summary Report

Table of Contents

General Well Data

Top Depth Meter	Bottom Depth Meter	Geological Data Type	Lithostrat Unit	Age Old-Young	Lithologies
0		Horizon	Blythesdale Group	Barremian	sandstone
1200		Horizon	Gubbermunda Sandstone Formation	Berriasian	siltstone
1400		Horizon	Westbourne Formation	Lower Tithonian	mudstone
1600		Horizon	Wailon Coal Measures	Carboniferous	sandstone
1850		Horizon	Hutton Sandstone	Bathonian	sandstone
2100		Horizon	Evergreen Formation	Toarcian	quartzose sandstone
2250		Horizon	Precipice Sandstone	Hettangian	quartzose sandstone

General Well Remarks

Carbon Transport and Storage Company (CTSCO) reported that the company had drilled West Moonie 1 well within EPIQ 10 permit in August 2020. The well was cased and suspended as a future injection well due to high potential of CO2 at this location.

The operator estimated the volume of GHG storage capacity of the Precipice Sandstone within the permit based on the following assumptions:

Pore Volume:

The operator believed the Precipice Sandstone depth greater than 800mGL (below ground level) with minimum and maximum depth around 1,670mGL and 2,660mGL with a mean mapped depth of 2,340mGL.

The operator assumed that CO2 to be within a supercritical state at a depth greater than 800mGL. However, given that the CO2 plume will move after supercritical CO2 has been injected, all the pore volume within the Precipice Sandstone at the permit been considered.

As permit area of 3,664 sq km with average thickness of 75m, average net to gross at 100% and average porosity of 13%, the operator estimated total pore volume equal to 35,724Mm³.

The operator also calculated that maximum stored CO2 volume around 1,826 Mm³tonnes using numbers of parameters as below:

- Maximum amount of CO2 that can be dissolved in the Precipice connate water (p, T) around 27.3 scm³/m³
- Average conditions for the Precipice: p=3.210 psia, t=100 C from the CO2 brine PVT
- FVF= 0.0035 Rm³/Sm³
- Average density for the Precipice equal to 0.535 tonnes/m³

Thus, maximum dissolved CO2 equated to 0.995 Rm³/Sm³.

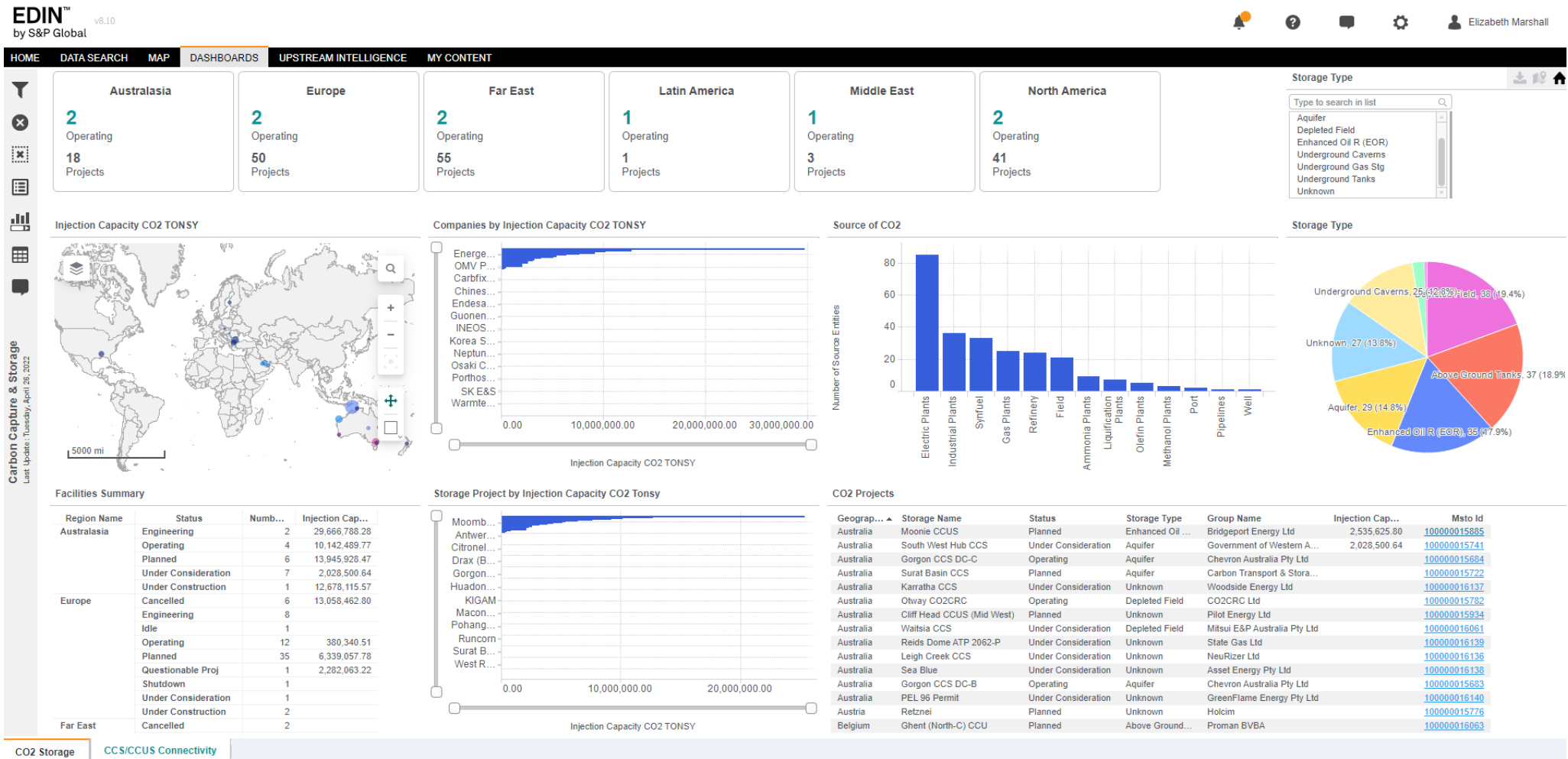
Estimation of effective storage capacity at low estimation equal to 183 Mm³tonnes, mid equal to 457 Mm³tonnes and for high estimation at 730 Mm³tonnes.

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Capturing CO2 pilot/exploration well details

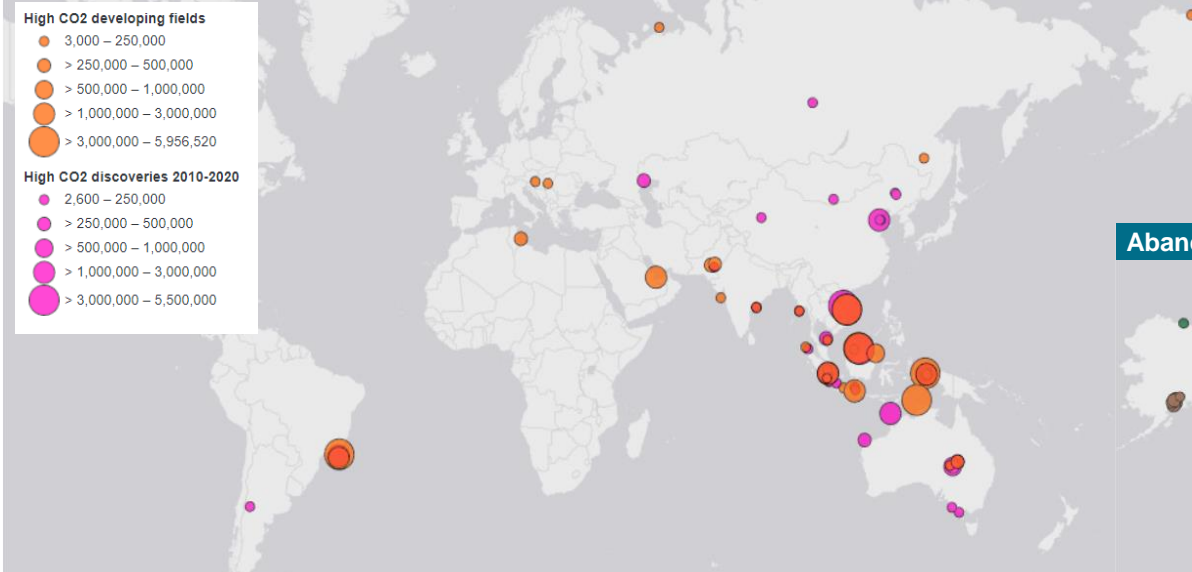
- New data flag identifies if a field has an event relating to "Carbon Capture" and/or "CO2 Producer"
- Recovery type to identify case study fields for CO2 EOR
- More commentaries, images related to CCUS/CCS

EDIN | CCUS Storage project list available via EDIN dashboard



EDIN | Where are high CO2 source fields or abandoned fields which may be candidate reservoirs?

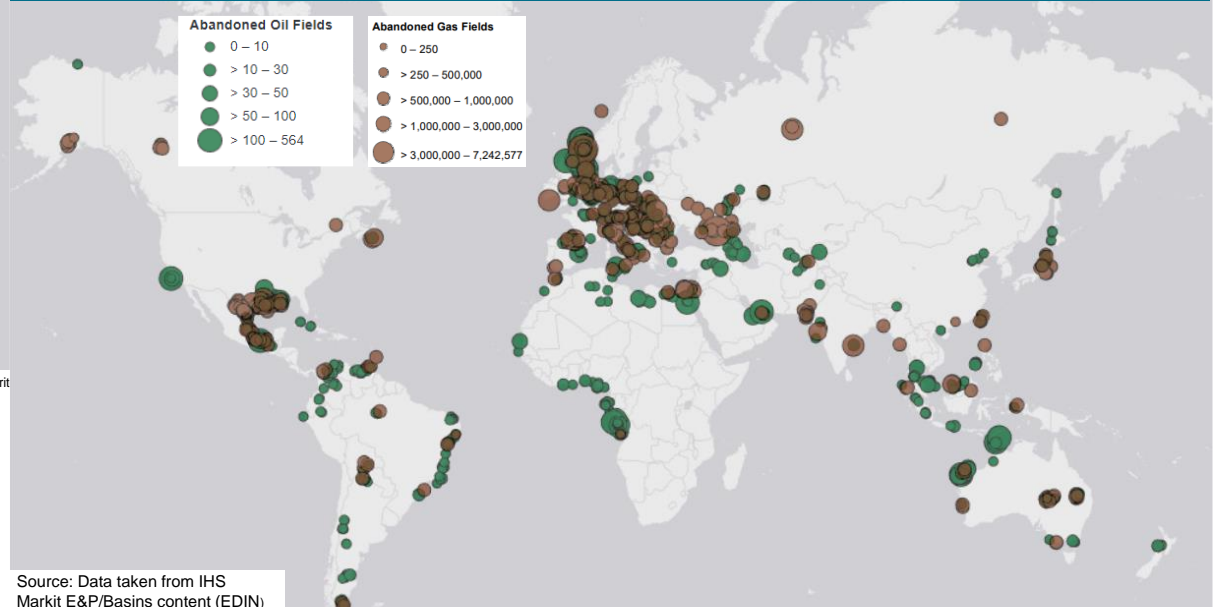
Recent gas discoveries and developing fields with more than 10% CO2 reported



Source: Data taken from IHS Markit E&P/Basins content (EDIN)

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Abandoned fields (reservoir depth >800m)



