TOPSIDES UK 2025

HOLISTIC APPLICATION OF CARBON CAPTURE AND STORAGE IN FPSOS

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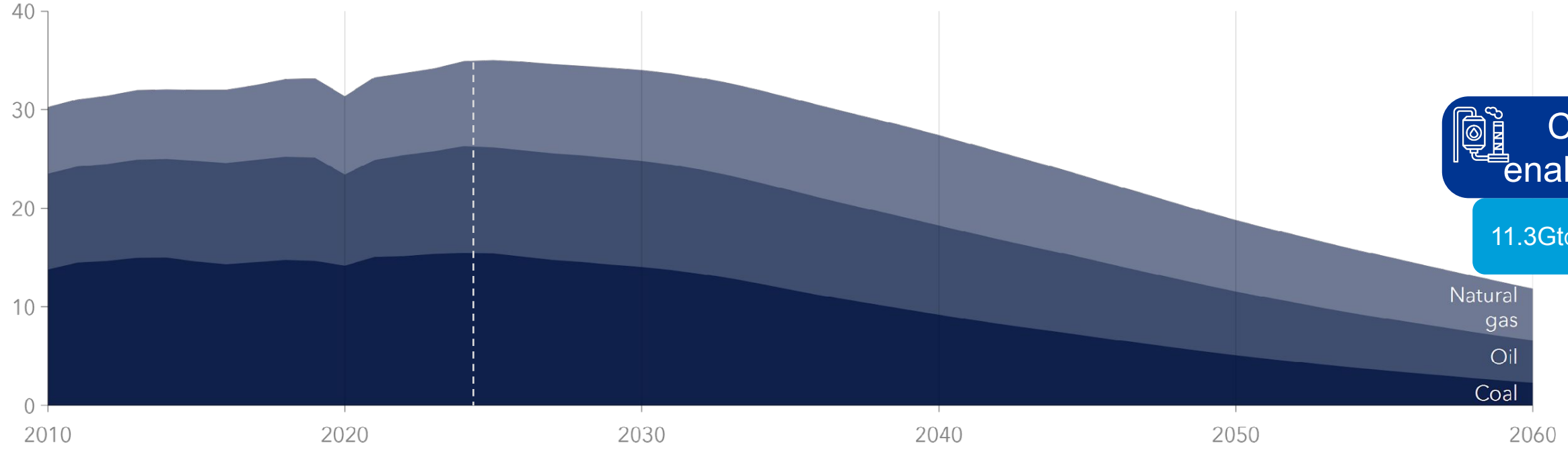
FOSSIL-FUEL CO_2 EMISSIONS DECLINE

…but not fast enough

World energy-related CO_2 emissions by fuel source ($GtCO_2$/yr)

DNV Energy Transition Outlook 2025



MARITIME INDUSTRY
Role of low-GHG fuels and CCS

The maritime sector will decarbonise quickly, even against last externalities

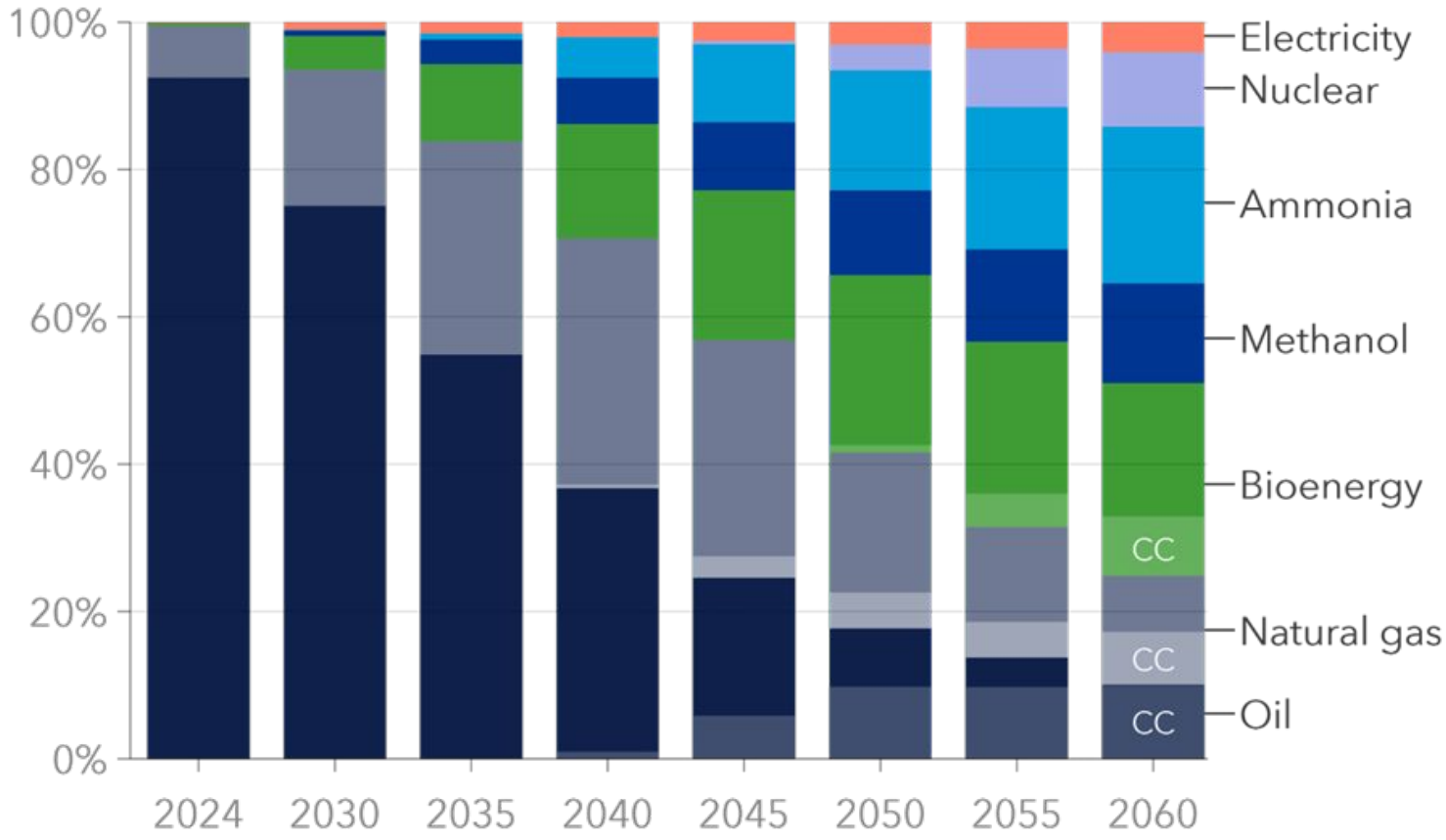
Several low-GHG fuels will enter the fuel mix, first bio-based, then e-methanol, and ammonia.

