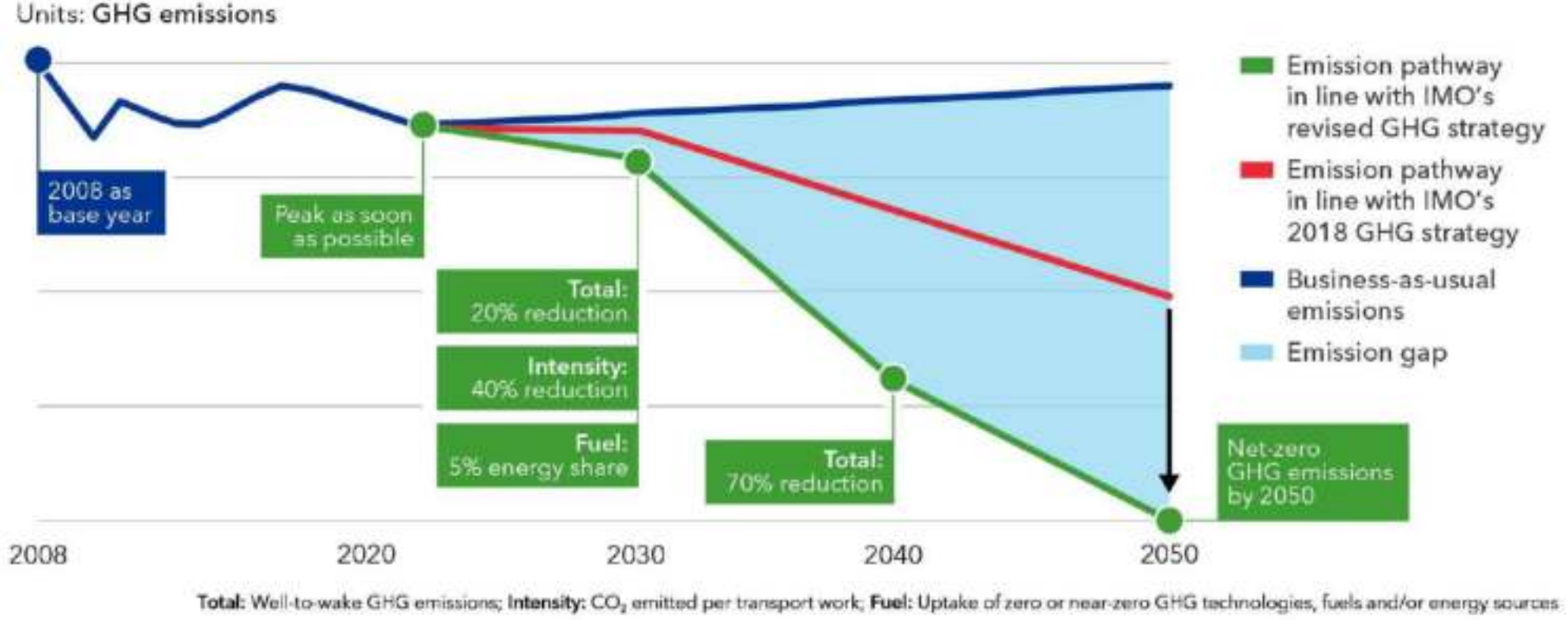
OCC

Avances en la tecnología de captura de carbono a bordo

Jose Allona, BDM

25 Abril 2024

Estrategia revisada de IMO sobre reduccion de emisiones de GEI



Dudas más fecuentes

Es OCC un tecnología madura de descarbonización ?

Tiene DNV alguna notacion de Clase OCC ready ?

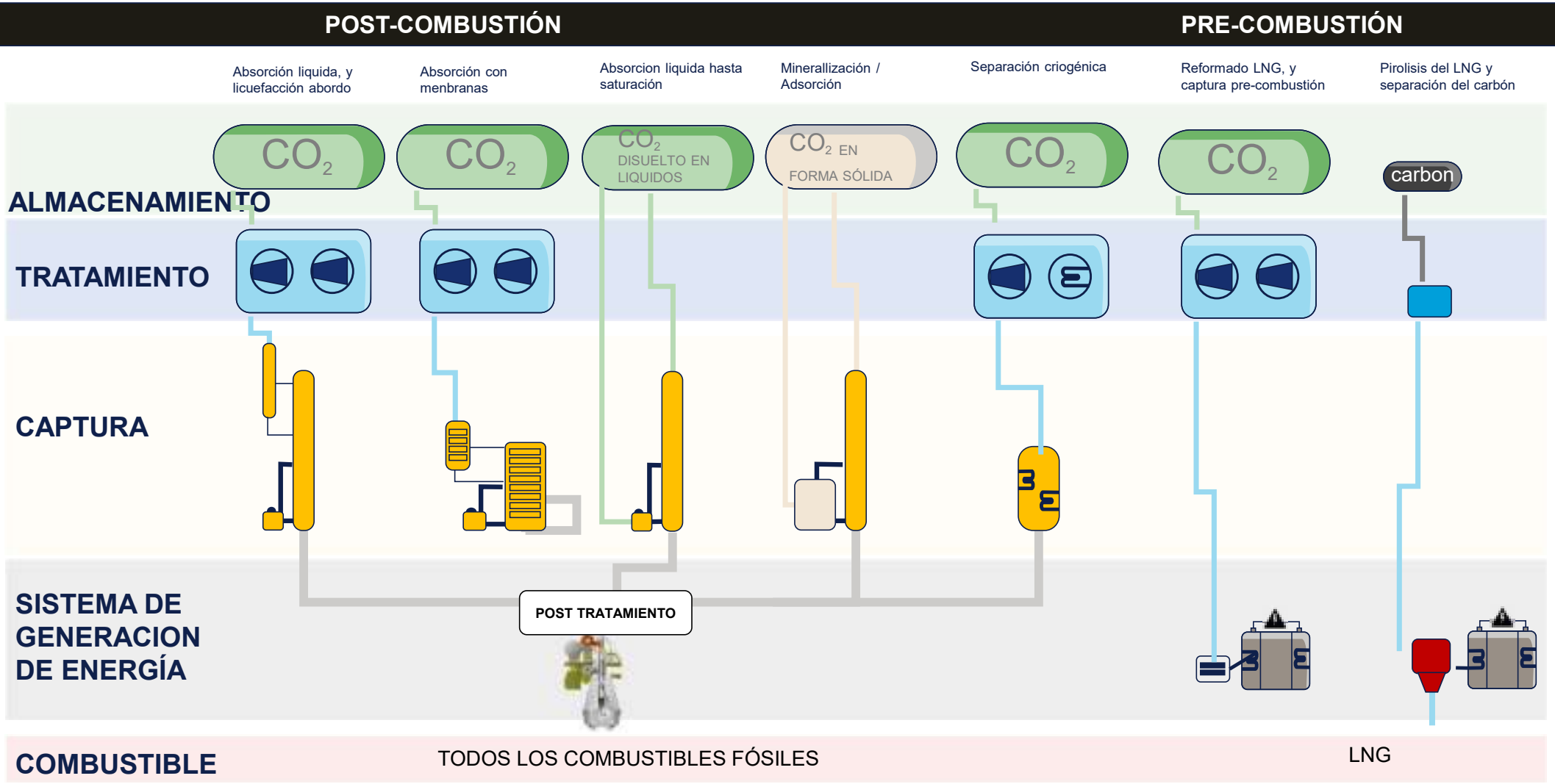
Como encaja OCC dentro del marco regulatorio?

Que tecnología es la más adecuada para cada linea ?

Como nos deshacemos del CO2 capturado abordo?