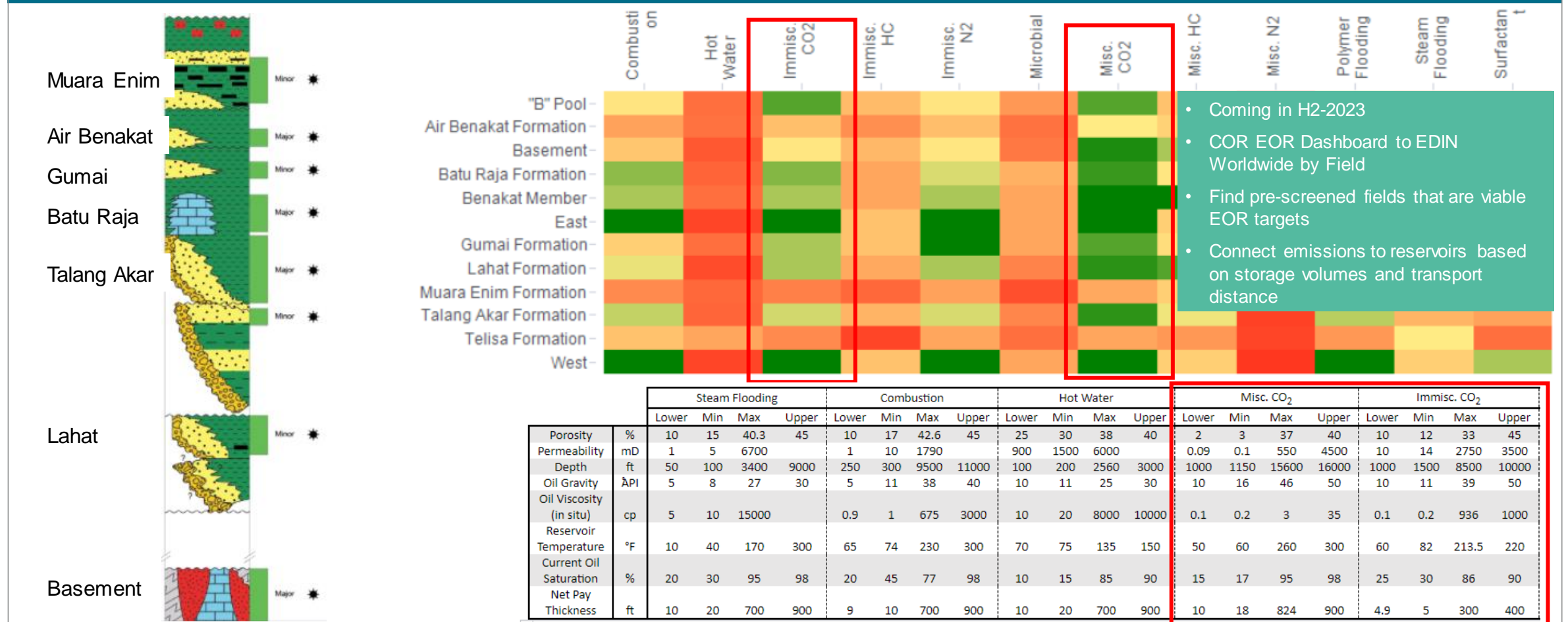
Source: Data taken from IHS Markit E&P/Basins content (EDIN)

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EDIN | Mature basins ideal for scoping CO₂ EOR

Subsurface parameters showcase good potential for CO₂ EOR in South Sumatra (57 oil reservoir units)

EDIN EOR screening tool applied to an Indonesian oil field example

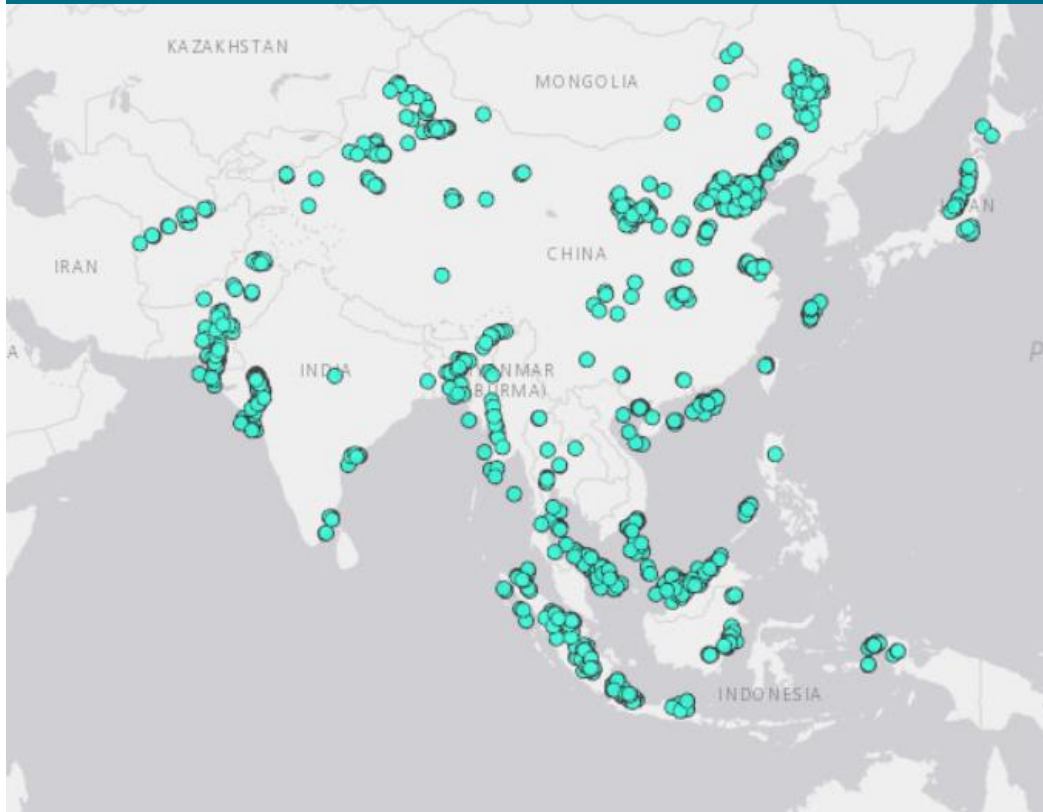


Source: IHS Markit EOR screening tool, data taken from IHS Markit upstream E&P/basins content (EDIN)

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EDIN | Use our new hydrocarbon significance of *aquifer* to identify target formations of interest

Far East fields with water drive mechanism



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- Synoptic basin analysis in digestible formats
- Updated with regular cadence
- Containing – structural setting, evolution, play and petroleum systems, source, reservoir, seal, exploration and development history.

HOME DATA SEARCH MAP DASHBOARDS UPSTREAM INTELLIGENCE MY CONTENT

Saved Searches My Searches Colleagues Shared Searches Domain Subject
 *Basins | Saline Aquifer | Wonnerup Member Basins Lithostrat Units

Global Filters

- Region
- Basin
- Country/Territory
- Company
- Contract
- Block
- Field
- Situation
- Lithology
- Lithostrat Unit
- Name
- Date

Template Filters

Add / Edit Template Filters...

Subject Filters

- Hc Significance
- Potential Aquifer
- Proven Aquifer
- Saline Aquifer

Add / Edit Subject Filters...

User Selection

Browse List selected items: 0

Imported List of IDs

No of Imported IDs: 0

Browse List | Lithostrat

1 - 100 per page of 67 item(s) | 0 selected item(s) | Batch mode

Lithostrat Unit	Geography	Alternate Lithostrat Unit Name	Lithostrat Hierarc	Lithostrat Status	Parent Lithostrat Unit
<input type="checkbox"/> C10.2 Unit	Algeria		Informal Unit	Informal	Gres de Kahla Formation
<input type="checkbox"/> Barracouta Formation	Australia		Formation	Formal	Hallbut Subgroup
<input type="checkbox"/> Dupuy Formation	Australia		Formation	Formal	
<input type="checkbox"/> Evergreen Formation	Australia		Formation	Formal	
<input type="checkbox"/> Lesueur Sandstone	Australia		Formation	Formal	
<input type="checkbox"/> Paaratte Formation	Australia		Formation	Formal	Sherbrook Group
<input type="checkbox"/> Precipice Sandstone	Australia		Formation	Formal	Bundamba Group
<input type="checkbox"/> Wonnerup Member	Australia		Member	Formal	Lesueur Sandstone
<input type="checkbox"/> Rio Bonito Formation	Brazil		Formation	Formal	Guata Group
<input type="checkbox"/> Basal Cambrian Sand	Canada		Informal Unit	Informal	
<input type="checkbox"/> Deadwood Formation	Canada		Formation	Formal	
<input type="checkbox"/> Nisku Formation	Canada		Formation	Formal	Saskatchewan Group
<input type="checkbox"/> Winnipeg Group	Canada		Group	Formal	
<input type="checkbox"/> Buxin Formation	China		Formation	Formal	
<input type="checkbox"/> Donggou Formation	China		Formation	Formal	
<input type="checkbox"/> Guantao Formation	China		Formation	Formal	
<input type="checkbox"/> Liujiagou Formation	China	Linjiagou Formation	Formation	Formal	
<input type="checkbox"/> Liushagang Formation	China		Formation	Formal	
<input type="checkbox"/> Majiagou Formation	China		Formation	Formal	
<input type="checkbox"/> Meishan Formation	China		Formation	Formal	
<input type="checkbox"/> Qianjiang Formation	China		Formation	Formal	
<input type="checkbox"/> Qingshankou Formation	China		Formation	Formal	Sonhuajiang Group

North America Data | Most comprehensive data-sets for both onshore and US Gulf of Mexico

Base Content

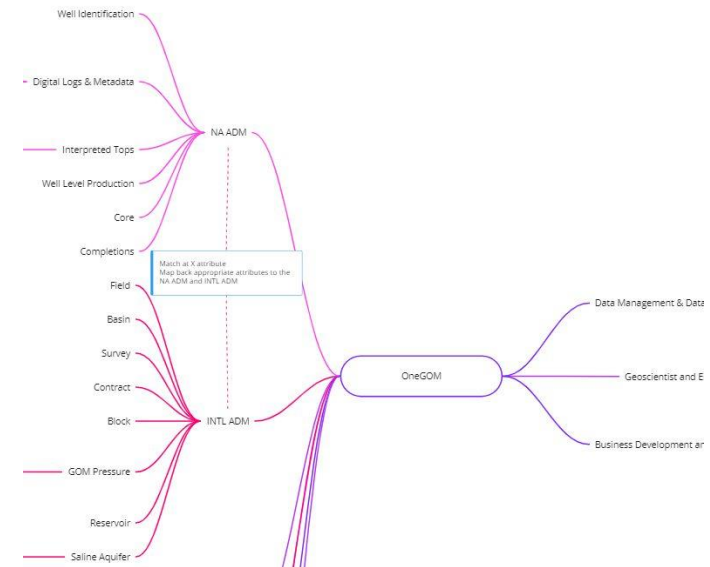
Historical to present well information

- Over 1,000 data attributes per well across 5+ million oil and gas well records in the United States
- API numbers for each wellbore and well event
- Over 3M producing entities, including many state regulatory agencies do not have record of allocated and unallocated
- Interpreted Tops (960k+ correlated wells; 20k wells per year)
- Structure Contours

Gulf of Mexico – Data Union

Coming H2-2023

- Unionizing legacy International E&P data model with North American data model with other additions.
- The integration will make it easier for Geoscientists, Business Development, and Data Managers