On-board carbon capture (CC) is expected onboard ships running on oil, natural gas, and bioenergy.

Nuclear propulsion is a possibility in the 2050s.

Shares in maritime final energy demand by carrier

DNV Energy Transition Outlook 2025



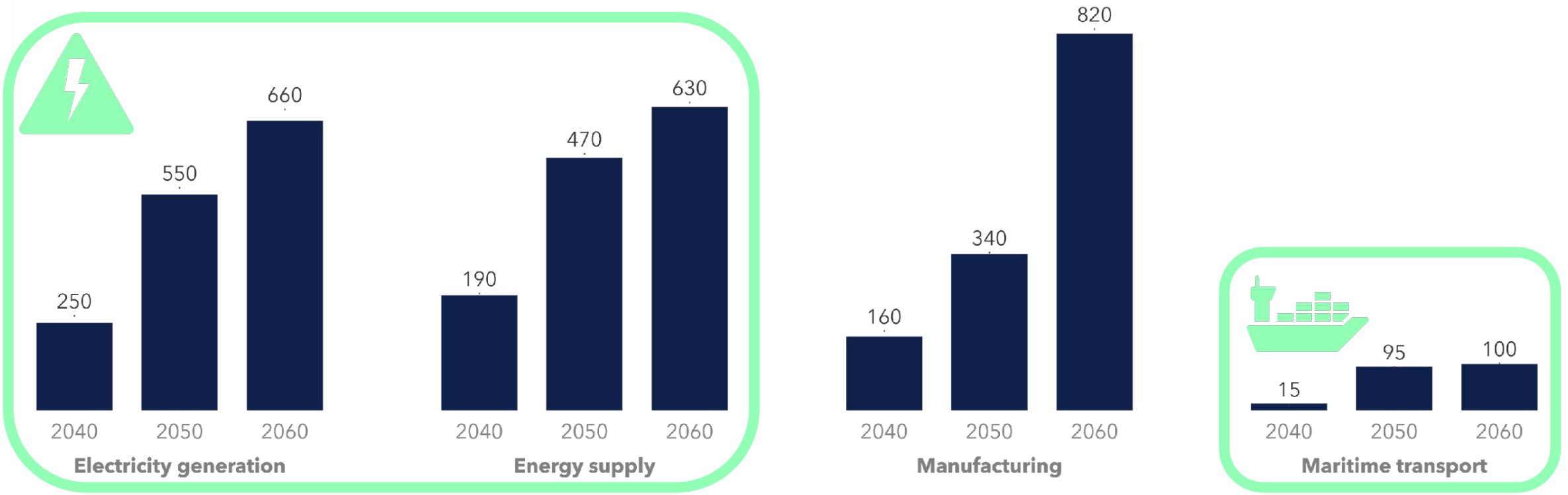
Historical data: IEA WEB (2025). Note: CC is on-board Carbon Capture.

CCS DEPLOYMENT

2,600 $MtCO_2$/year, 16% of emissions in 2060, including Direct Air Capture

CCS deployment across sectors ($MtCO_2$/yr)

DNV Energy Transition Outlook 2025



WHY CARBON CAPTURE MATTERS?