Estado del arte
Servicios de DNV
Cumplimiento
Comparativa
Entrega

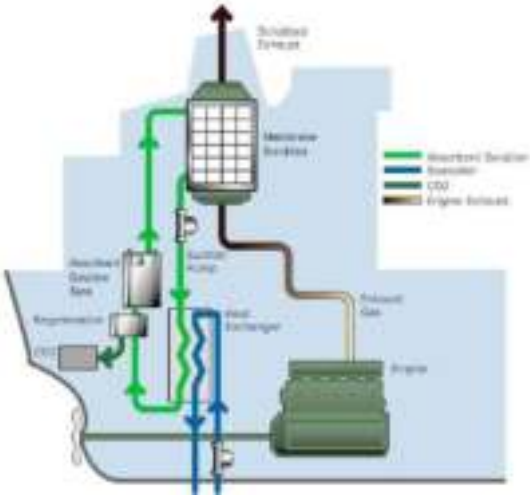
Situación del mercado


POST-COMBUSTIÓN
PRE-COMBUSTIÓN
Absorción liquida, y licuefacción abordo
Absorción con menbranas
Absorcion liquida hasta saturación
Minerallización / Adsorción
Separación criogénica
Reformado LNG, y captura pre-combustión
Pirolisis del LNG y separación del carbón
CO2
CO2
CO2 DISUELTO EN LIQUIDOS
CO2 EN FORMA SÓLIDA
CO2
CO2
carbon
ALMACENAMIENTO
TRATAMIENTO
CAPTURA
SISTEMA DE GENERACION DE ENERGÍA
POST TRATAMIENTO
COMBUSTIBLE
TODOS LOS COMBUSTIBLES FÓSILES
LNG

OCC – Algunos Fabricantes

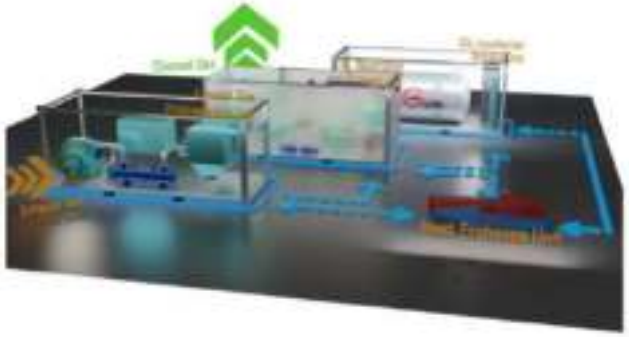
Mitsubishi

Ionada



Wartsila

Headway



Panaisia, Baker Hughes, Daphne, Seabound, Ecospray y muchos otros

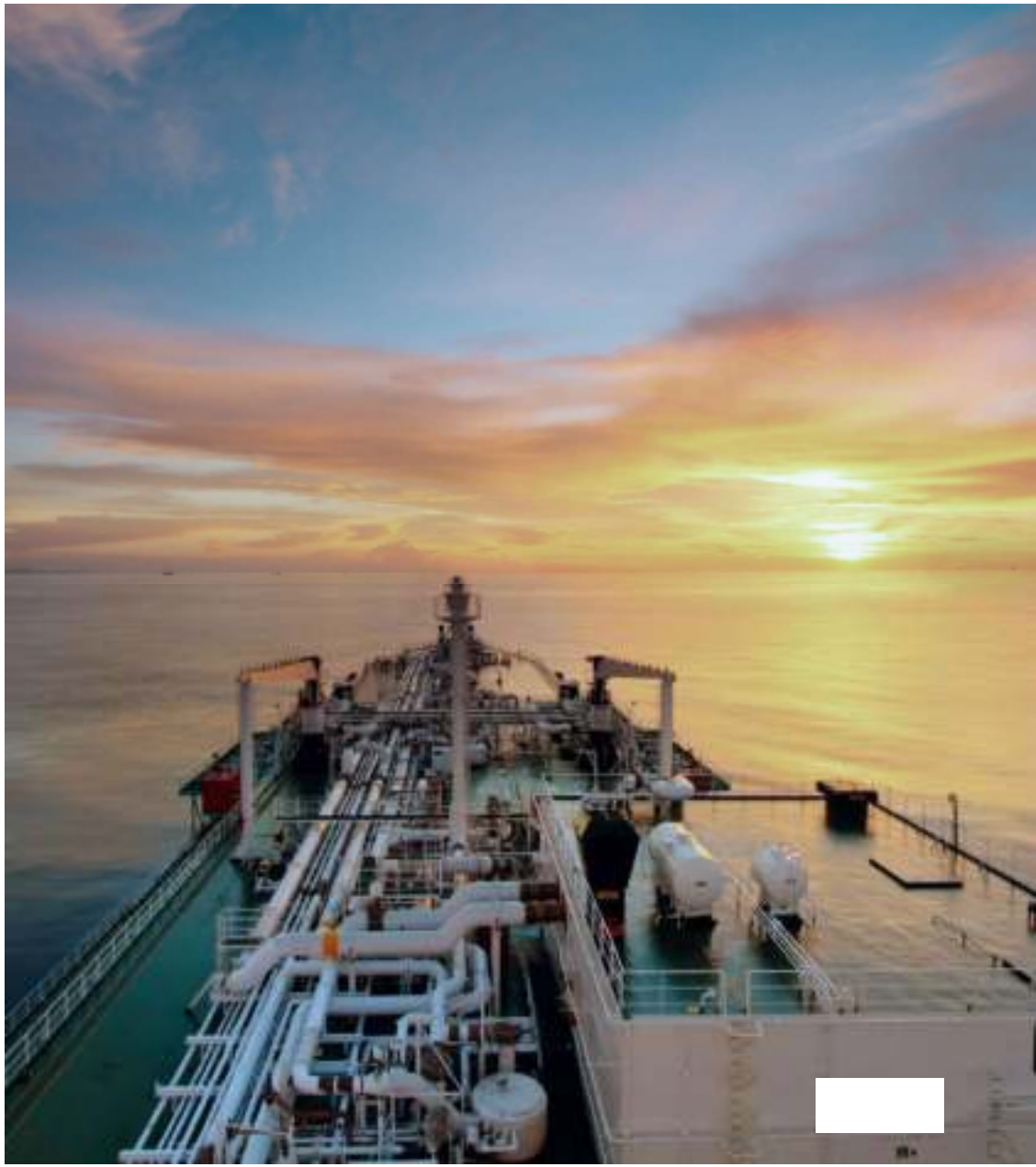
Value Maritime

VM | Value Maritime

…y muchos otros!

DNV – Poyectos Pilotos de OCC

Solvang – Wartsila
Danaos land-based pilot
SinOceanic – GSP
Altera – GSP
Everlong
BW, Hanwa
Value Maritime
Icon3 RCCL



Proyecto Piloto: Altera OCC

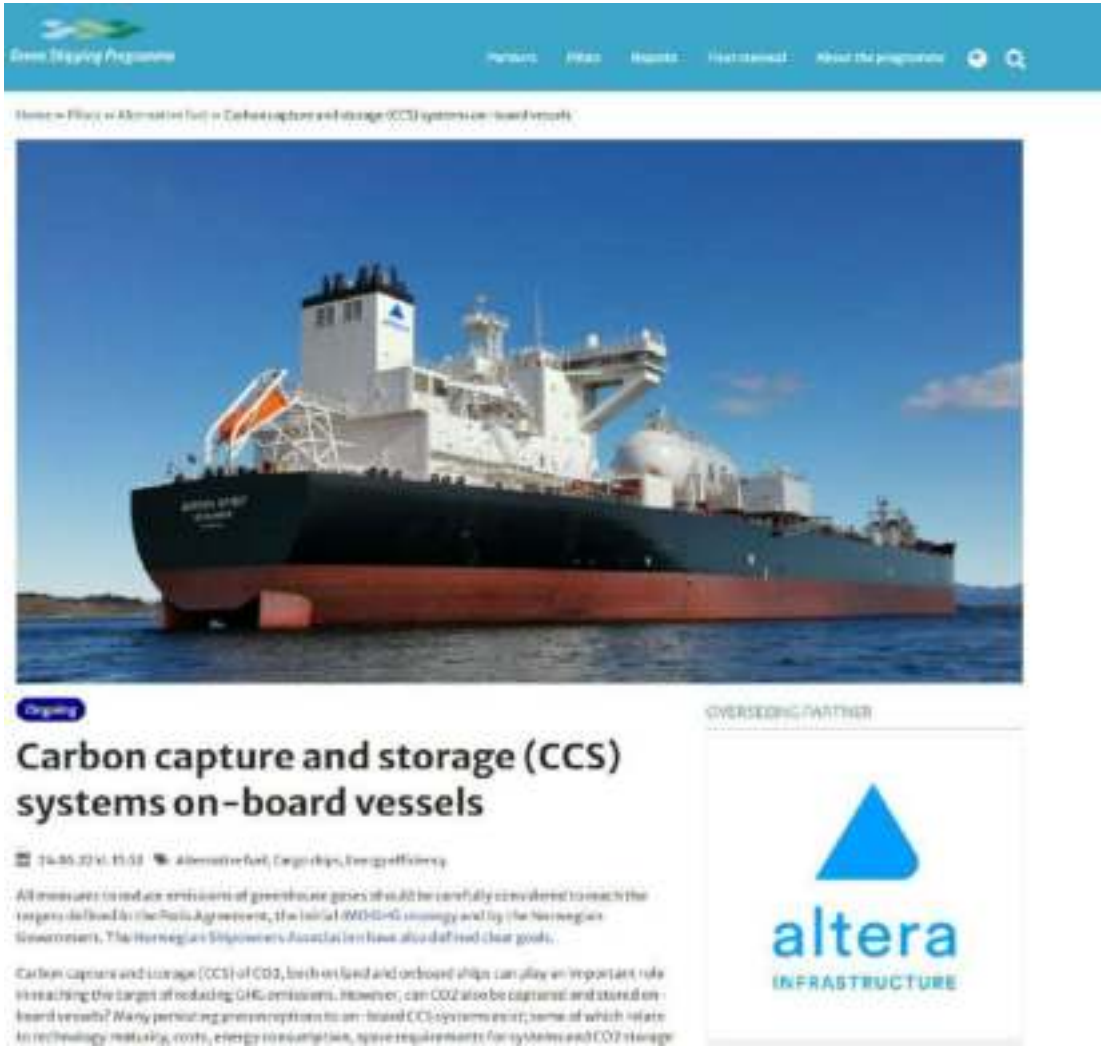
Green Shipping Programme

OCC retrofit del Altera's e-Shuttle tankers

Escalable

CO_2 Líquido

https://www.dnv.com/maritime/green-shipping-programme/index.html



Proyecto Piloto: Wartsila – Solvang

Proyecto piloto en el "Clipper Eos" (21k-cbm ethylene Carrier) para prueba y optimizacion a escala real