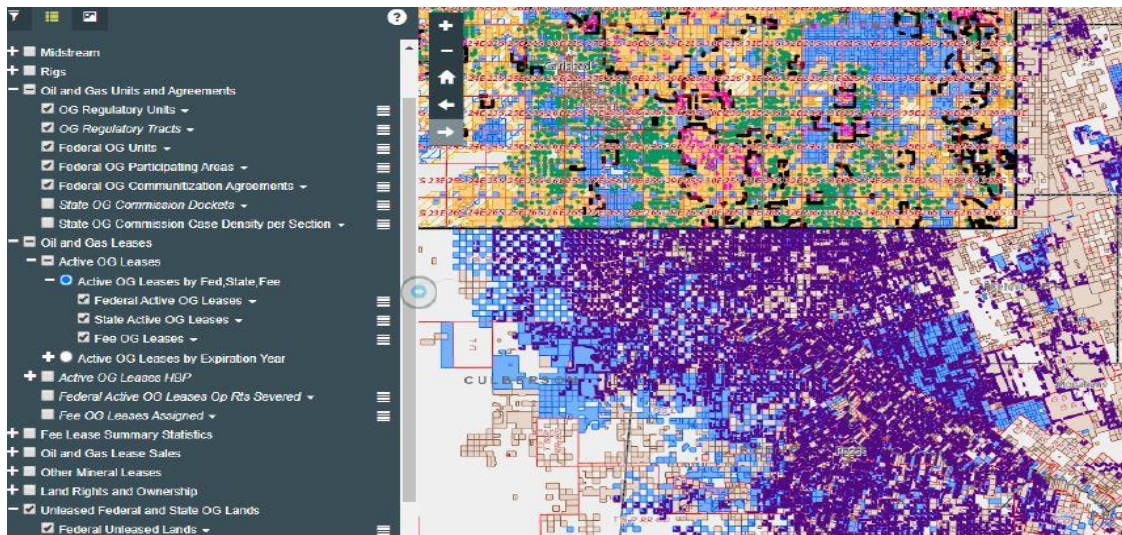


North America Data | Most comprehensive data-sets for both onshore and US Gulf of Mexico

Land and Locations

Most accurate well and lease acreage

- Fee leases (263+ counties, 70k+ unit w tracts)
- Fed and State leases (Units, unleased lands, lease sales)
- Identifies well spots tied to a US Land grid
- Integrates lease data and map coordinates
- Seamless 1":24,000' scale grid, referenced to NAD27
- Shapefiles and Geodatabase
- Survey framework includes lots, tracts, and special survey information
- Map coordinates updated daily



Impact

Advanced analytics-ready data across the full North America value chain

- Analytics-ready, normalized well & production data on the full history of wells, including 5 million+ wells in North America and every oil or gas producing entity, spud and permit over all time
- Derivative content including spacing, reserves, economics & forecasted production
- Acreage and Inventory data, including derived acreage ownership, quality and remaining inventory
- Rig data with history dating back to 2013; Midstream data covering pipelines and facilities
- Summary level transactions data



Sub-surface Analytics / Tools / Software

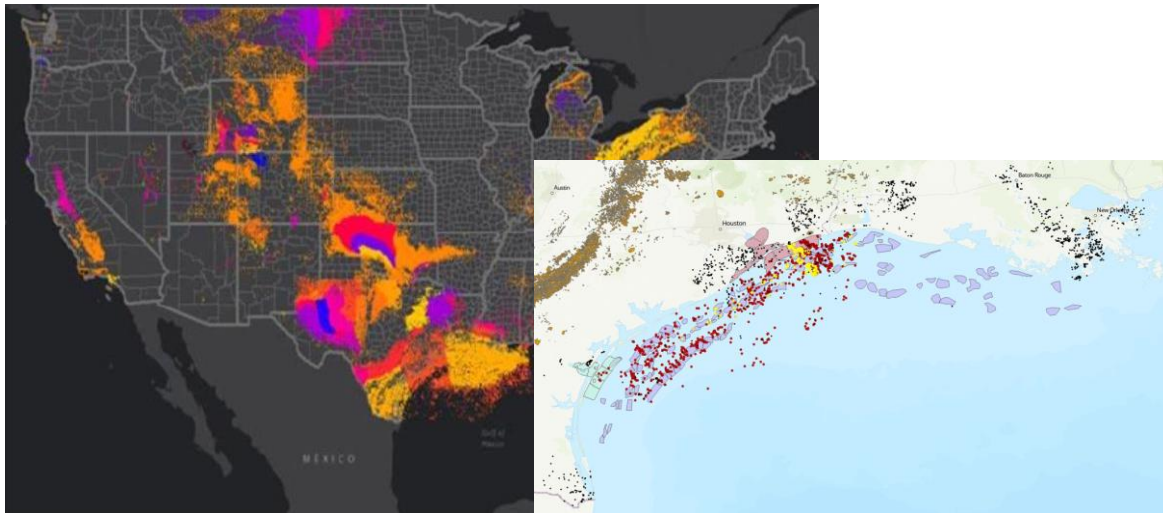


Analytics, Tools & Software | Digital Logs and Kingdom

Digital Logs

Digital Curve data with streamlined integration

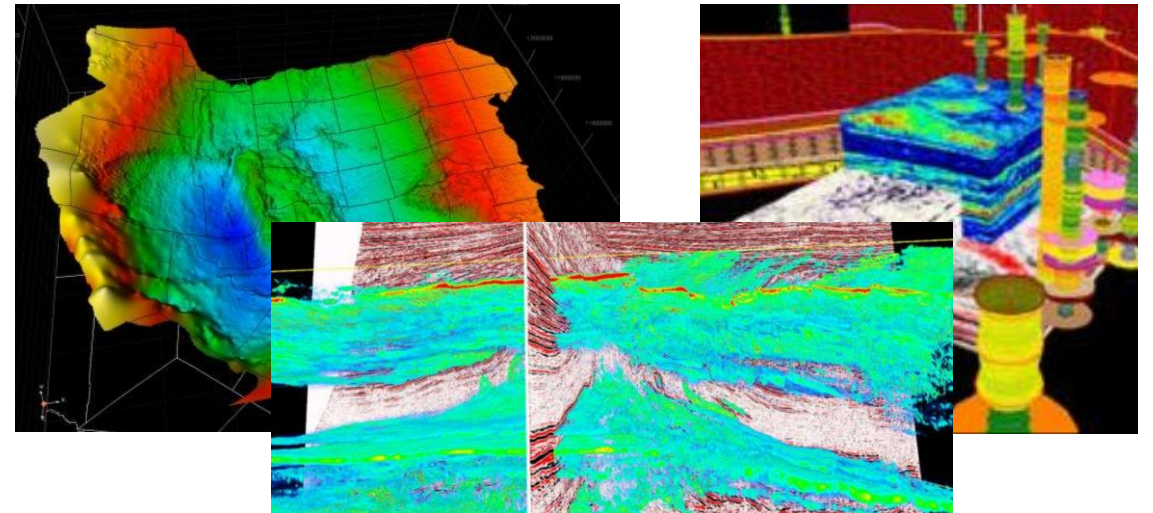
- Over 370,000 logs
- Improves
 - Stratigraphic models
 - Structural models
 - Depositional history
 - Reservoir models
 - Drilling and completions programs
- **New:** Infilling log digitalization in areas of CCUS interest; Derived Petrophysical Attributes (Vshale and Vclay)



Kingdom

Geological and Geophysical Interpretation Software

- Visualization and interpretation of 2D and 3D seismic data, pre-stack gather data and Microseismic data (Synthetic modeling, both 1D and 2D)
- Creating horizons and grids with flexibility provided by basic & advanced algorithms.
- Interpreting of faults and fractures, finding bright and dim spots, identifying geobodies with a suite of more than 50 seismic attributes, powered by multiprocessing Intel libraries and CUDA technology.
- In-depth analysis of identified structures with extended surface calculator functions.
- High-definition velocity modeling with uncertainty estimation. Efficiently creating accurate maps of the subsurface and quickly updating the well plans with the Dynamic Depth Conversion

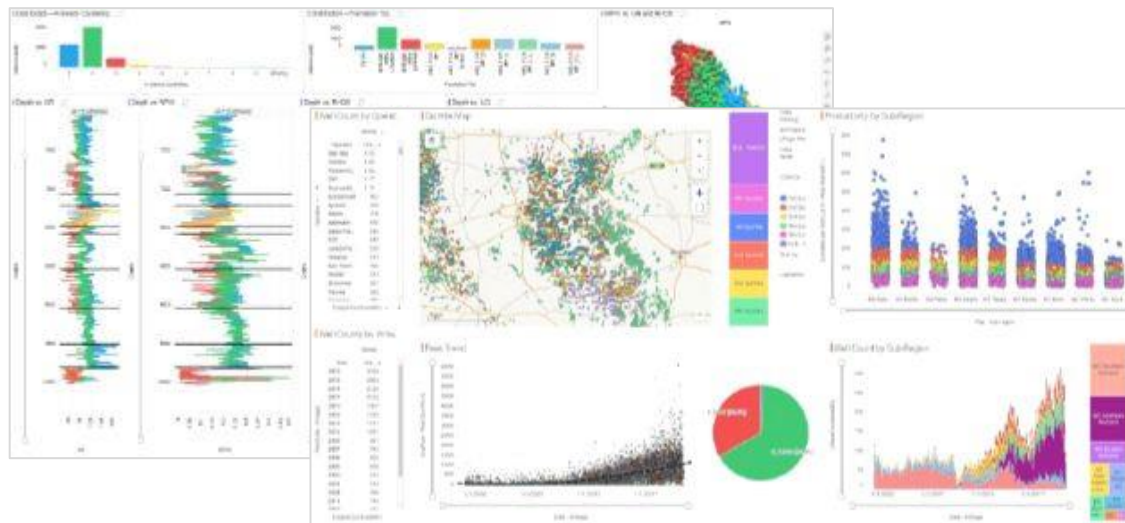


Analytics, Tools & Software | Analytics Explorer and Harmony

Analytics Explorer

Analytics tool integrated into our data, Kingdom, and Harmony suites to enhance your workflows and provide extra layers of intelligence

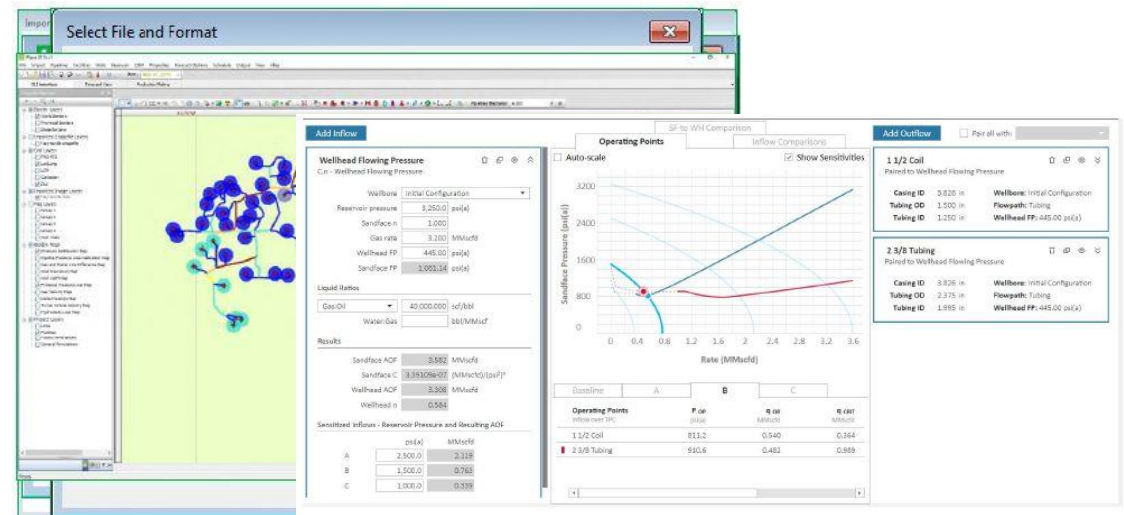
- Enhanced collaboration across disciplines
- Validation of results through the measurement and visualization of error metrics through our provided templates.
- Make better decision through reduced uncertainty and risk
- Optimization of data and analysis for reducing cost and improving efficiency.
- Improved business agility and responsiveness to market volatility.