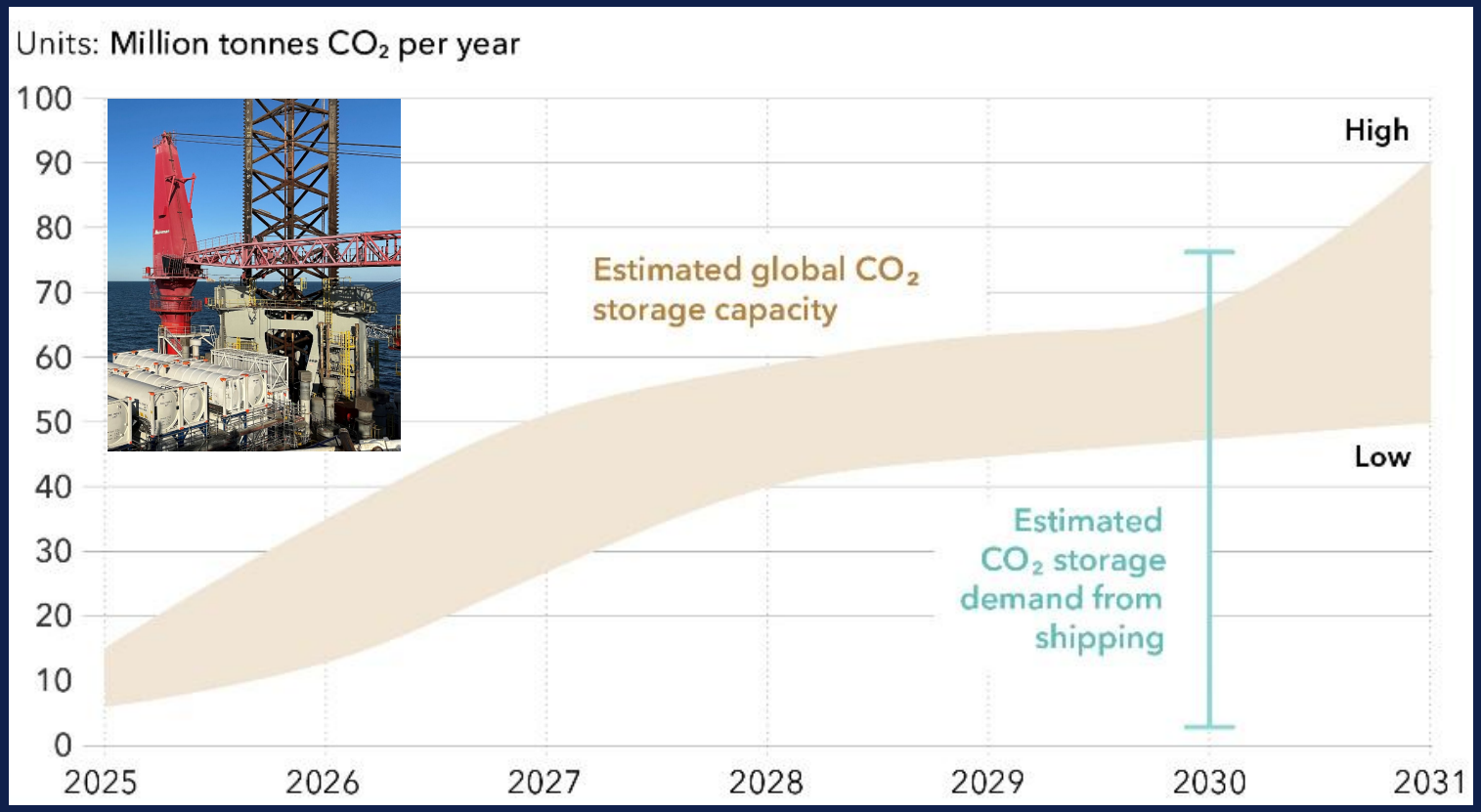
Cost-effective Integration

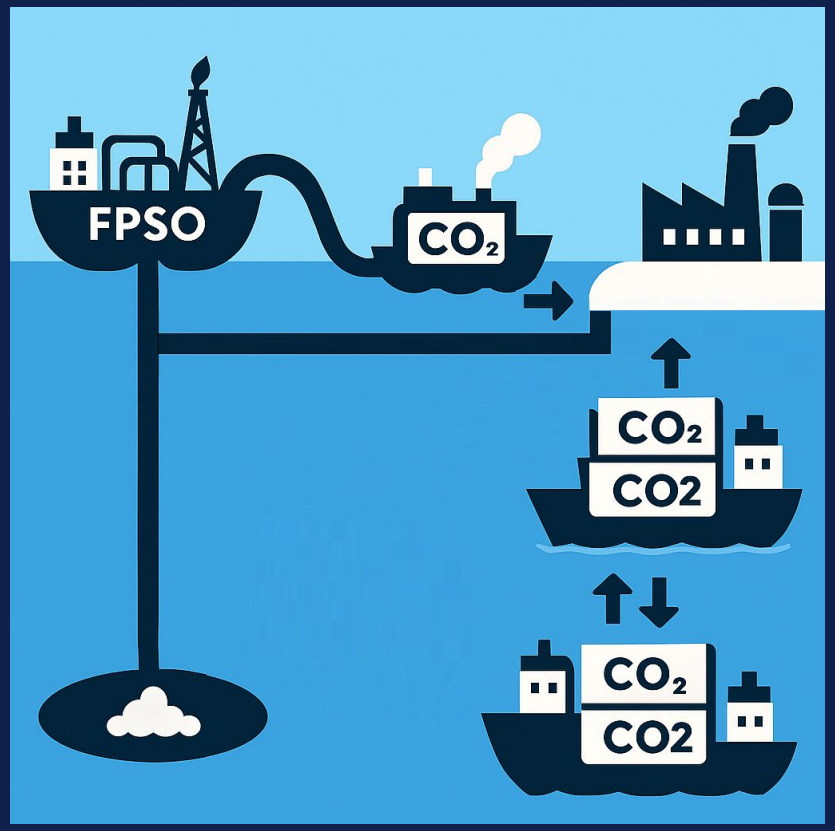
Regulatory Compliance

Corporate Sustainability

Pathway to Net-Zero

ESCALABILITY?
On-board carbon capture and storage retrofitting





DNV IN CCUS

200+ projects

In the past 10 years we have delivered more than 200 CCS project for clients around the world.