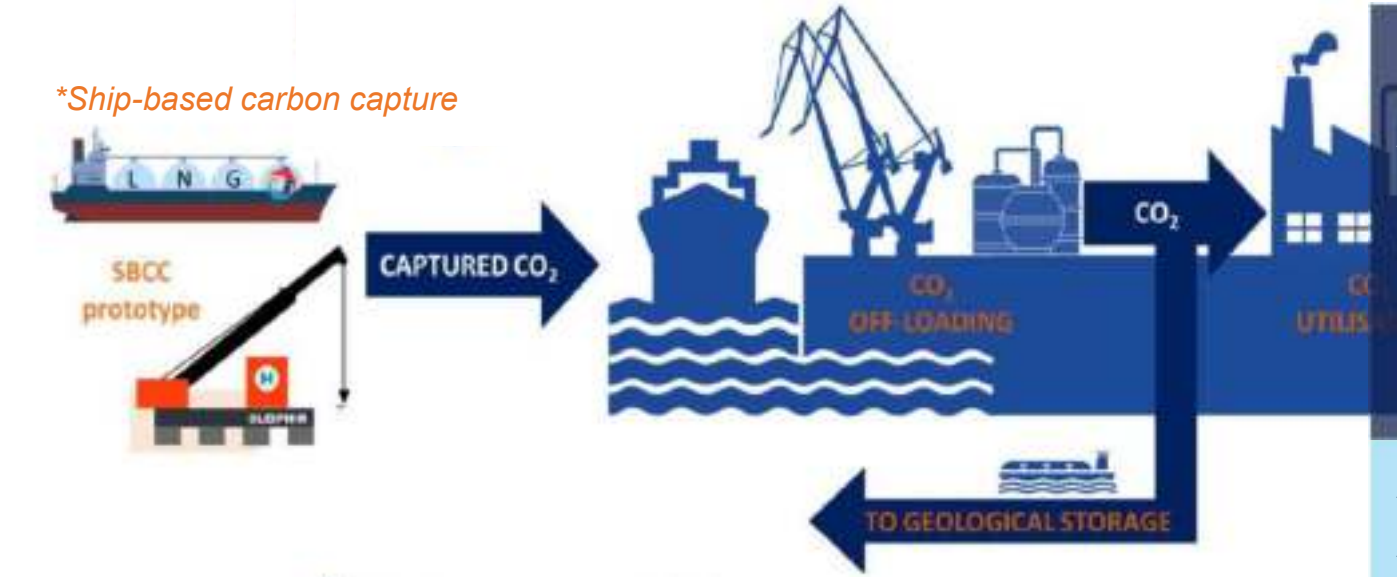
Objetivo: Conseguir una captura del 70% de las emisiones de CO2

Comercializar y escalar la producción

Fuente: Wärtsilä

Everlong R&D project & pilot

*Ship-based carbon capture

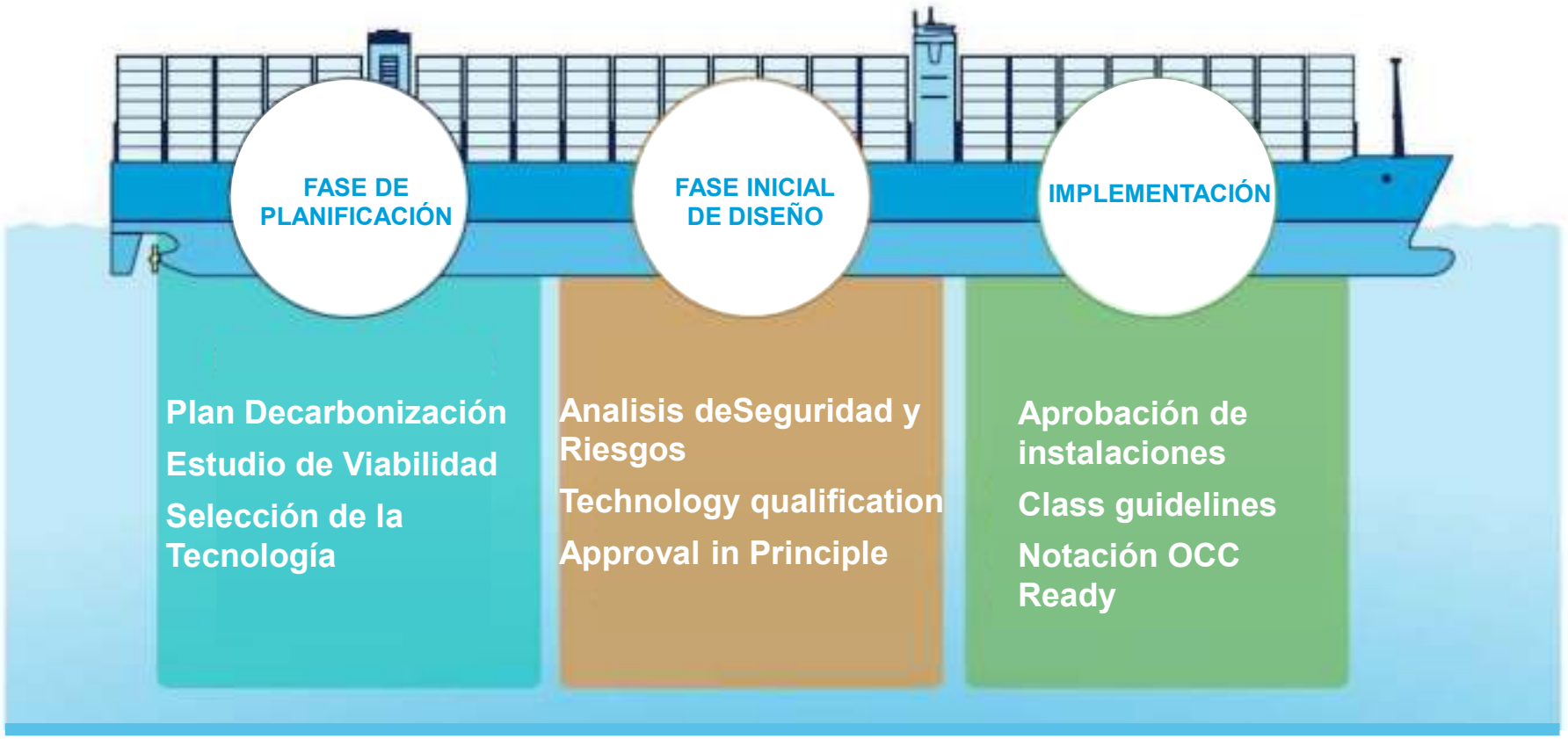


- Alcanzar reduccion de emisiones del 70%
- Cadena de valor de CCUS rentable
- Impacto en la infraestructura del buque
- Estrategias de descarga

- Análisis de los “vacios” reglamentarios
- Análisis de seguridad
- Establecer las bases para una futura aprobacion por la Clase


Estado del arte
Servicios de DNV
Cumplimiento
Comparativa
Entrega

OCC: Referencias y Servicios de DNV



En Julio 2024 OCC estará en la Reglas de DNV!