Harmony

Reservoir engineering package to define injection and reservoir effects

- Well Test
- Pressure Gradient
- Flow Assurance
- Pipeline planning
- Multi-well injection
- Seamless loads
- Direct syncing with Kingdom Spatial Explorer

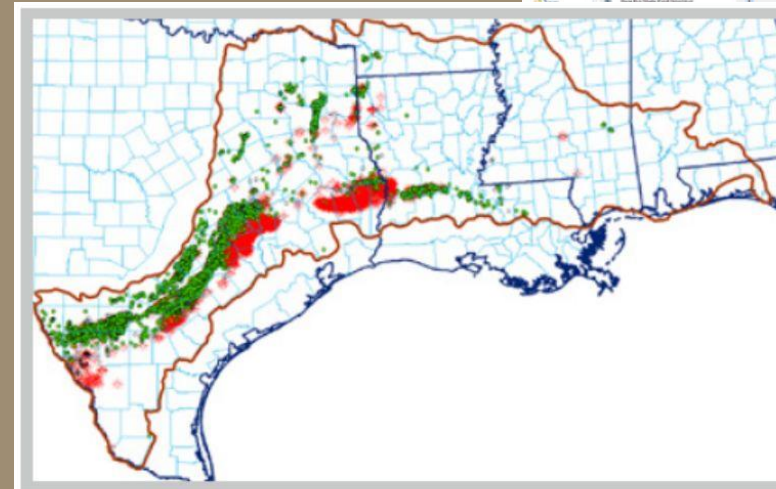
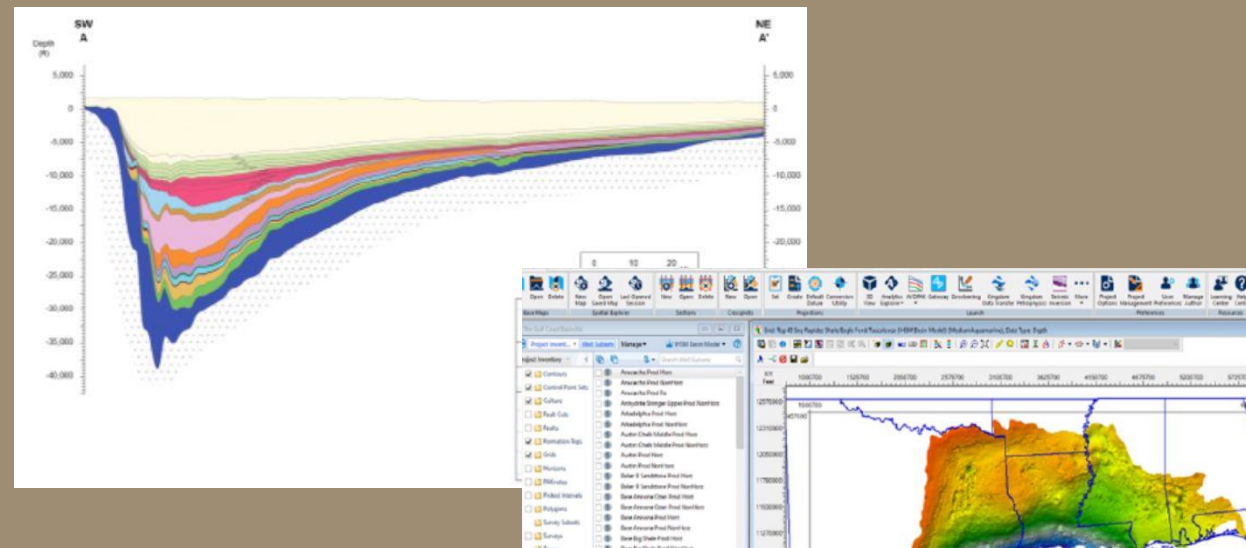


Projects / Case-Studies / Insights

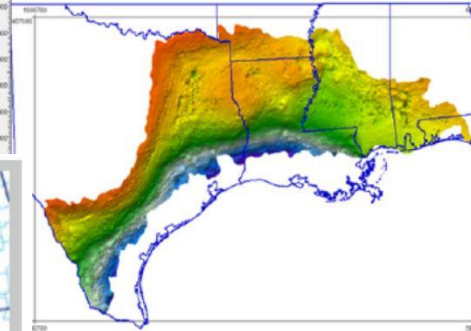


Kingdom Projects | Pre-built subsurface model – Gulf Coast, Permian, Anadarko

- 3D geological model over many formations from the Basement to the Upper viable formations, built from hHSM interpreted tops.
- Cleaned Wells, Interpreted Tops, Digital Logs and Allocated Production raw data.
- Various analytical data including Zones Attributes and GRID files, and the results of analyses of numerous continuous and non-continuous plays
- Incorporates PRODFit (Producing Formation from Interpreted Tops), an enhanced well database.
- Objective is to provide a basic readymade geological platform, raw data, and derived data for any further work on any area of interest within the basin where users can readily incorporate their proprietary data.
- Saves users hundreds of man hours required for data mining, population and collation.



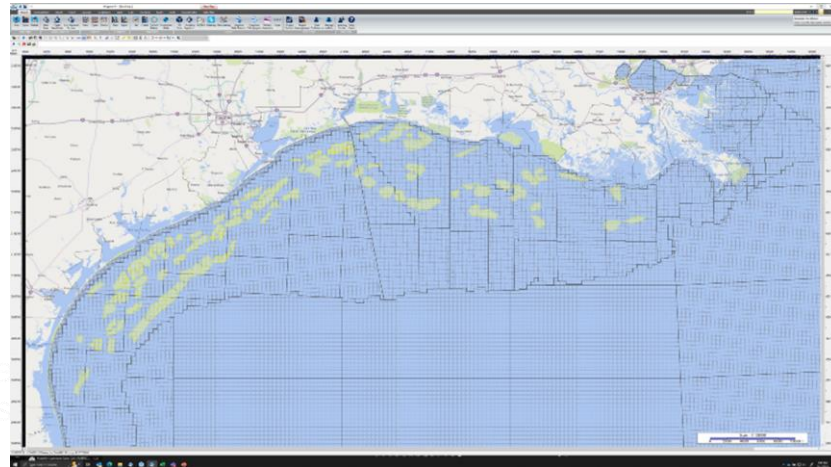
Strati-Structural (Non-Continuous) Play example derived from The Gulf Coast Kingdom™
Project: Austin Play



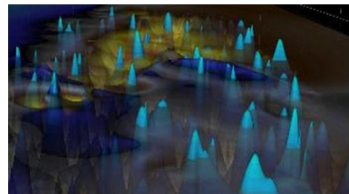
Thermal maturity Play map example derived from The Gulf Coast Kingdom™
Project: Eagle Ford Shale

Kingdom Projects | Pre-built subsurface model – Gulf Coast, Permian, Anadarko

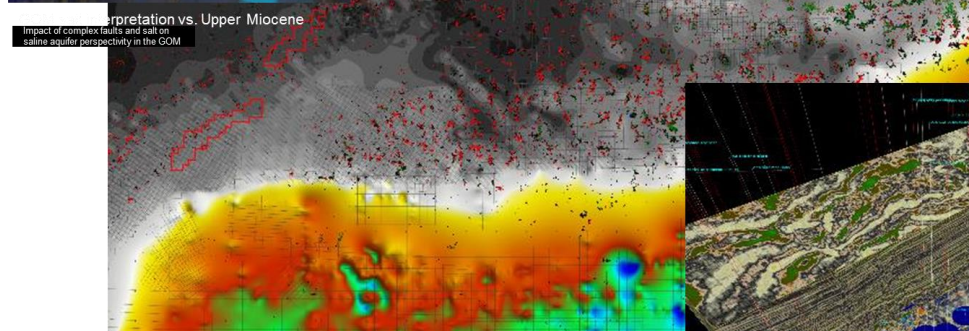
Coming Q2 2023



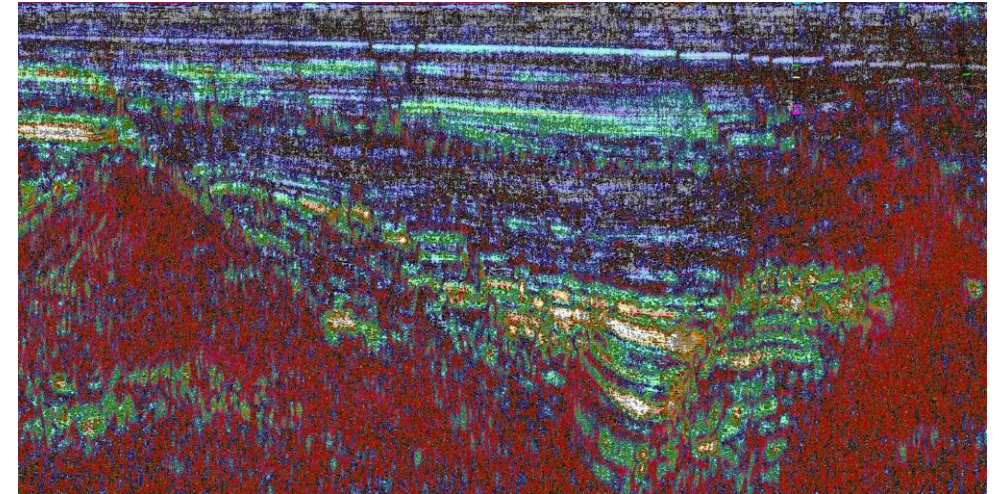
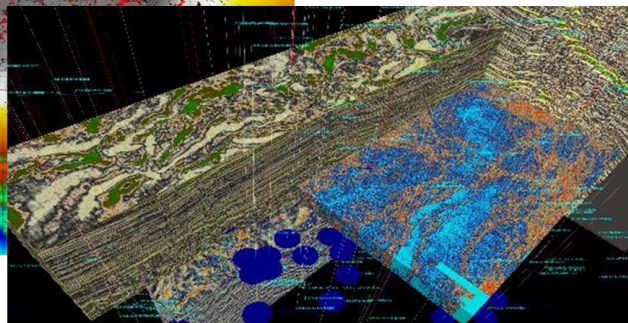
US GOM storage options: depth
A look at risks and opportunities