International standards

DNV has been a leading contributor to the first international standards for CCS.

Full value chain

We support customers across the value chain, with specialist capabilities related to capture, transport and subsurface storage.

CO_2 JIPs

We lead and facilitate CO_2 joint industry projects and participating in research programs to enable greater deployment.

Inter-disciplinary

We assemble multi-disciplinary teams to address the unique requirements of each client project.

RPs

We have developed several recommended practices covering CO_2 capture, transport and storage.

20

We operate 9 world leading Technology Centres with 20 individual laboratories across three continents.

Global team, local experience

We leverage the expertise of a global team alongside a familiarity with local policy and regulations.

DNV

POSITIVE ASPECTS

- **Regulatory Compliance**: CCS helps offshore operators meet strict environmental regulations and emissions targets like the Paris Accord.
- **Corporate Sustainability**: Implementing CCS supports sustainability goals and enhances social license by showing environmental commitment.
- **Cost-effective Integration:** CCS can be retrofitted into existing infrastructure, offering a scalable, cost-effective offshore decarbonization solution.

CHALLENGES

- **Space Constraints on FPSOs:** CCS systems demand significant space for absorbers, compressors, and storage tanks, challenging integration on FPSOs.
- **Cost and Operational Challenges:** High capital and operational expenses, including energy use and maintenance, increase CCS implementation complexity.
- **Logistics and CO_2 Handling:** Managing CO_2 offloading and transportation to storage sites adds logistical complexity to CCS on FPSOs.

FPSO EMISSIONS

GHG emissions from offshore production (UK)

CO_2 from power generation and flaring

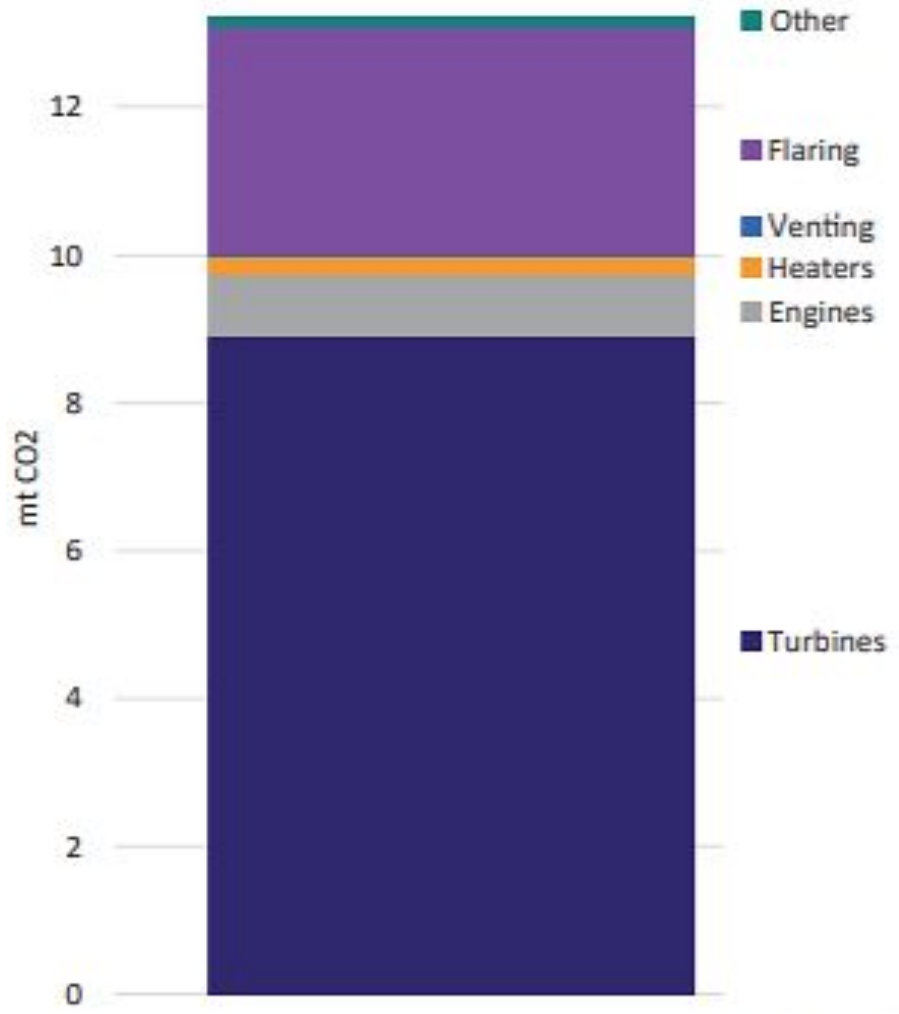
- Power or heat generation from turbines, engines and heaters