DNV Approval in Principle

El primer paso para obtener la aprobación de la Clase

Detención temprana de posibles problemas

Estudio independiente

Alcance de los servicios de DNV:

- Revision de la documentación
- Carta de la Clase, con comentarios al AiP
- Comentarios a tener en cuenta en la siguiente aprobación
- Emisión del "AIP statement"

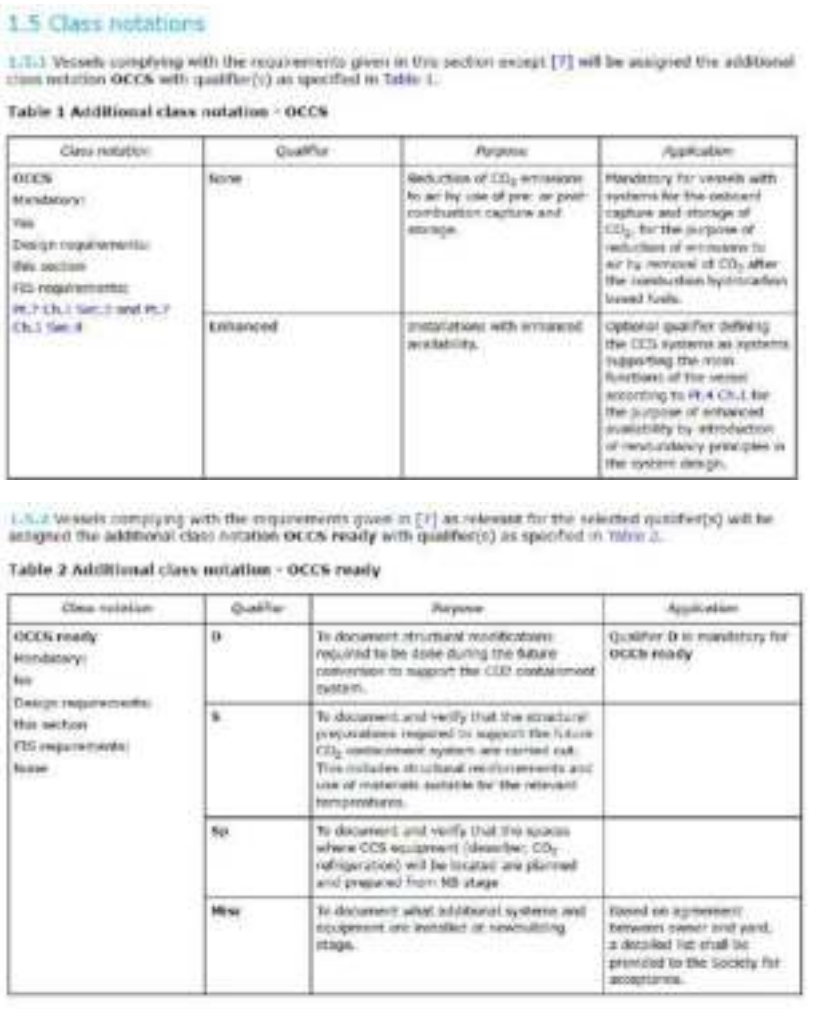
DNV

Para July 2024!

DNV OCCS Notation

Preparate para futuras conversiones

- Varias opciones segun el alcance
- Modificaciones y preparativos de la estructura
- Captura de Carbono, tratamiento y almacenamiento
- En linea con las "DNV OCC guidelines"



1.5 Class notations

1.5.1 Vessels complying with the requirements given in this section except [7] will be assigned the additional class notation **OCCS** with qualifier(s) as specified in Table 1.

Table 1 Additional class notation - OCCS

Class notation	Qualifier	Purpose	Application
OCCS Mandatory: Yes Design requirements: this section FDS requirements: Pt.7 Ch.1 Sec.3 and Pt.7 Ch.1 Sec.4	None	Reduction of CO_2 emissions to air by use of pre- or post-combustion capture and storage.	Mandatory for vessels with systems for the onboard capture and storage of CO_2, for the purpose of reductions of emissions to air by removal of CO_2 after the combustion hydrocarbon based fuels.
	Enhanced	Installations with enhanced availability.	Optional qualifier defining the CCS systems as systems supporting the main functions of the vessel according to Pt.4 Ch.1 for the purpose of enhanced availability by introduction of redundancy principles in the system design.

1.5.2 Vessels complying with the requirements given in [7] as relevant for the selected qualifier(s) will be assigned the additional class notation **OCCS ready** with qualifier(s) as specified in Table 2.

Table 2 Additional class notation - OCCS ready

Class notation	Qualifier	Purpose	Application
OCCS ready Mandatory: No Design requirements: this section FDS requirements: None	D	To document structural modifications required to be done during the future conversion to support the CO2 containment system.	Qualifier D is mandatory for **OCCS ready**
	S	To document and verify that the structural preparations required to support the future CO_2 containment system are carried out. This includes structural reinforcements and use of materials suitable for the relevant temperatures.	
	Sp	To document and verify that the spaces where CCS equipment (describe; CO_2 refrigeration) will be located are planned and prepared from NB stage	
	Misc	To document what additional systems and equipment are installed or newbuilding stage.	Based on agreement between owner and yard. A detailed list shall be provided to the Society for acceptance.

DNV

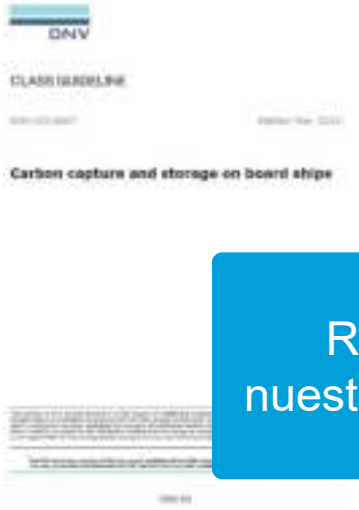
For tech providers!

Risk assessment

Objetivo:
Identificacion y análisis de riesgos para el proyecto y la operacion de buques con OCC

Alcance de los servicios de DNV:

- Estudios HAZID y HAZOP
- Taller para revision de del diseño y hacer recomendaciones de seguridad



Requerido en nuestras “Guidelines”

Technology qualification

Objetivo:
DNV-RP-A203: Provide the evidence that technology will function within specified limits with an acceptable level of confidence.

Es decir, validar tecnologías novedosas

For tech providers

Qualification Basis
Set the performance target
→ Technology Qualification Basis

Technology Assessment
Analyze how to assure the functions
→ Technology Assessment Report

Threat Assessment
Identify the failure modes and risks
→ FMECA Report

Qualification Plan
Plan the provision of evidence
→ Qualification Plan Report

Qualification Execution
Provision of the evidence

Performance Assessment
Compare with the performance target

Target met

Technology Qualified

Technology Qualification Report

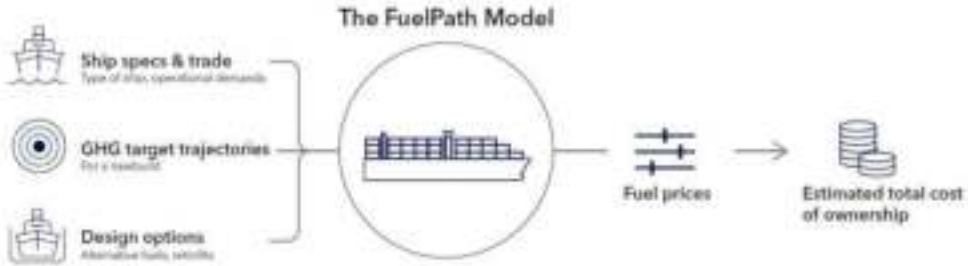
DNV

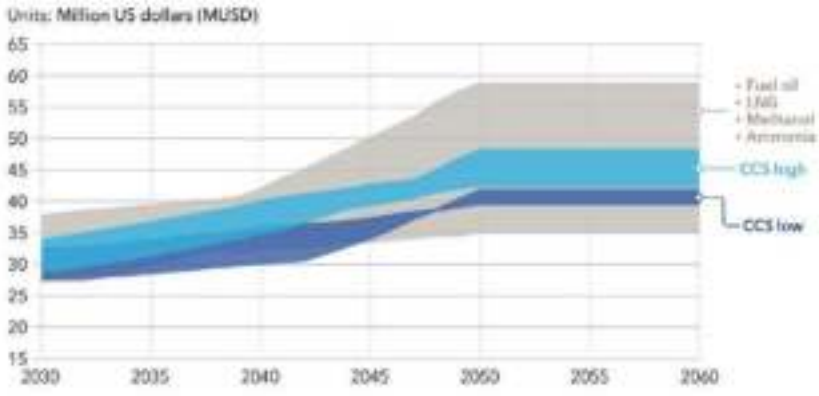
DNV FuelPath:
(en referencia al Maritime Forecast 2023)

Objetivo:
Puede OCC competir con otras opciones de descarbonización para un Proyecto determinado?