Impact of key risks from abandoned wells and complex geology

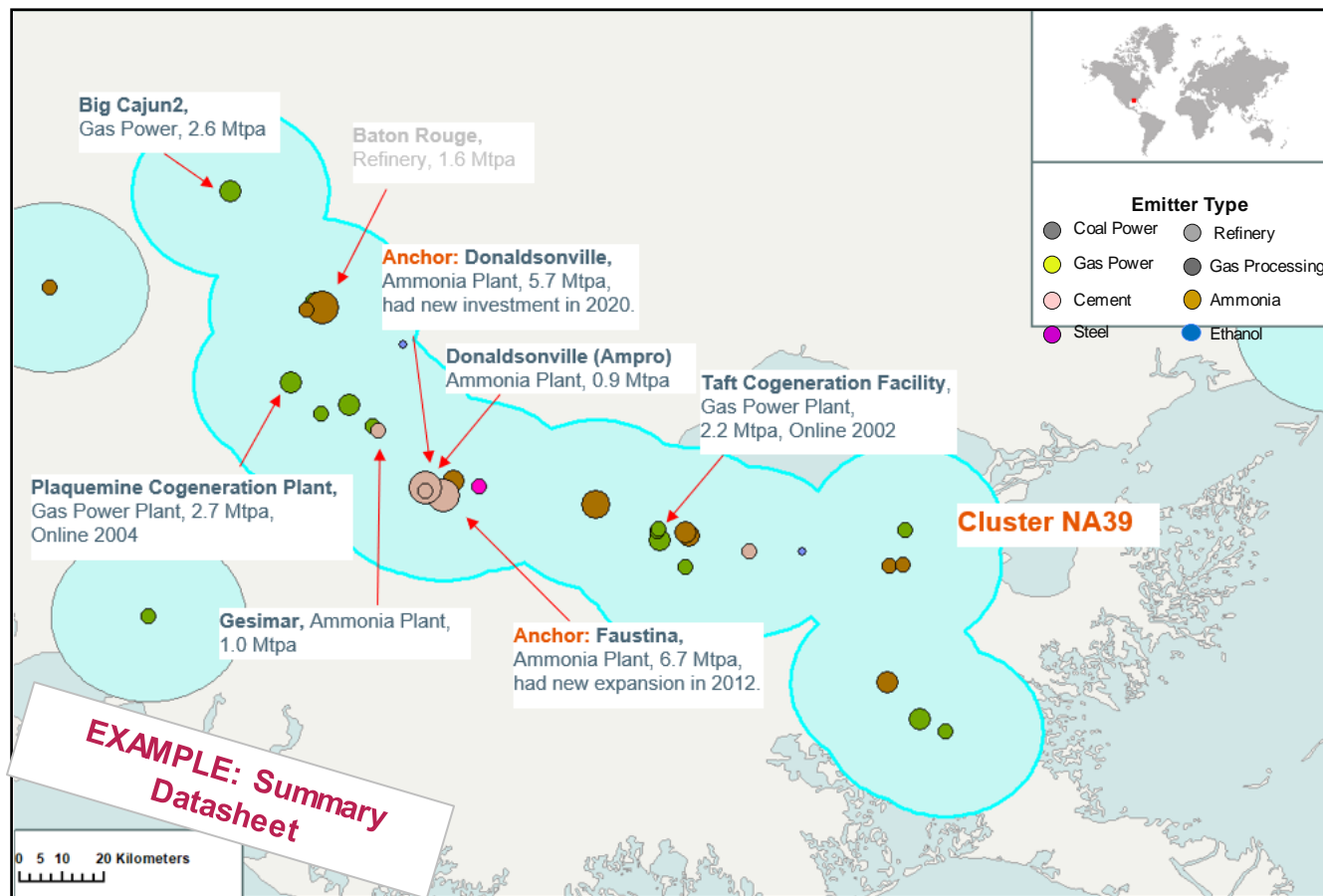


Interpretation vs. Upper Miocene
Impact of complex faults and salt on saline aquifer permeability in the GOM



- 6+ TB Kingdom project
- Save months of work
- Loaded with publicly available 2D and 3D seismic

US Gulf | Emissions Corridors a key starting point in building a CCUS business



*Economically Capturable Volume

** Assumes existing wells have been adequately P&A'd by previous operator to prevent CO2 leakage

***Project life extends beyond the capacity of the two reservoirs, therefore injection assumed to continue into the aquifer later in the field life. It is assumed the wells drilled into the initial sink (Block 0014) will be side tracked and recompleted to the aquifer depth. Includes allowance for spare injectors to facilitate testing, maintenance and loss of injectivity

Foundational emitters for hub development (available volume 23.4 out of 43 Mtpa, hub designed volume 20 Mtpa)

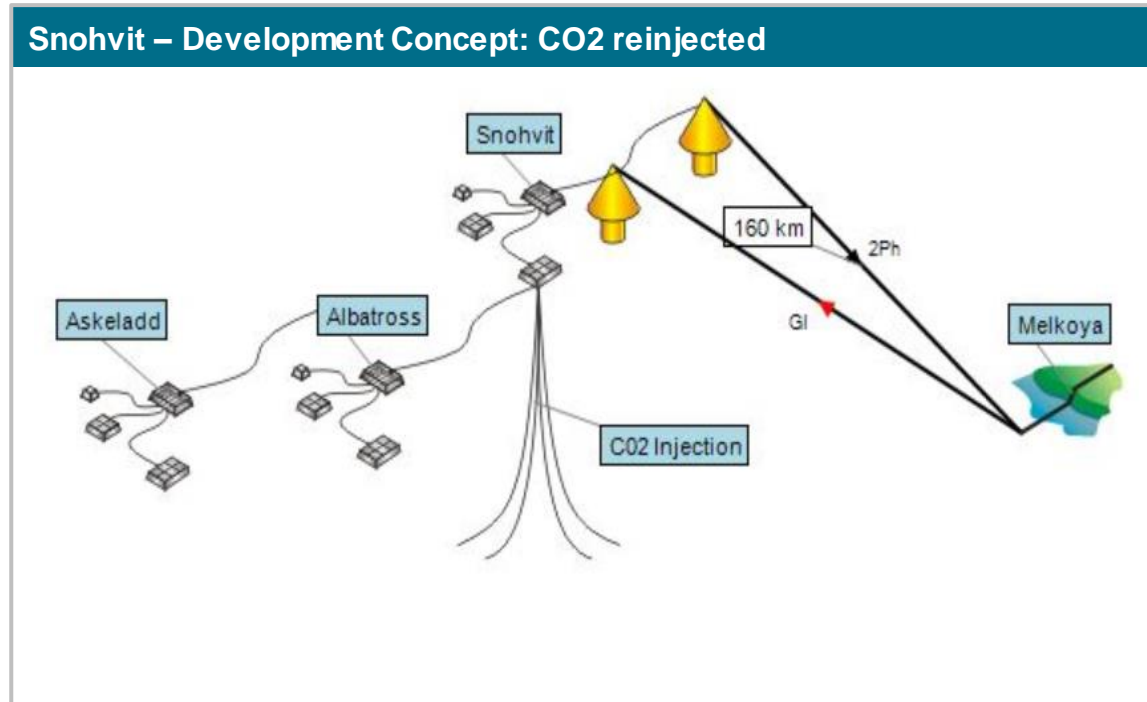
Plant Name	Plant Type	Emission (Mtpa)*	Capture Cost (\$/t)
Faustina	Ammonia	6.7 (6.7)	10-30
Donaldsonville	Ammonia	5.7 (5.7)	10-30
Geismar	Ammonia	1.0 (1.0)	10-30
Donaldsonville (Ampro)	Ammonia	0.9 (0.9)	10-30
Plaquemine Cogeneration Plant	Gas Power	2.7 (1.9)	70-90
Big Cajun2	Gas Power	2.6 (1.9)	70-90
Taft Cogeneration Facility	Gas Power	2.2 (1.9)	70-90
Baton Rouge	Refinery	1.6	70-90

Hub Development – Fact Sheet

Item	Description	Item	Description
Injectivity	1Mtpa / well High	# boosting stations	1 comp hub at Donaldsonville
# wells	25inj*** + 5 monitor per sink	Size of storage	N/A
Onshore pipeline (km)	2x5-10km + 1x60-70km gathering. 1x~200km export	Appraisal	N/A
Offshore pipeline (km)	~10km plus 20km to offshore sinks	Ancillary infrastructure	Power from grid (unlikely renewable 30%) short road to plant
# pipelines	3 gathering, 2 export	Use existing facilities	No**. Use of existing pipeline corridors
Hub volume	20Mtpa	Ramp-up (amount and years)	Yr 1: 6.7Mtpa Yr 2: 14.3Mtpa Yr 3: 20Mtpa
Hub Life	20 years		

Saline aquifer lessons | Norway's Snohvit CCS Project

With 5-8% CO₂, Snohvit was the second large scale CCS project to be implemented on the NCS. Secondary storage formation utilized. Key enabler – carbon tax avoidance.



Snohvit: Impact of CO₂ Injection (Lifecycle costs in real 2021)

CAPEX (MM USD)	4,104
Lifecycle OPEX (MM USD)	11,514
CO ₂ Content (%)	5-8
CO ₂ emissions (Mte)	141,918
CO ₂ intensity (kg/boe)	0.58
Breakeven gas price (\$/Mcf)	~\$2

Source: Data taken from IHS Markit Upstream E&P content (Vantage)

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Current Value:

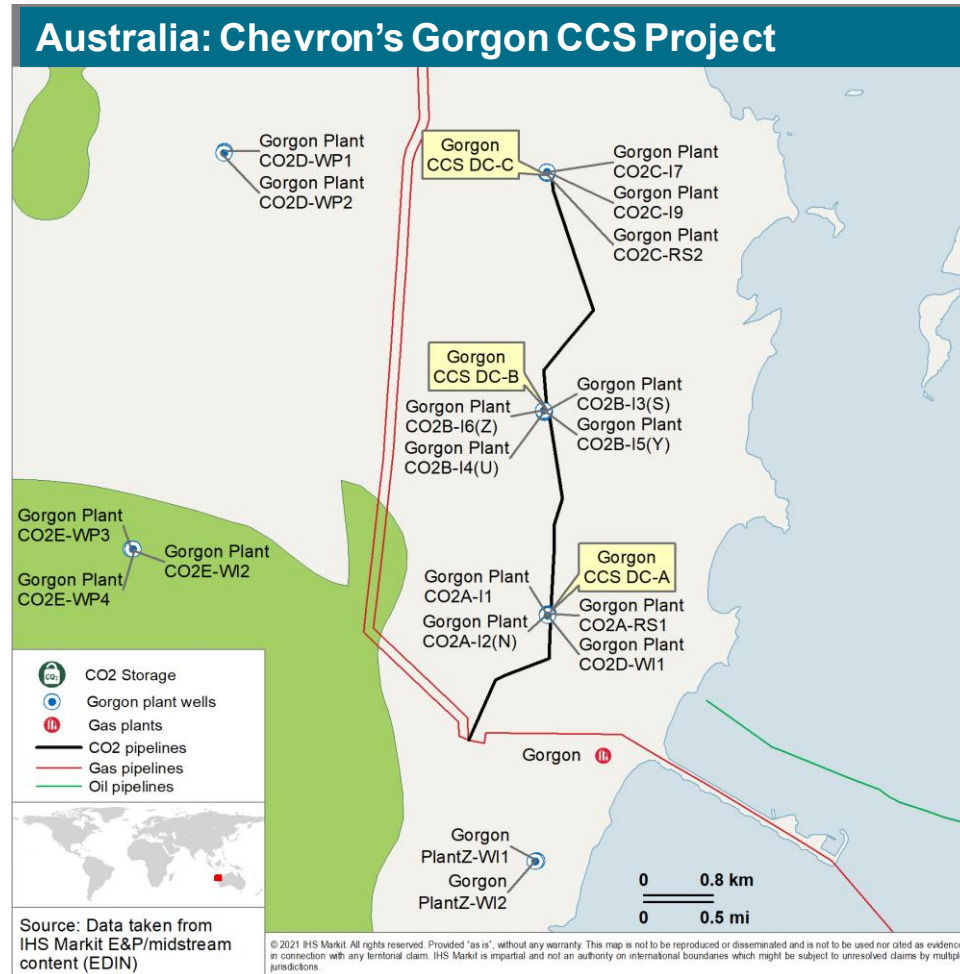
- Point Forward AT NPV = \$3,900 MM (@67/bbl)