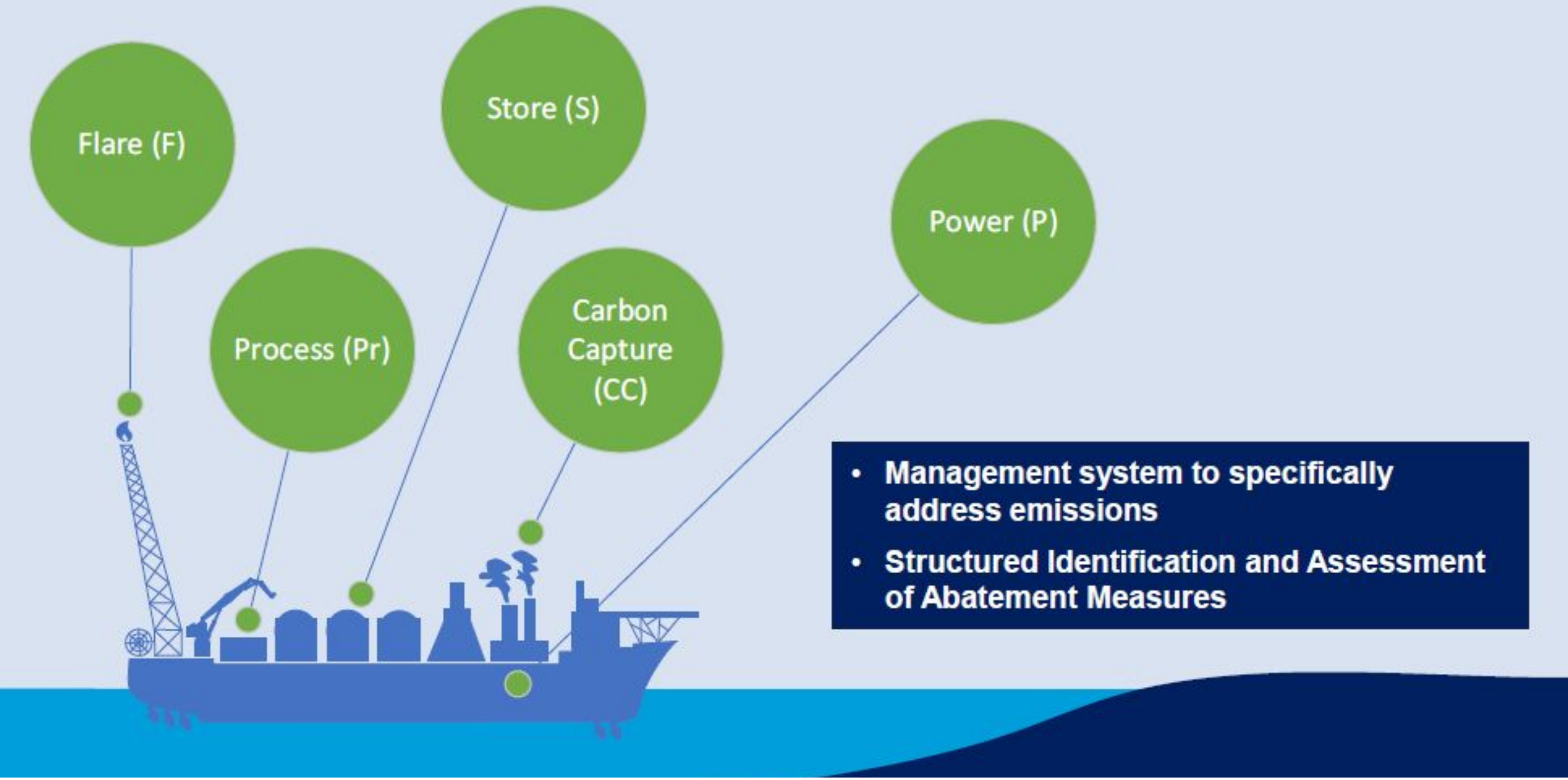
Methane emissions from process

- Leaks and venting from the process plant

VOC – Methane and Non methane volatile organic compounds

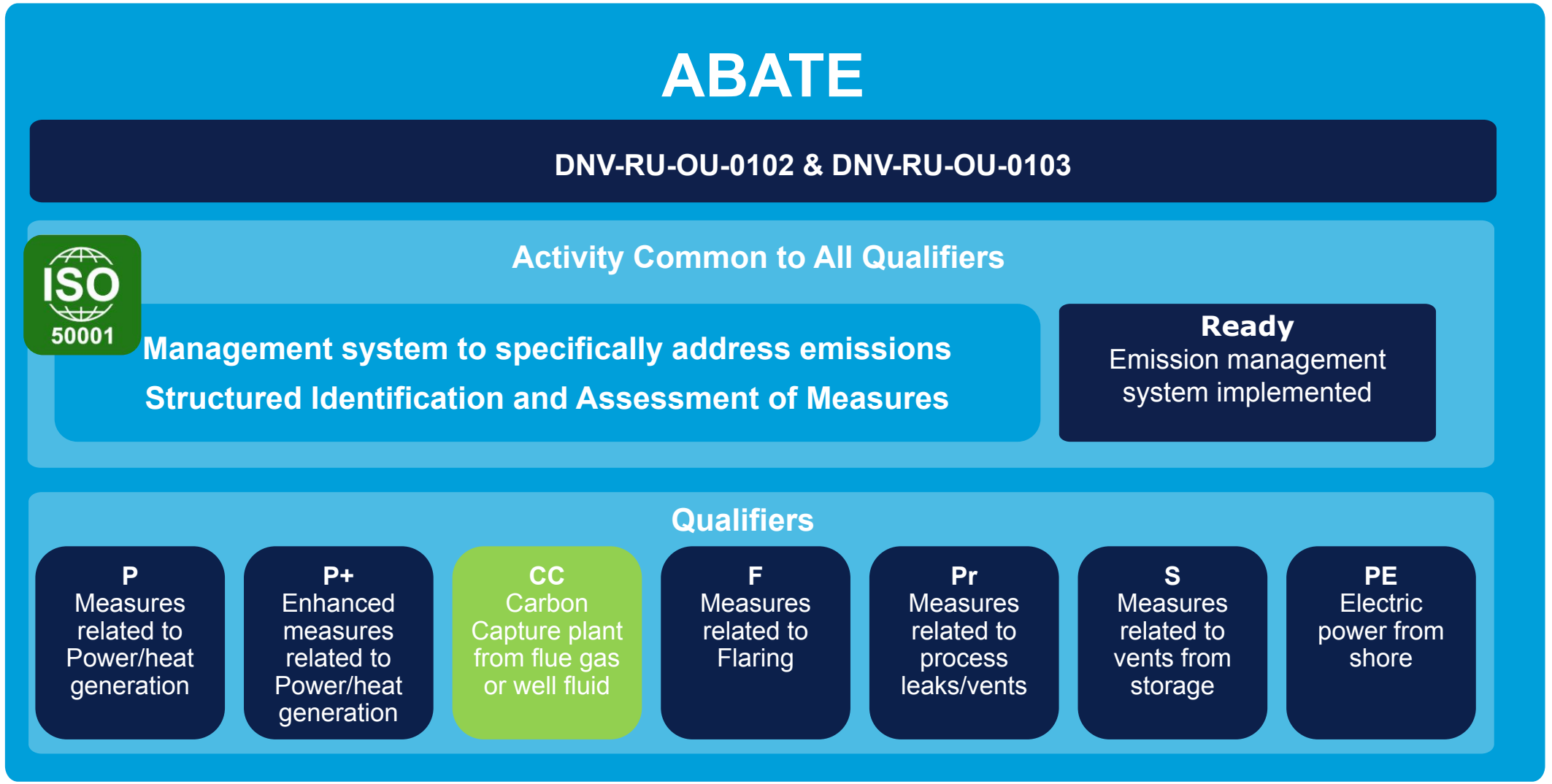
- Organic compounds from tanks and vents and from product storage on FPSO's and FSO's




Flare (F)
Store (S)
Power (P)
Process (Pr)
Carbon Capture (CC)
• Management system to specifically address emissions
• Structured Identification and Assessment of Abatement Measures

ABATE NOTATION

Framework for floating production



ABATE Document Requirement – specific for qualifiers

ABATE (P) - Power	ABATE (P+) - Power	ABATE (CC) - Carbon Capture	ABATE (F) -Flare	ABATE (PR)-Process	ABATE (S) - Storage
Energy efficiency study, including: • Emission philosophy related to releases from power/heat generation • Measures identified to optimize/reduce energy demand. Energy source study: e.g. external electrification, closed bus, hybrid system using battery or fuel cell and/or consideration of future use of alternate fuels with lower greenhouse gas footprint Energy demand optimization study - including system to monitor power consumption Description of implemented measures identified to optimize/reduce energy demand	In addition to Abate(P): Description of additional enhanced measures like: - Combined cycle/exhaust heat recovery system. - Hybrid power - Heat recovery systems	Documentation of carbon capture technology including storage solution Technology qualification evidence for selected carbon capture technology	Flare scenario identification and reduction study. Including identification of circumstances where flaring occurs (root cause) and assessment of the possibility for eliminating or reducing those occurrences. Flare gas capture study including assessment of the possibility of and technology needed in order to re-direct uncaptured flare gas to other parts of the process plant. Flare efficiency study including: - efficiency of flare tip (ensure complete combustion) - ignition reliability - pilot gas usage Relief and Blowdown system report Flare P&Ids	Vent and leakage study identifying potential sources of process emission and vents and what sources are captured. Source of release schedule Process Flow Diagrams Best-Available Tech. review of possible GHG emission reduction measures form production plant. Reliability, availability, maintainability and safety (RAMS) documentation – system (upon request)	Storage tank release study including: - identification of methane release scenarios - assessment of possible reduction measures including; optimizing operational procedures (e.g. frequency of tank entry), design changes VOC management plan, ref. MARPOL Annex VI Reg.15. P&ID - Vapor Recovery including tie-in to topside plant