Alcance de los servicios de DNV:

- Analizar la especificación y el tráfico, la trayectoria de emisiones de GEI, las distintas opciones de diseño en cuanto a combustibles, precios de los Combustibles y distintas alternativas de OCC, bajo distintos escenarios de ratios de absorción, fuel penalty, precios de descarga, etc..
- Valorar distintas opciones de diseño a lo largo de la vida del buque, en términos del coste total, y otros parámetros económicos.
- Valorar el comportamiento en terminos economicos de una solucion OCC, en comparación con FO, LNG, Metanol y Amoniaco





OCC: Viabilidad y optimizacion de la maquinaria existente

Objectivo:
Bajo que condiciones de la maquinaria existente, puede ser viable OCC para un buque en particular?

Alcance de los servicios de DNV:

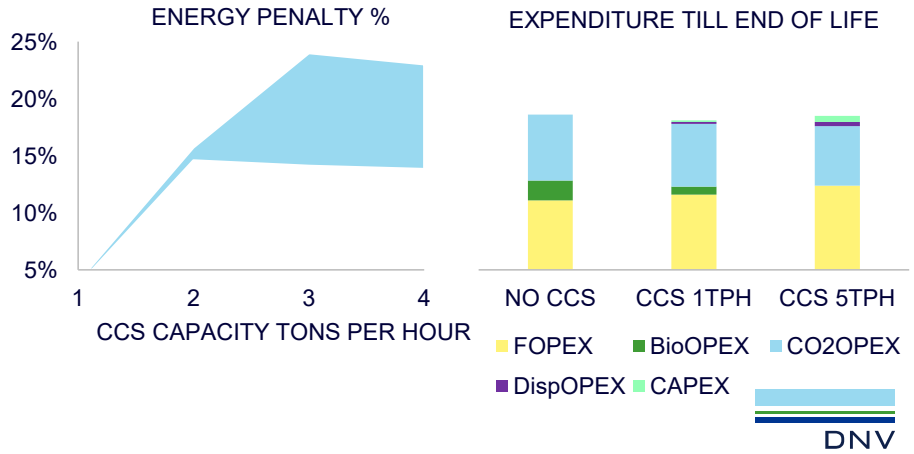
Estudio comparative de distintas tecnologías

Analisis mediante una simulacion de la planta de maquinaria abordo

- Con / sin OCC
- Estudio sistemático: PTO, WHR, AEECO
- Viabilidad de ratios de captura de CO2
- Energy penalty y comportamiento de GEI

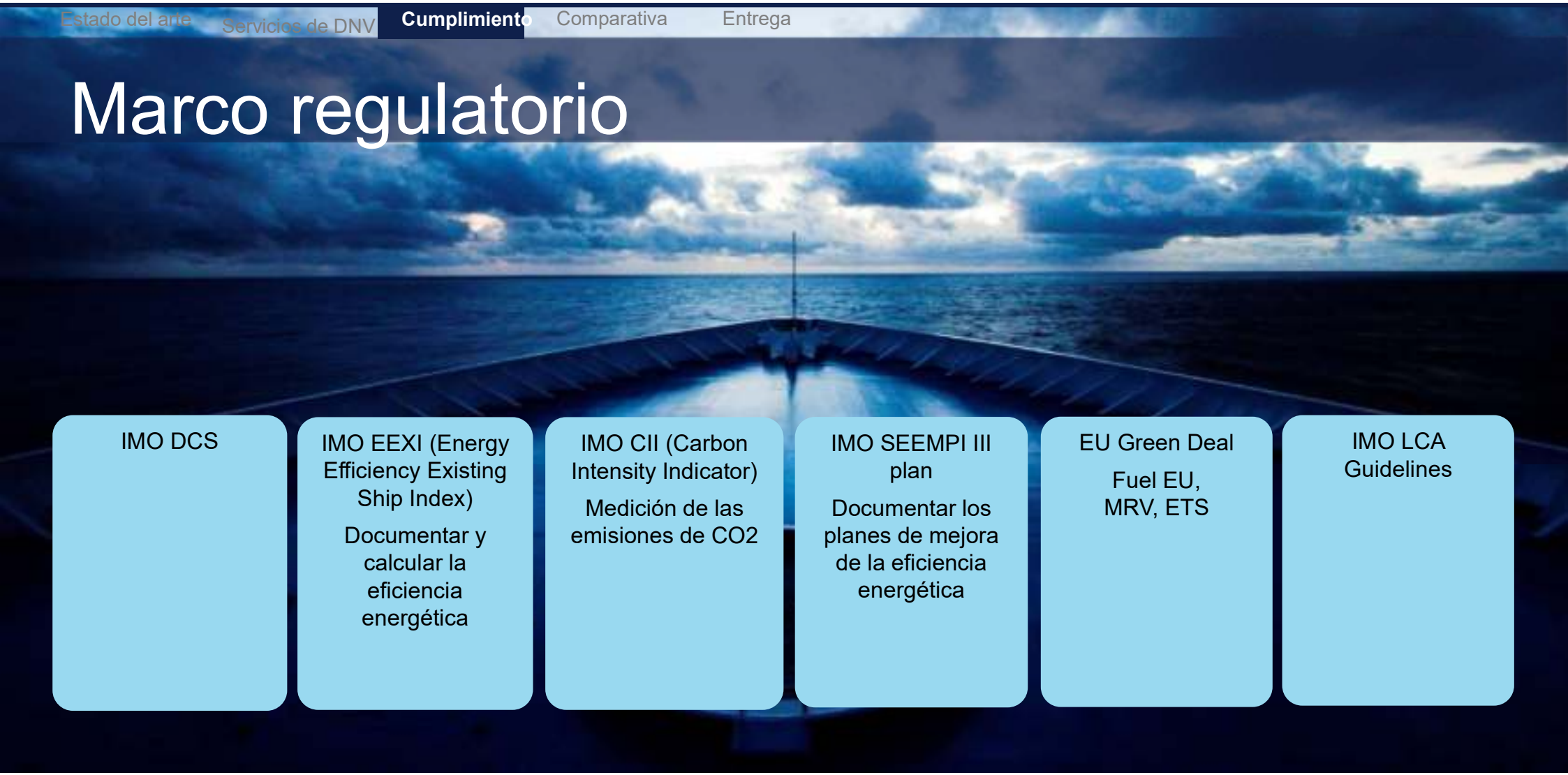
Analisis de sensibilidad antes variaciones, como: Fuel OPEX, precio del CO2, etc.

For tech providers & shipping companies




Estado del arte
Servicios de DNV
Cumplimiento
Comparativa
Entrega

Marco regulatorio



IMO DCS	IMO EEXI (Energy Efficiency Existing Ship Index) Documentar y calcular la eficiencia energética	IMO CII (Carbon Intensity Indicator) Medición de las emisiones de CO2	IMO SEEMPI III plan Documentar los planes de mejora de la eficiencia energética	EU Green Deal Fuel EU, MRV, ETS	IMO LCA Guidelines

EU ETS

Regulation (EU) 2023/957

The items for derogation (DIRECTIVE (EU) 2023/959 as amendment of 2003/87/EC (articles 12(3a) + (3b))

f) the following paragraph is inserted: '3b. An obligation to surrender allowances shall not arise in respect of emissions of greenhouse gases which are considered to have been captured and utilised in **such a way that they have become permanently chemically bound in a product** so that they do not enter the atmosphere under normal use, including any normal activity taking place after the end of the life of the product.

Directive 2003/87/EC, Annex II to Regulation (EU) 2015/757 should provide for a set of derogations to be applied to the revised formulae in Part A of Annex I to that Regulation, as well as the order for their application as presented therein. To align Annex II to Regulation (EU) 2015/757 with the implementing acts adopted under Article 14(1) of Directive 2003/87/EC, rules should be established for the treatment of biomass, renewable fuels of non-biological origin and recycle carbon fuel, as a derogation to the general rule. Further derogations should be established to reflect the inclusion of maritime transport greenhouse gas emissions in the EU ETS, notably concerning the application of the geographical scope referred to in Article 3gs of Directive 2003/87/EC, the treatment of greenhouse gas emissions falling within the scope of Article 12(3a) and (3b) of that Directive, the treatment of greenhouse gas emissions falling within the scope of Article 12(3-d), (3-e) and (3-b) of that Directive, the application of the derogation provided for in Article 12(3-e) of that Directive, and the phase-in requirements provided for in Article 3gb of that Directive.

4. Method D: Direct greenhouse gas emissions measurement

The direct greenhouse gas emission measurements may be used for voyages and for greenhouse gas emissions occurring within ports located in a Member State's jurisdiction. For ships for which CO_2 reporting is based on this method applied to all emissions sources on board the ship, the fuel consumption shall be calculated using the measured CO_2 emissions and the applicable emission factors of the relevant fuels and emissions sources.

This method is based on the determination of greenhouse gas emission flows in exhaust gas stacks (funnels) by multiplying the greenhouse gas concentrations of the exhaust gas with the exhaust gas flow.