Cost benefit analysis:

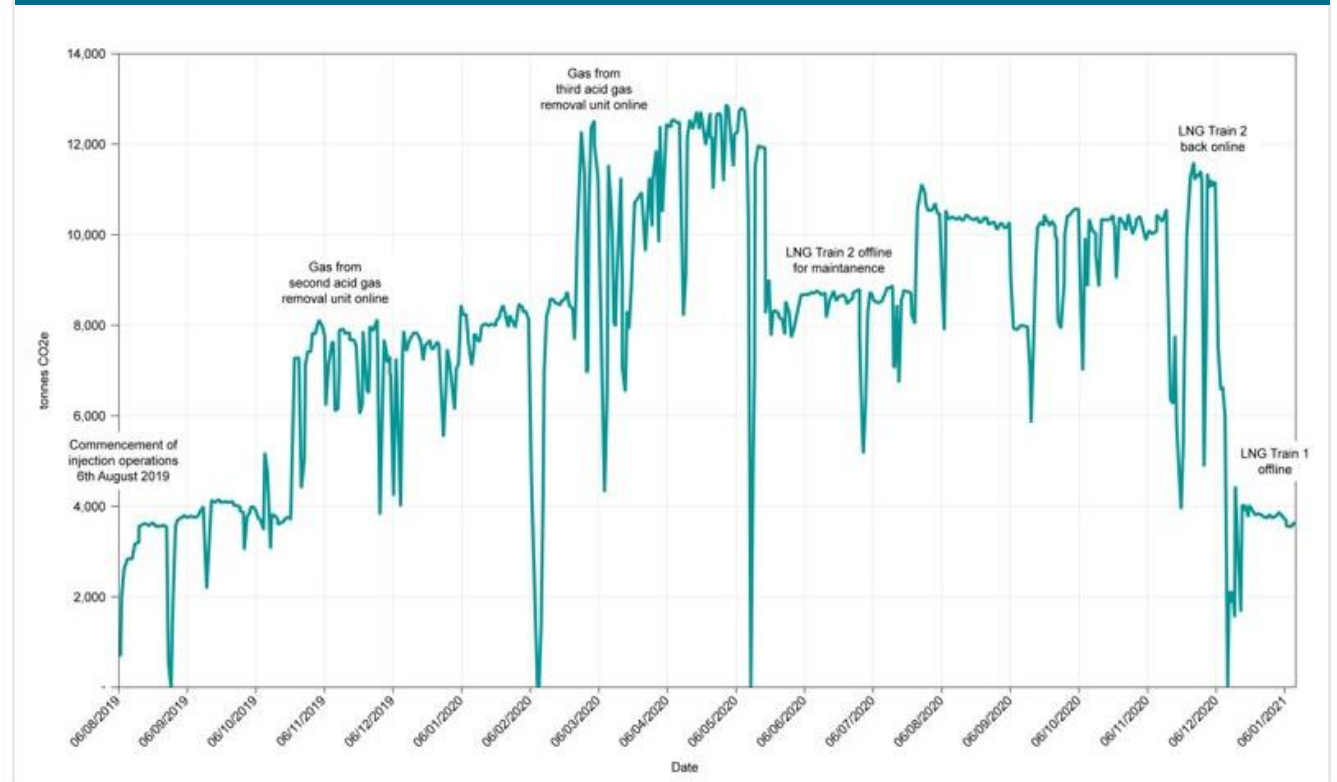
- Historical CO₂ tax avoided by reinjection (MM USD) = 470
- Future CO₂ tax savings (MM USD) = 454 (@ NOK 590/tonne)
- Future savings after CO₂ tax increases by 2030 (MM USD) = 2,150 (@ NOK 2000/tonne)

Saline aquifer lessons | Chevron's Gorgon CCS project in Australia

Start-up and operational challenges encountered but has injected more than 6 million tonnes of CO2 into the Dupuy Formation (2,500 m)



Australia: Daily Co2 injection at Chevron's Gorgon CCS Project

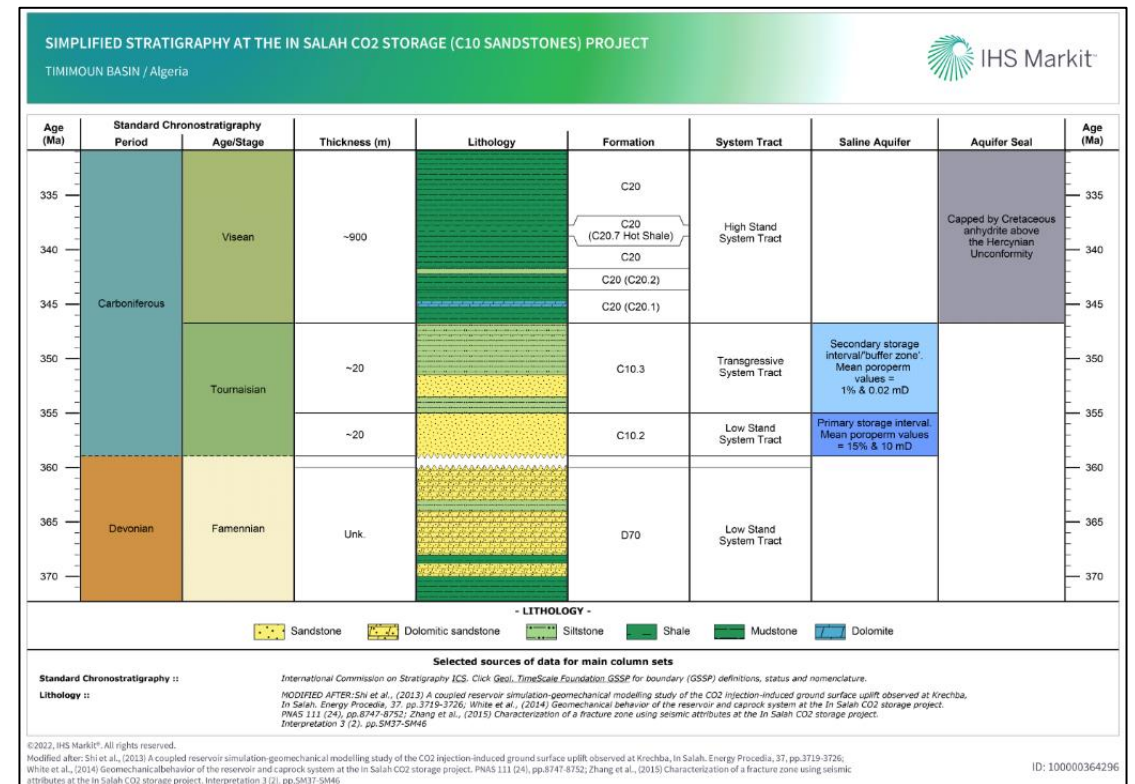
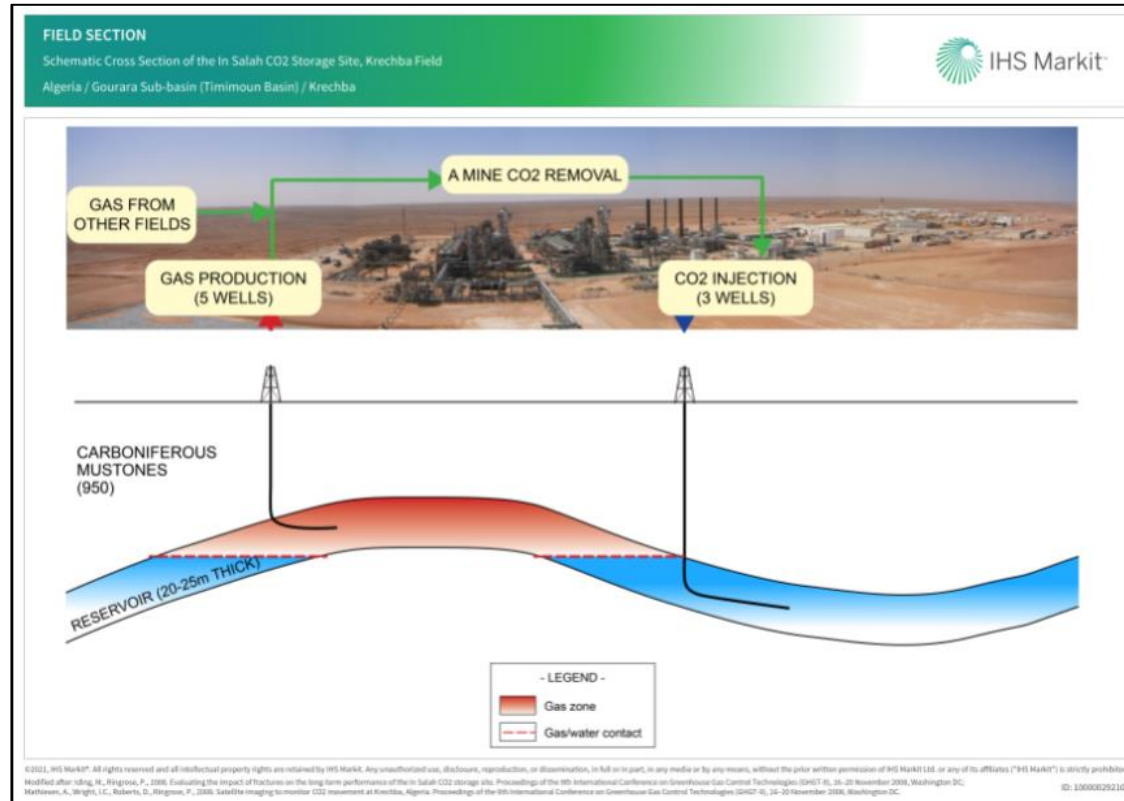


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Modified after: Chevron Australia, Developing the world's largest CO2 injection System - a history of the Gorgon Carbon Dioxide Injection System, Page. 10 (2021)