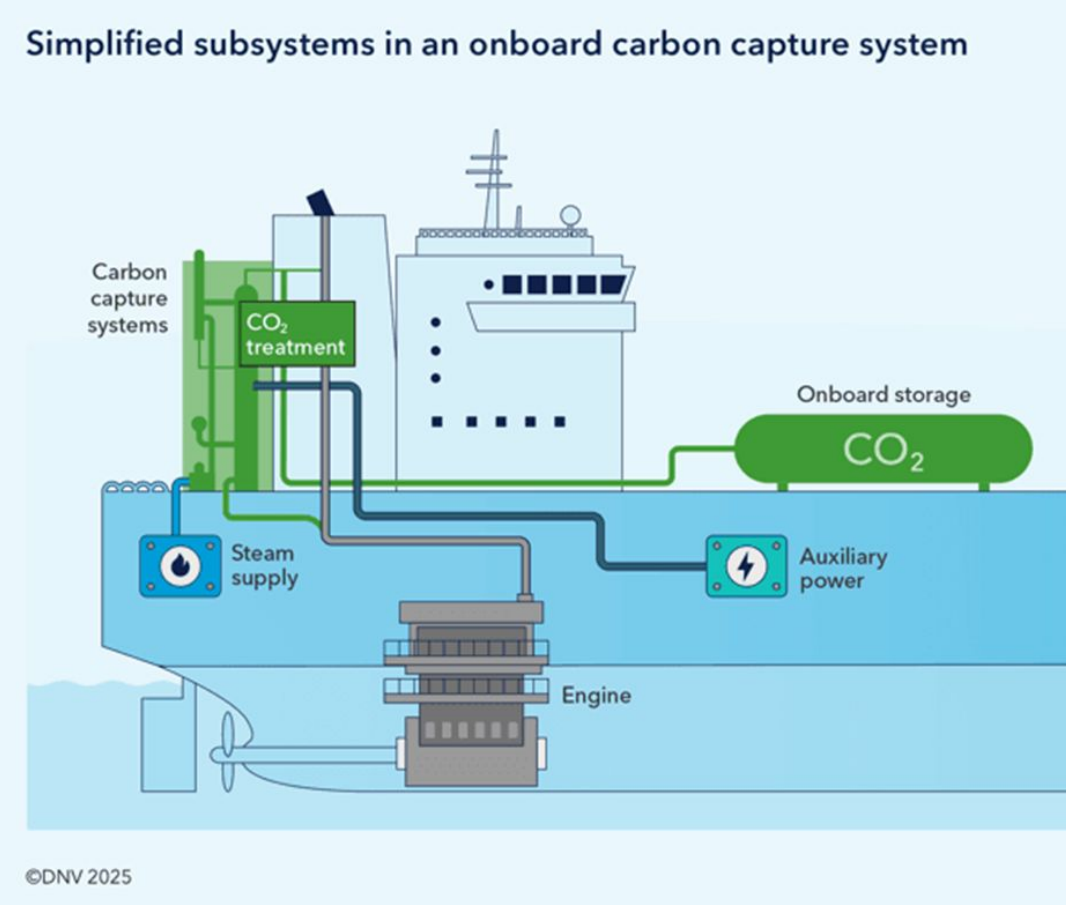
CURRENT TECHNOLOGIES

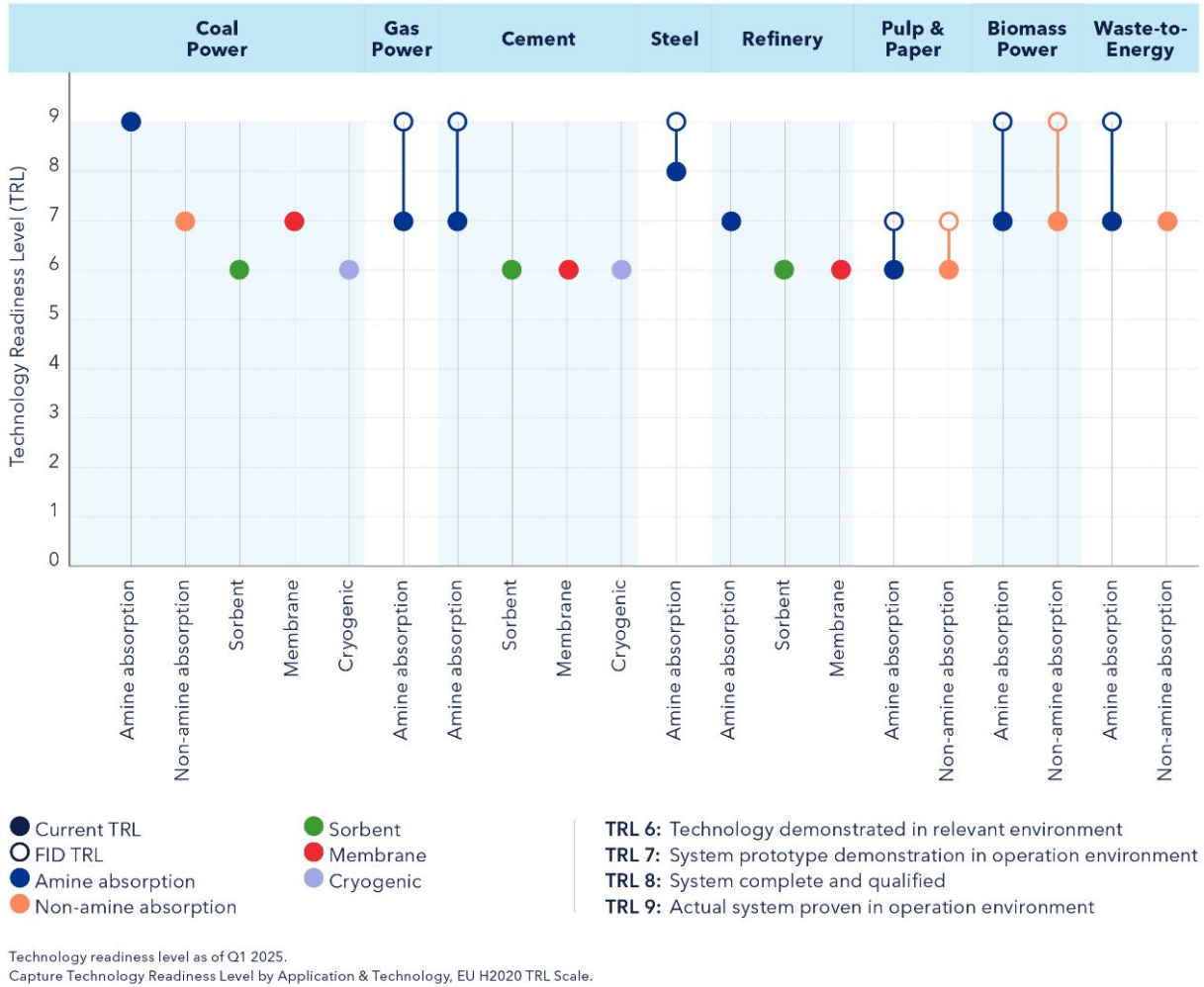
Sampling alternatives in other industries