The application of this method to determine emissions of a greenhouse gas shall not prevent companies from applying any other of the methods described under this Part to any other greenhouse gas.

The calibration methods applied and the uncertainty associated with the devices used shall be specified in the monitoring plan.

1.3 General principle

For the purpose of monitoring the ship's total aggregated emissions of greenhouse gases to be reported under the Directive 2003/87/EC, companies shall apply the formulae established in Part A of Annex I to this Regulation, considering the types of greenhouse gases emissions covered by Directive 2003/87/EC.

1.4 Derogation from the general principle in the case of CO_2 emissions referred to in Article 12(3a) and (3b) of Directive 2003/87/EC

By way of derogation from point 1.1, where CO_2 emissions fall within the scope of Article 12(3a) or (3b) of Directive 2003/87/EC, the amounts of such emissions calculated in accordance with points 1.1, 1.2 and 1.3 of this Part shall be multiplied by zero.

CERTEZAS

En discusión la posibilidad de que sea tenido en cuenta a efectos de cumplir con IMO CII

Ambigüedad sobre OCC en EU ETS

Reguladores a favor de soluciones para el almacenamiento del carbono de forma permanente en un compuesto

INCERTIDUMBRES

No está claro aún como será OCC tenido en cuenta a efectos de CII, Fuel EU, LCA Guidelines


Estado del arte
Servicios de DNV
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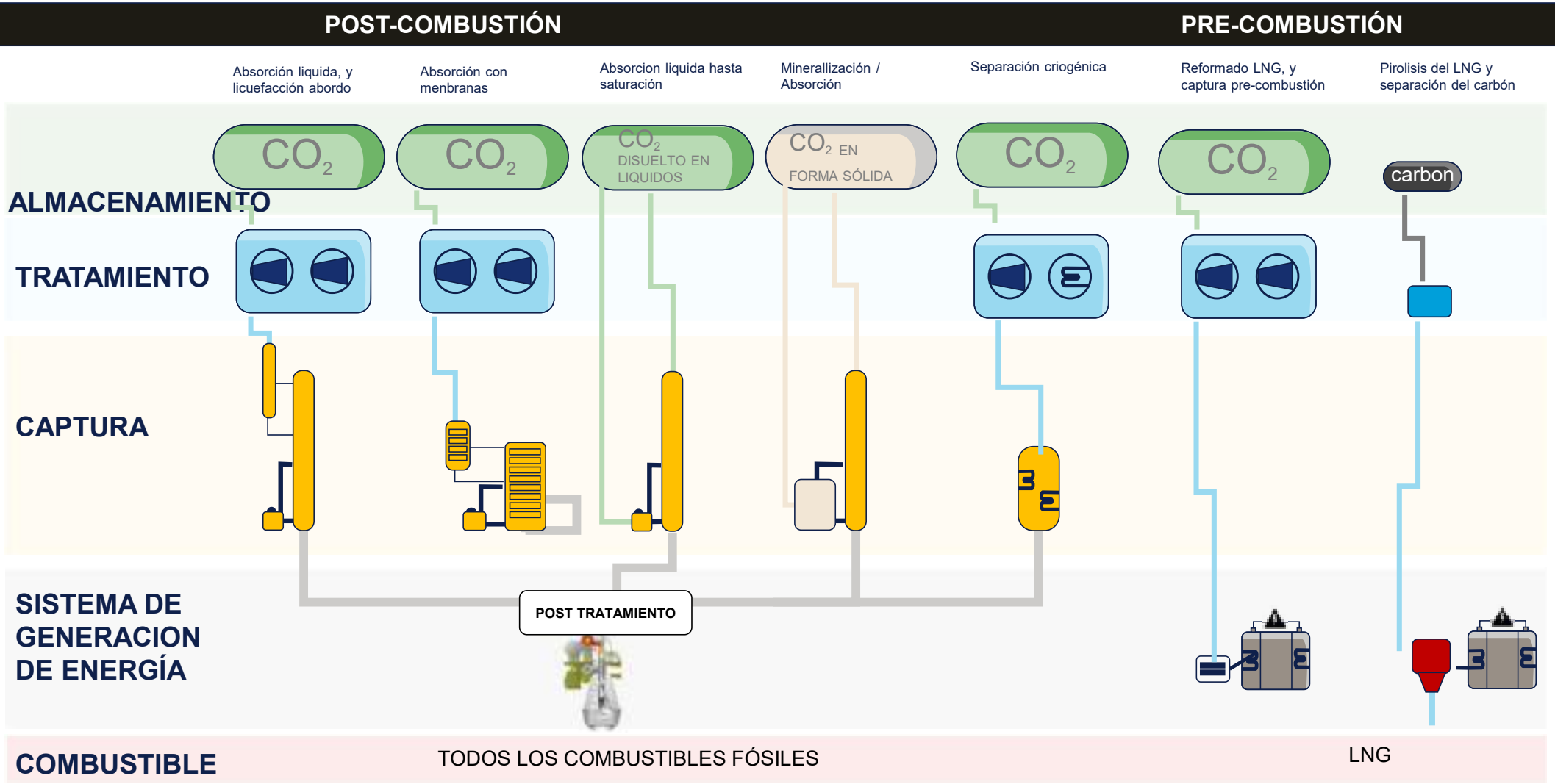
Comparativa
Entrega


POST-COMBUSTIÓN
PRE-COMBUSTIÓN
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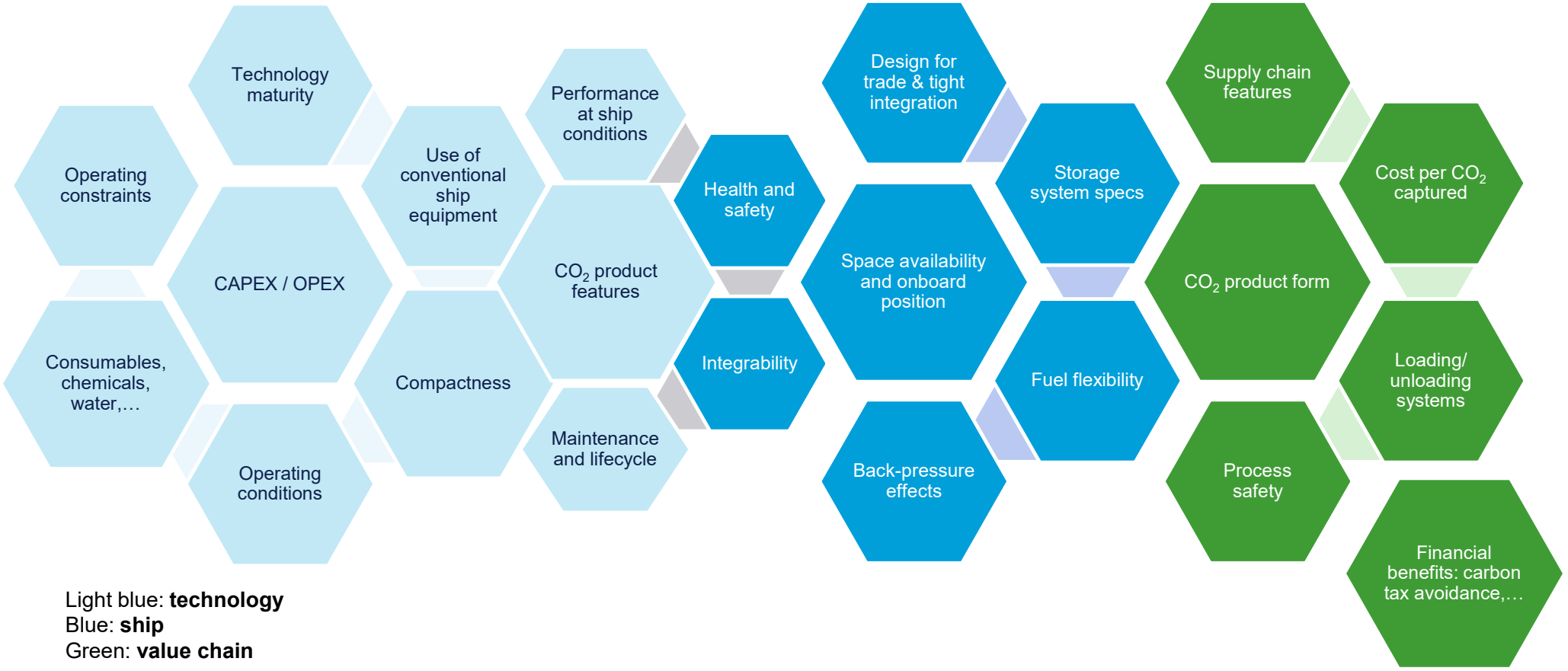
Absorción con menbranas
Absorcion liquida hasta saturación
Minerallización / Absorción
Separación criogénica
Reformado LNG, y captura pre-combustión
Pirolisis del LNG y separación del carbón
CO2
CO2
CO2 DISUELTO EN LIQUIDOS
CO2 EN FORMA SÓLIDA
CO2
CO2
carbon
ALMACENAMIENTO
TRATAMIENTO
CAPTURA
SISTEMA DE GENERACION DE ENERGÍA
POST TRATAMIENTO
COMBUSTIBLE
TODOS LOS COMBUSTIBLES FÓSILES
LNG

Factores clave!