ID: 100000357733

Saline aquifer lessons | In Salah CCS project in Algeria

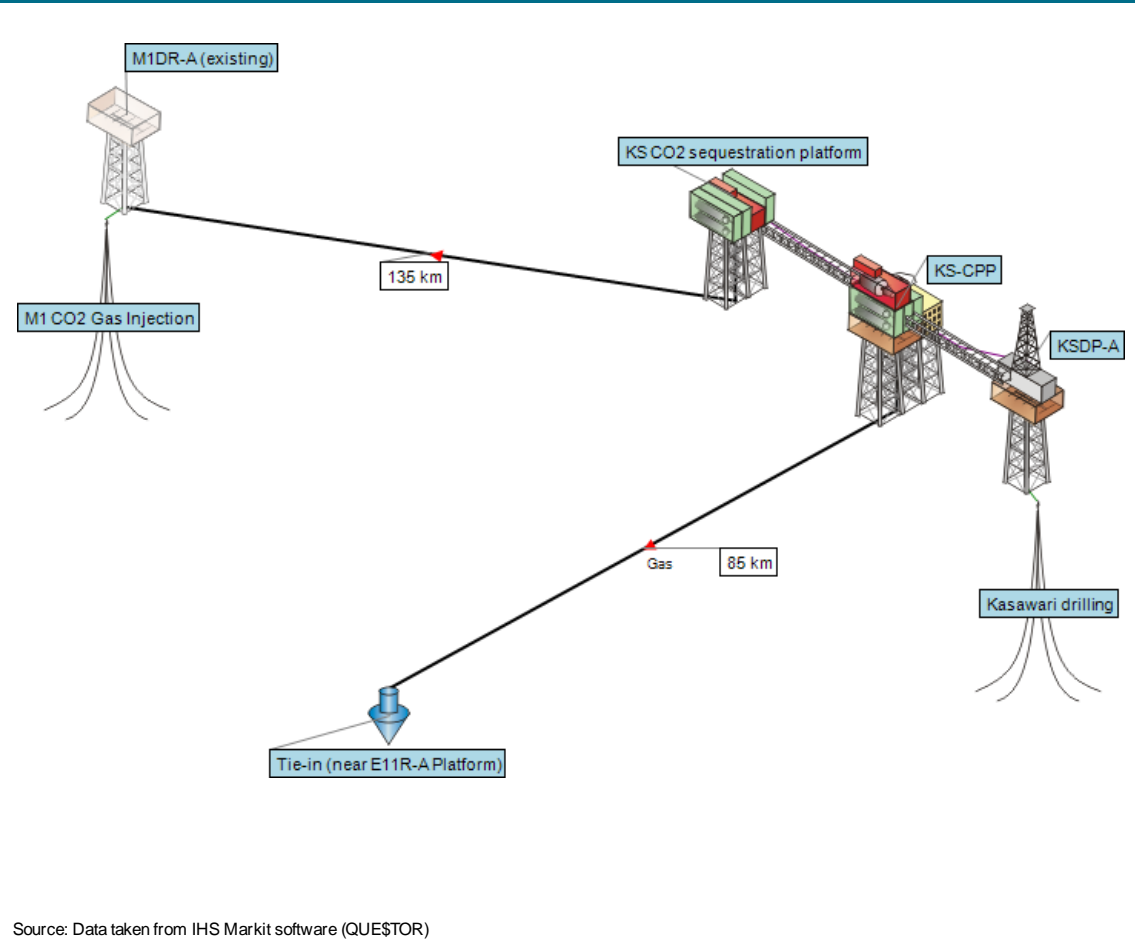
Injection from 2004 to 2011 stored 3.8MtCO₂. Lessons learned - potential migration of CO₂ to the north -outside of the hydrocarbon lease; leak detection of CO₂ in a well-head; and potential leakage to the caprock/seal



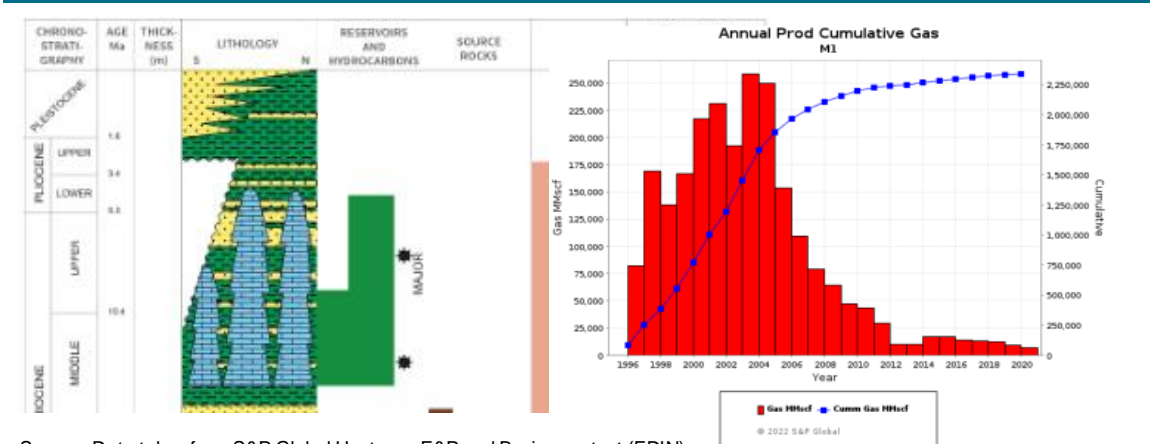
Malaysia | Petronas integral in country's push for net zero target

CCS hubs planned linked to key gas projects. Petronas' Kasawari Phase 2 development include CO2 storage at M1 field. First injection targeted in Q4 2025.

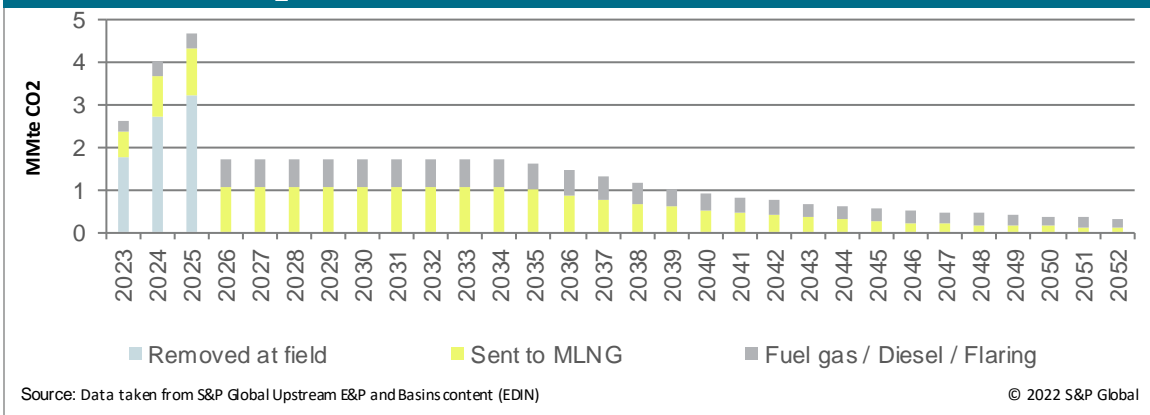
Kasawari – Phase 2 field development



M1 storage field



Kasawari - CO2 emissions estimates



Malaysia | The impact of including CCS on Kasawari

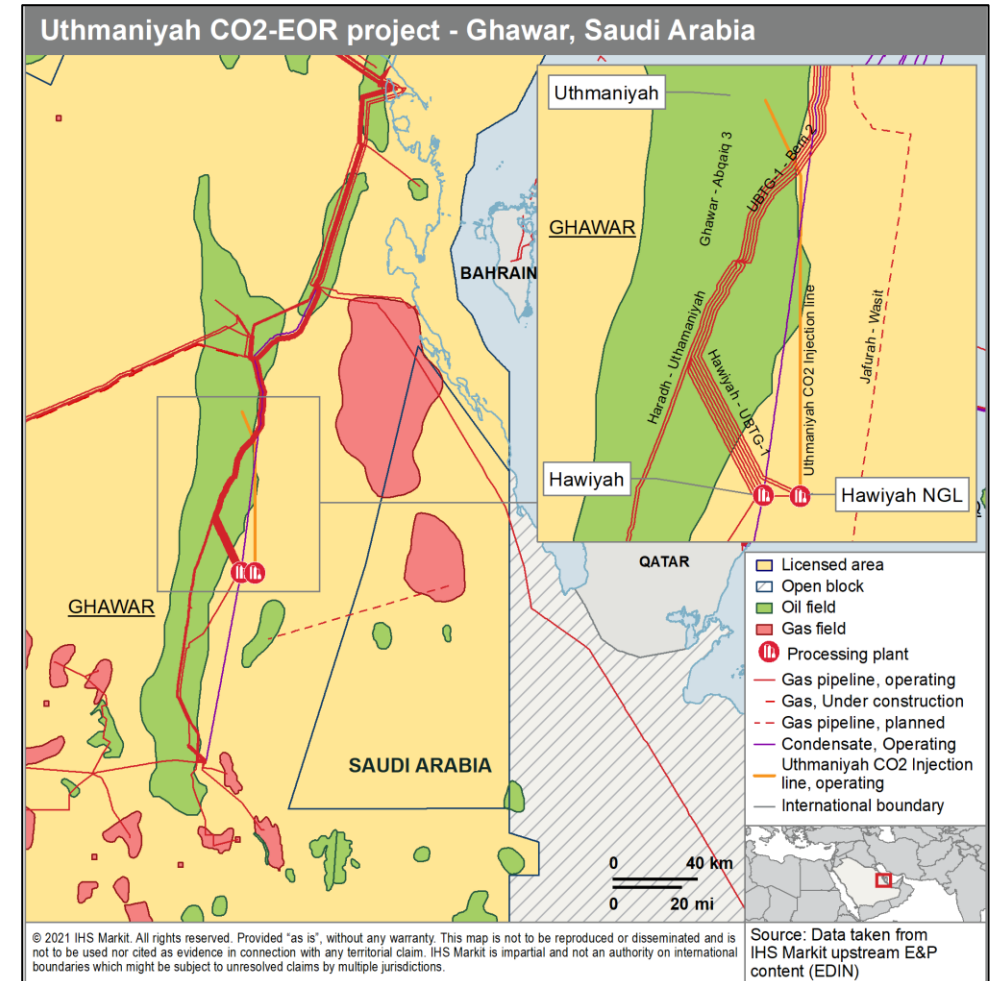
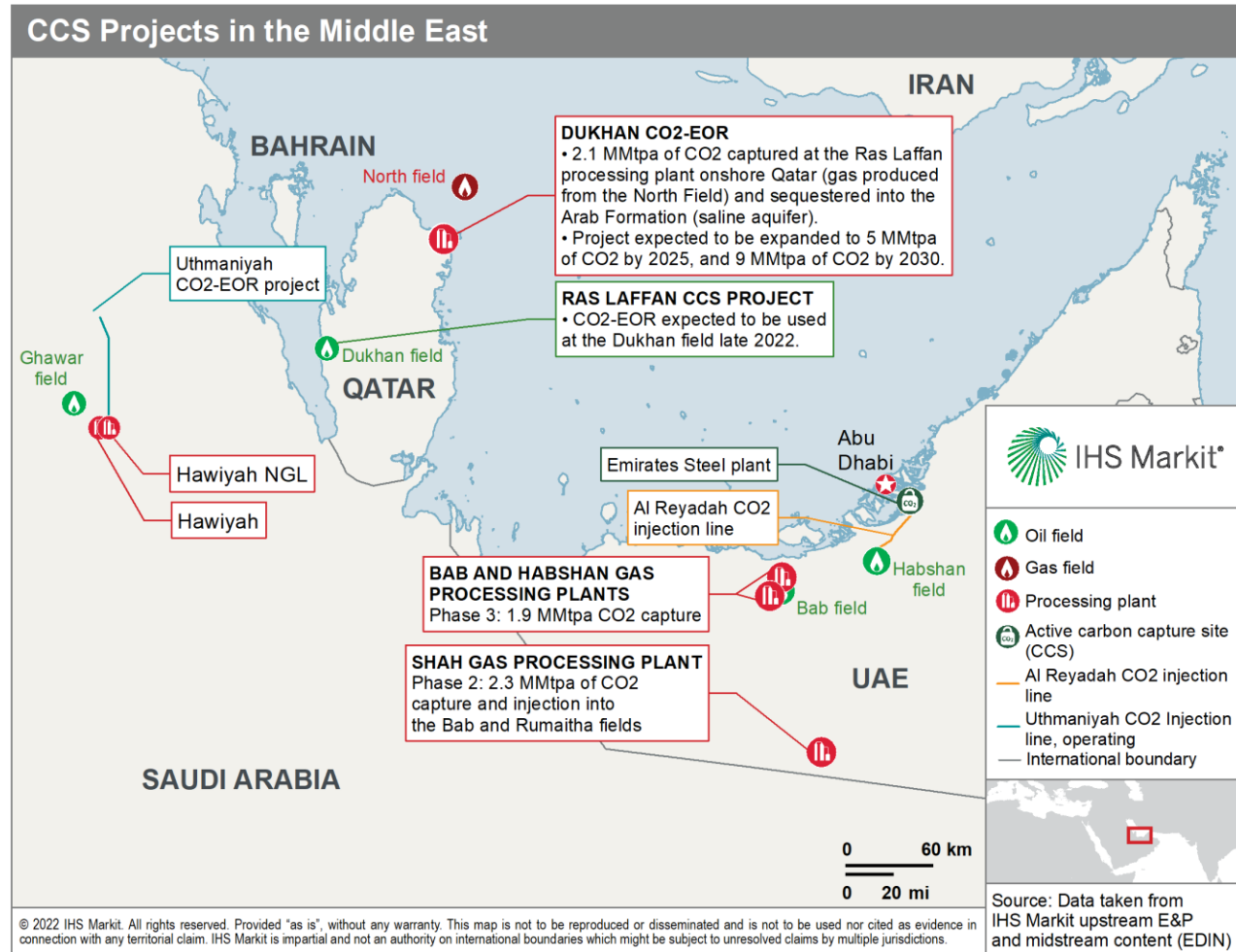
Significant reduction in emissions, but it comes at a cost to both PETRONAS and the Malaysian government