Company Product	Readiness	Capture Rate (tpd)	Modular	Feed CO_2 (vol%)	Energy Consumption (GJ/tCO_2)	Capture Efficiency (%)	Key Notes
Capsol – CapsolGT®	5	200 – 1,000 @ 95%+	Yes	2 – 4	0 (electric only)	90 – 95	Stand-alone unit; self-heated; no steam input; designed for 4–100 MWe open-cycle GTs; pre-FEED completed Q2 2024; partnered with GE Vernova
Entropy – iCCS Turbine	9	40 – 3,000+	Yes	3 – 20+	~2.4	90 – 98	Modular; deployed at Glacier Gas Plant; 15 MW GT in Phase 2; part of iCCS suite (Recip, Thermal)
NetPower – Allam Cycle	6	~800 – 900 ktpa	~	~	~	>97	Integrated oxy-combustion sCO_2 cycle; inherent capture; demo at La Porte, TX; Project Permian in development

Source: 2024 Global CCS Institute

CURRENT TECHNOLOGIES
What is Fit for Service?





Technology readiness level as of Q1 2025.
Capture Technology Readiness Level by Application & Technology, EU H2020 TRL Scale.

CONVERSIONS
What is the stake?

Opportunities	Risks
Stakeholder's needs	HSE hazards
Smart gas flaring	Energy efficiency/heat balance penalty (CCUS power consumption)
Aftermarket to Liquefied CO_2 (CO_2 as a by-product)	Deck space (CO2 modular fright containers)
Power management system, turbine optimisation	Shore reception facility readiness
OSV regular trading	Liquefied CO_2 surplus
Cost reduction on direct connection with CCS offshore field	Cargo capacity

DNV ABATE NOTATION
Carbon capture

ANPG And Azule Energy Announce First Oil From The Agogo FPSO

AUGUST 6, 2025 BY AZULE ENERGY

The National Agency for Petroleum, Gas and Biofuels (ANPG) and Azule Energy announced on Tuesday, 29 July, the successful startup and first oil production from the Agogo FPSO. This is the centrepiece of the Agogo Integrated West Hub (Agogo IWH) project, offshore Angola, which involves the development of two fields, Agogo and Ndungu, in the West Hub of Block 15/06.

The Agogo IWH project operated by Azule Energy in Block 15/06, with a 36.84% stake alongside partners Sonangol E&P (36.84%) and Sinopec International (26.32%), is set to add substantial production to Angola's energy landscape. The Agogo and the Ndungu fields, combined have estimated reserves of approximately 450 million barrels, with projected peak production of 175,000 barrels per day, produced via two FPSOs (Agogo and Ngoma).

AZULE ENERGY
a bp and Eni company

Photo // Azule Energy

Sanctioned in February 2023, the Agogo IWH project began production in just 29 months, setting new benchmarks for the industry. This was made possible by a phased development approach, allowing for development while appraising, which helped de-risk the full field exploitation.

CONCLUSIVE REMARKS

O&G will play a key role also in 2050

- Addressing CO_2 emissions is key
- Every tonne of CO_2 counts

Technology

- Some technology does exist today. Due diligence
- Prepare for implementation of future technology

Competence

- FPSO industry competence will be needed

Complex problems

- All hard-to-abate emission industries need to join forces
- Supply chain
- Surplus of liquefied CO_2

Collaboration is the fuel of the future!

Thank you!

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