Toma de decisions: Que opción elegir, y por que no es una decision facil de tomar

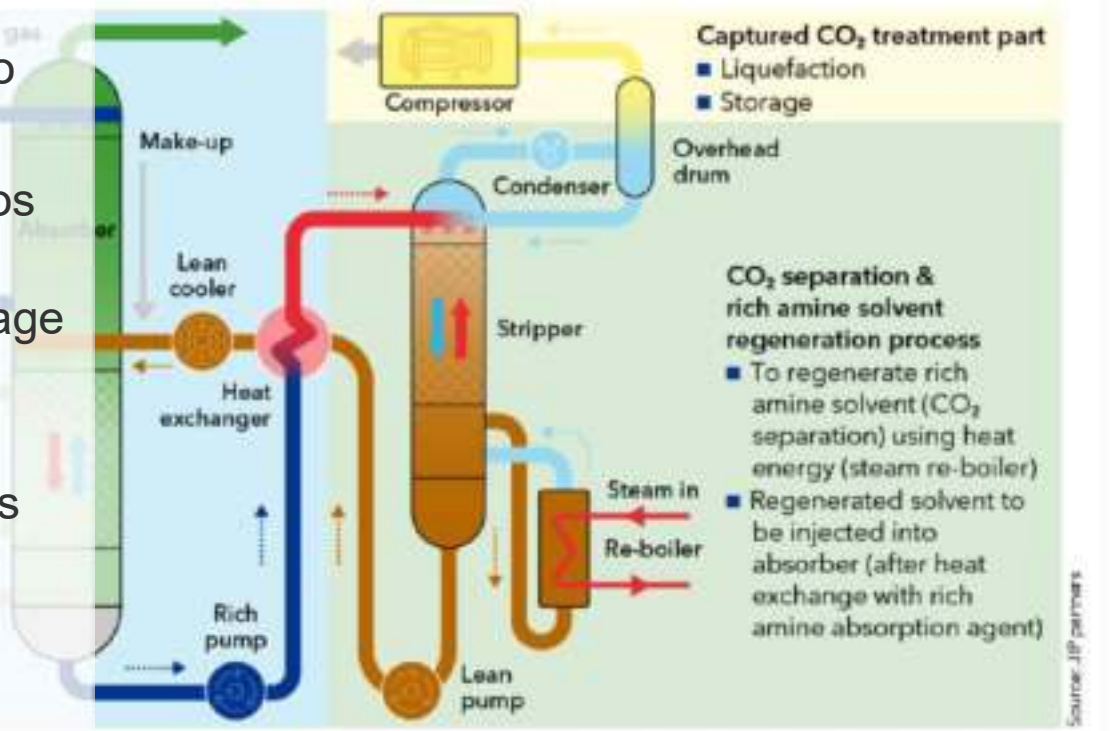


Light blue: **technology**
Blue: **ship**
Green: **value chain**

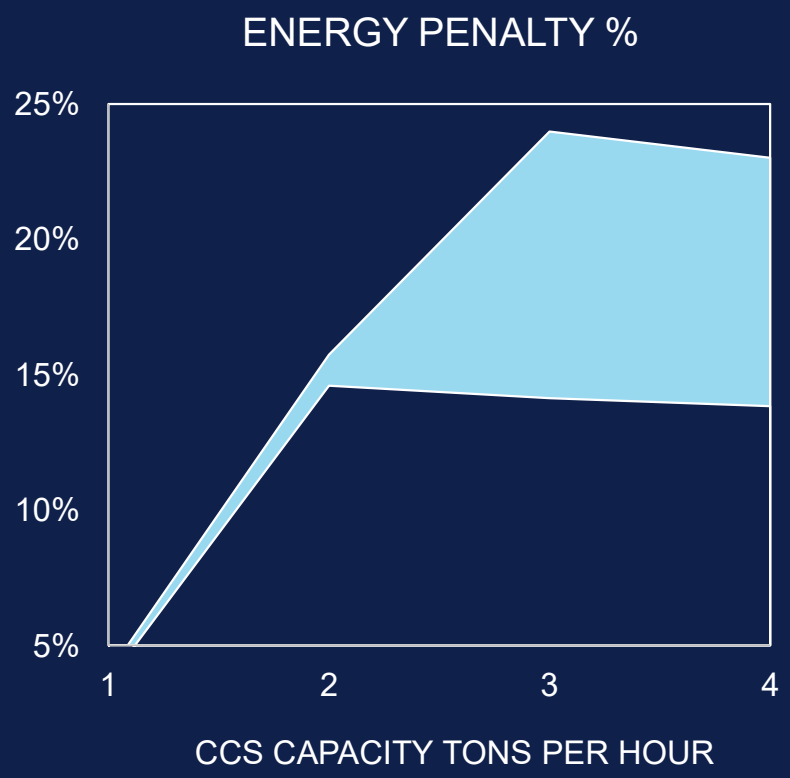
Viabilidad y Optimización de la Tecnología

Optimizar el percentage de captura, para máximo beneficio y mínimo empacho

- TRL 9 en instalaciones en tierra
- Funcionamiento con gases pobres en carbono
- Sensibles a las impurezas
- Demanda de espacio y energía depende de los disolventes
- Su huella de carbono depende de su percentage de captura
- Se necesitan energía y calor
- Se necesitan agua dulce y productos químicos
- CO2 obtenido en forma gaseosa
- Necesidad de almacenamiento y gestion del CO2 de forma temporal



Energy penalty

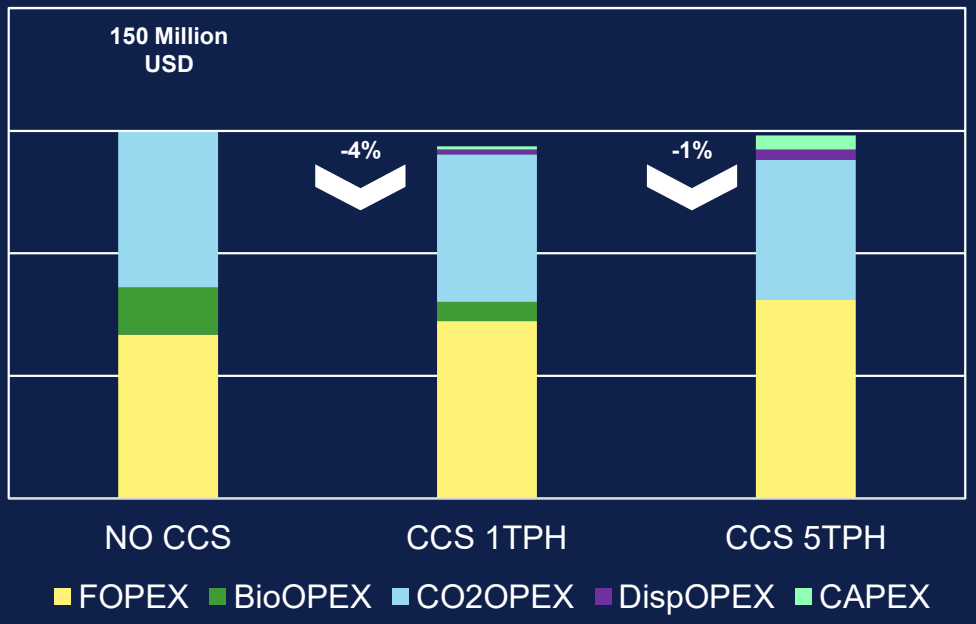


Consumos
Emisiones
Comparativa entre tecnologías
Capacidad de la planta
% de captura de CO2
Gasto anual
Rendimiento en viajes