Impact of CCS on Kasawari project

No CCS		CCS	Difference	Difference (%)
6 Tcf	Recoverable reserves	6 Tcf	-	-
4.68 Tcf	Sales gas	4.68 Tcf	-	-
\$1,800	CAPEX (millions USD – Real 2021)	\$2,700	+ \$900	+ 50%
\$5,800	Lifecycle OPEX (millions USD – Real 2021)	\$7,900	+ \$2,100	+ 36%
67.1	Upstream CO ₂ emissions (million tonnes CO ₂ e)	21.0	- 46.1	- 69%
84.9	Upstream CO ₂ intensity (kg/boe)	26.6	- 58.3	- 69%
\$580	PETRONAS NPV10 (millions USD)	\$150	- \$430	- 74%
\$4,000	Government NPV10 (millions USD)	\$3,200	- \$800	- 20%
\$2.4	Breakeven upstream gas price (\$/Mcf)	\$3.3	+ \$0.9	+ 38%

Note: Economics undertaken at a Brent price of \$60/bbl, with an assumed upstream gas price of \$3.9/Mcf

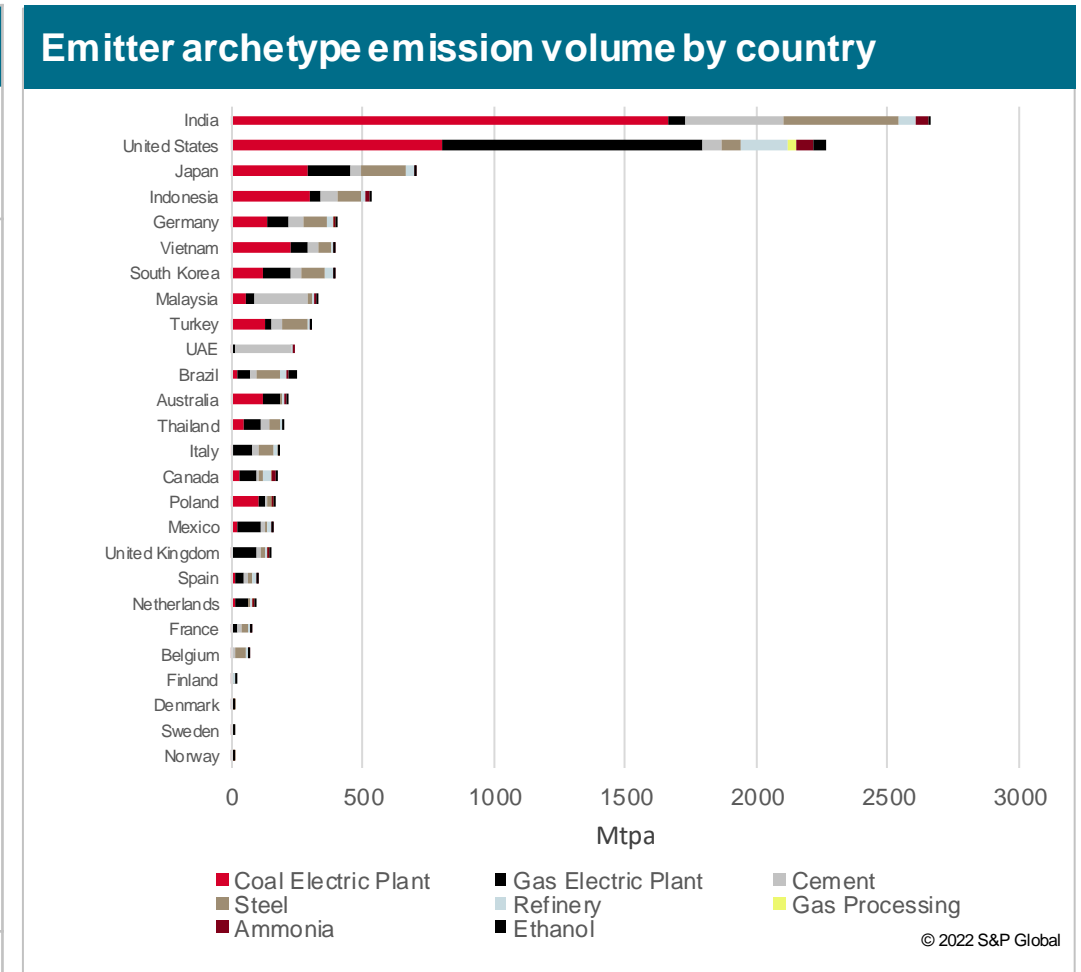
Middle East CCUS | UAE, Qatar and Saudi lead efforts to scale up capacity



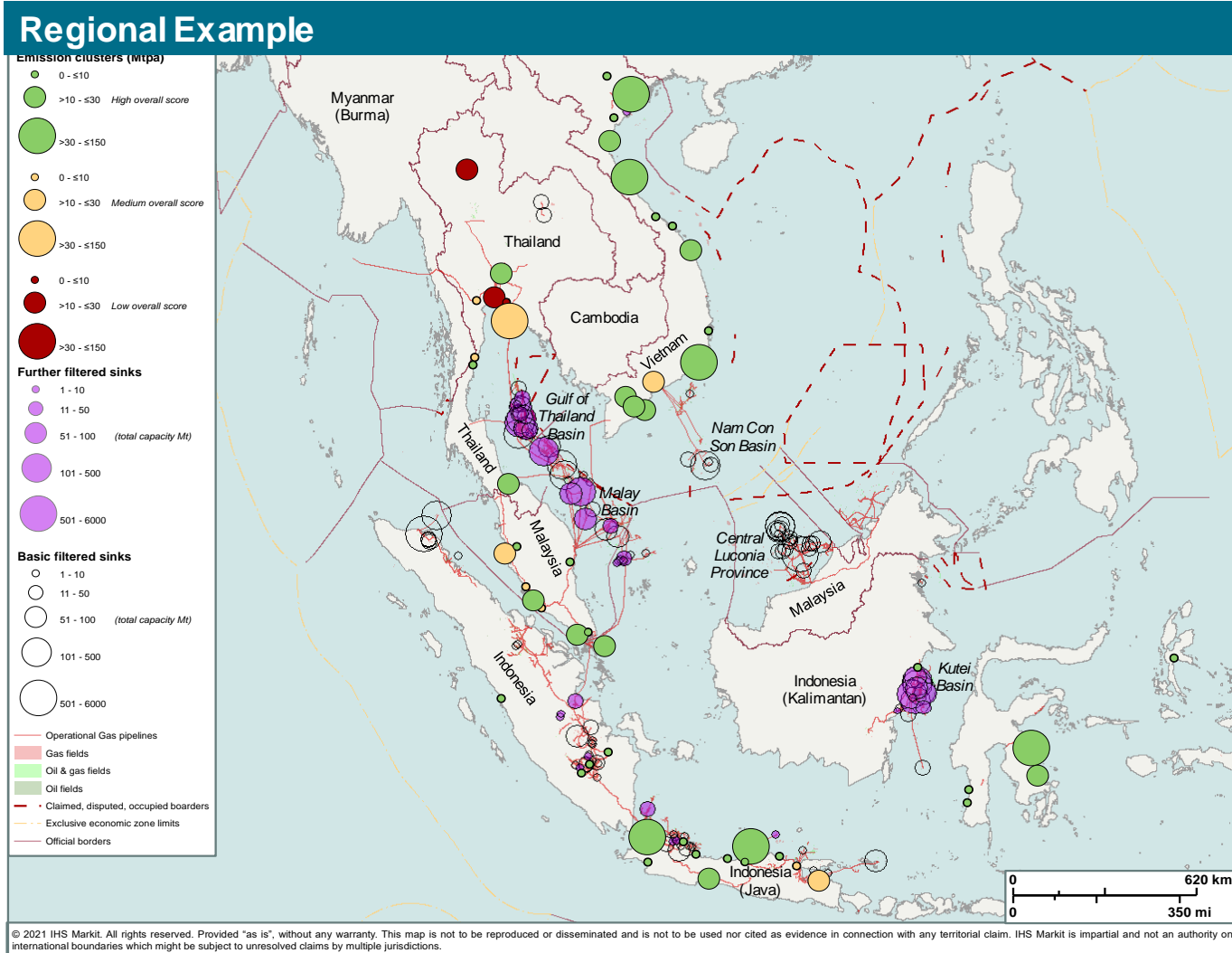
Source-Sink Matching | Hubs will be sourced by the most significant CO2 emitters — S&P Global identified 13,165 emitters

Emitter archetype scorecard				
Archetype name	Count of facility	Average emissions per facility (Mtpa)	10 th percentile emission scale	Capture cost range (\$/Mt CO ₂)
Coal Power Plant	1,218	3.4	9.0	40-110
Gas Power Plant	6,344	0.5	1.3	65-145
Cement Plant	864	1.5	2.1	45-128
Steel Plant	597	2.5	6.7	45-130
Refinery	362	1.5	3.2	50-170
Gas Processing	2,124	-	-	15-40
Ammonia Plant	170	1.3	2.8	20-35
Ethanol plant	1,486	0.1	0.2	17-38

Source: S&P Global Commodity Insights - EDIN Midstream database



Source-Sink Matching | Distance and international borders complicate source-sink matching for the SE Asia region



- Vietnam
 - The Nam Con Son Basin containing all the clear circled sinks comprises of predominantly carbonate reservoirs, with distances of >200 km.
 - There are mature oil fields in the vicinity which could be the upside. Technically CO2 EOR has been proven in a pilot but did not push through because of economics at that time (without much incentives).
- Indonesia
 - A cluster of sinks in the Kutei Basin (Kalimantan), provides significant storage, but its not proximal to any emissions clusters, with the closest being > 400 km.
- Malaysia
 - Good sinks in the Malay Basin, however, proximal in-country emission clusters are on the other side of the island. The Central Luconia Province contains mostly carbonate sinks.
- Thailand
 - Several hubs have been identified with sinks in the Gulf of Thailand Basin and emissions clusters on the coast.

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