DNV

Comparativa con otros combustibles

COMPARATIVA DE GASTO PARA EL CICLO DE VIDA



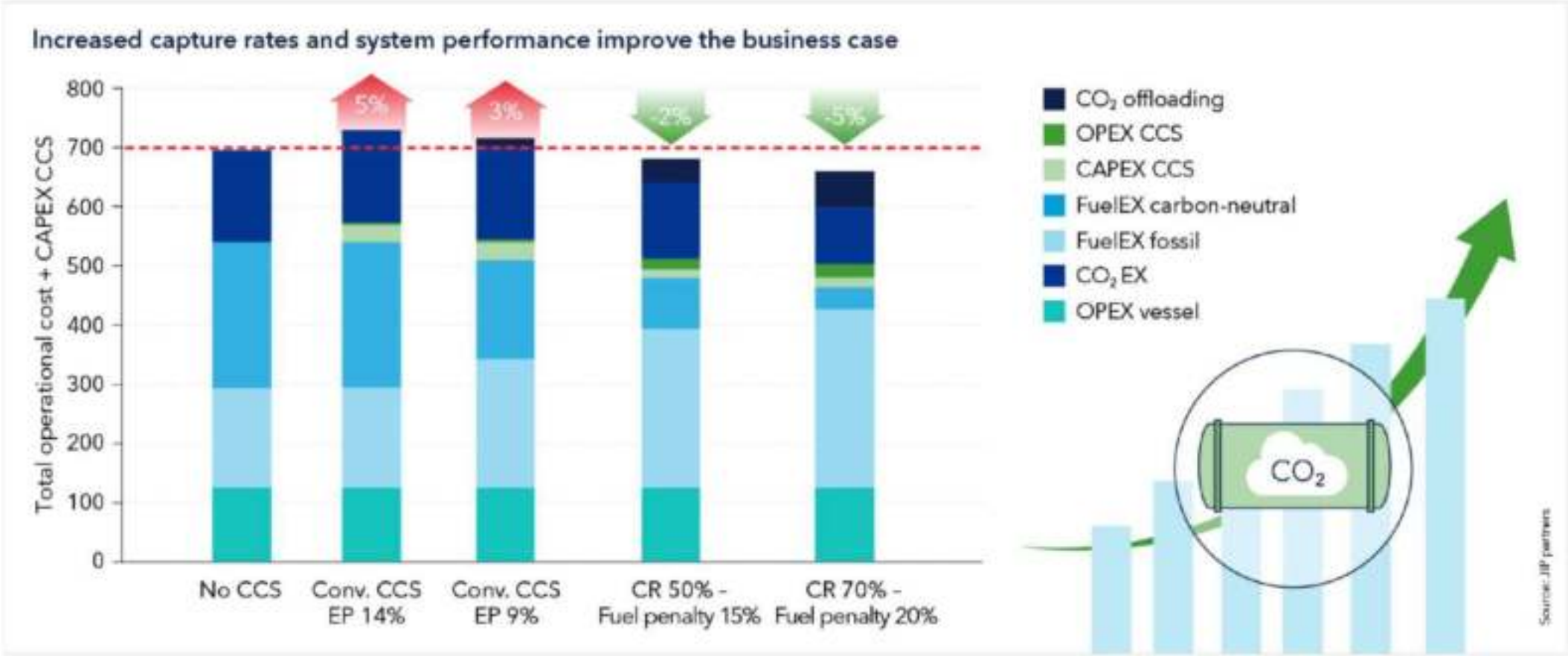
Ship & trade

GHG targets

CO_2 Technologies

- Consumos
- Emisiones
- Comparativa entre tecnologías
- Capacidad de la planta
- % de captura de CO2
- Gasto anual
- Rendimiento en viajes

DNV



What conditions would make CCS a good business case for this ship? A better performing, reasonably priced CCS system and more powerful CO2 solvents will greatly improve the business case. CCS system manufacturers should be incentivized to continue research and development of shore-based CCS technology, improving performance parameters, maximizing capture rates, upscaling production, and making systems cheaper and smarter. A more mature CCS technology will greatly benefit the maritime industry. A logistics and value chain including in-port offloading infrastructure for captured, liquefied CO2 is of utmost importance. CCS hubs are planned or being built at many ports; however, for CCS to succeed, low offloading costs are crucial and should be ensured by governments as part of their national decarbonization strategies.


Estado del arte
Servicios de DNV
Cumplimiento
Comparativa
Entrega

Almacenamiento hasta su descarga

Licuefacción & almacenamiento en tanques tipo C

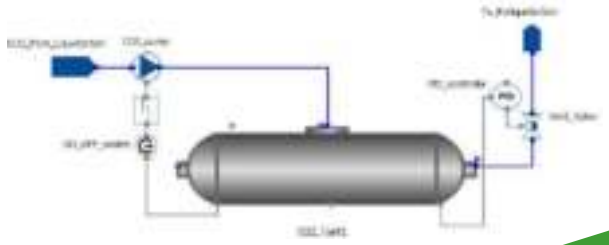
Absorción líquida, membranas, Max presión 18~20bar para CO_2 carriers

Estado sólido

Absorción química

Estado gaseoso

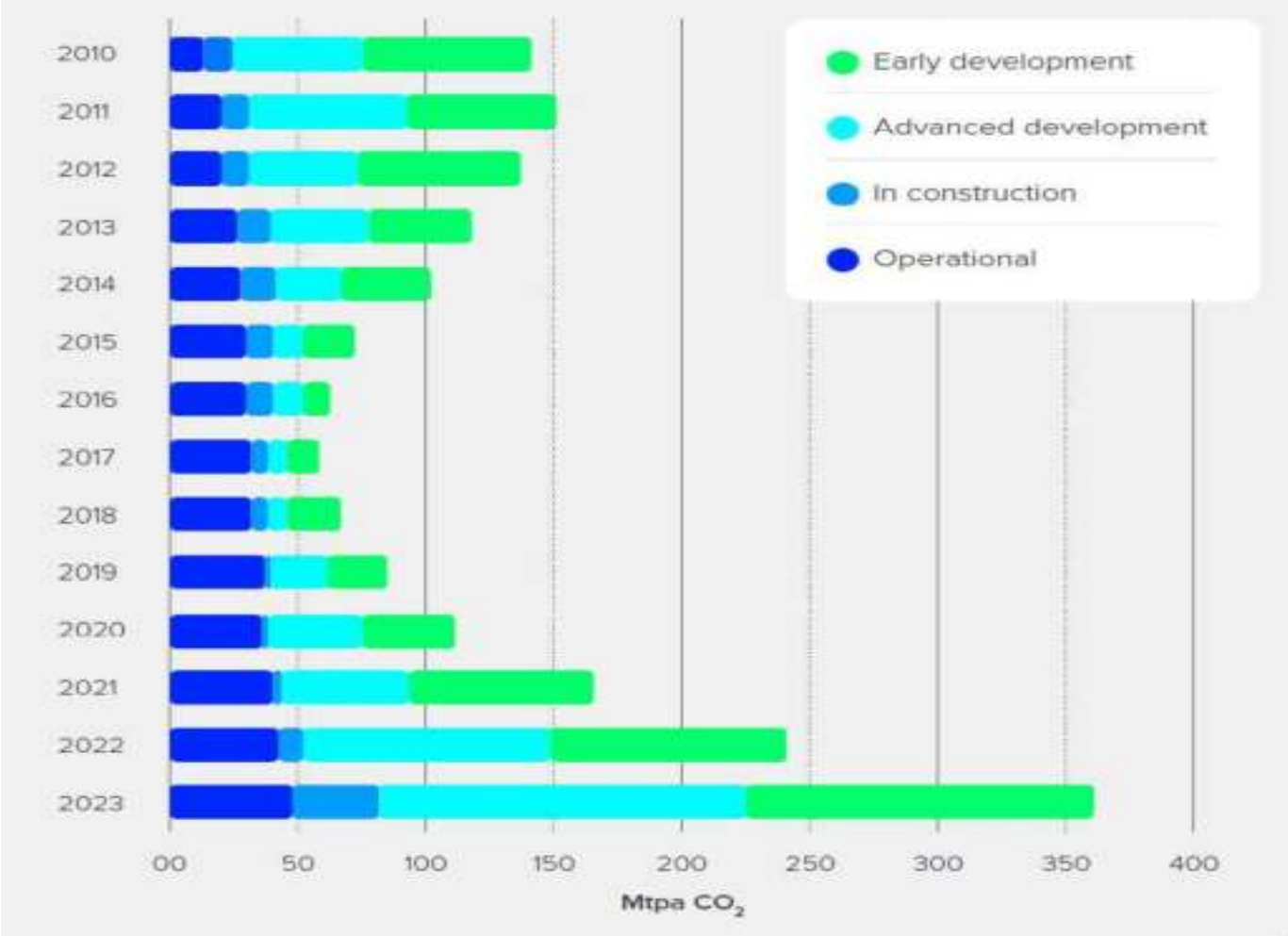
Comprimido/rutas cortas



La decision depende de la seguridad, el costo, la ruta, y la cadena de valor

Proyectos en Desarrollo de CCS en todo el mundo

Global picture: CCUS project pipeline

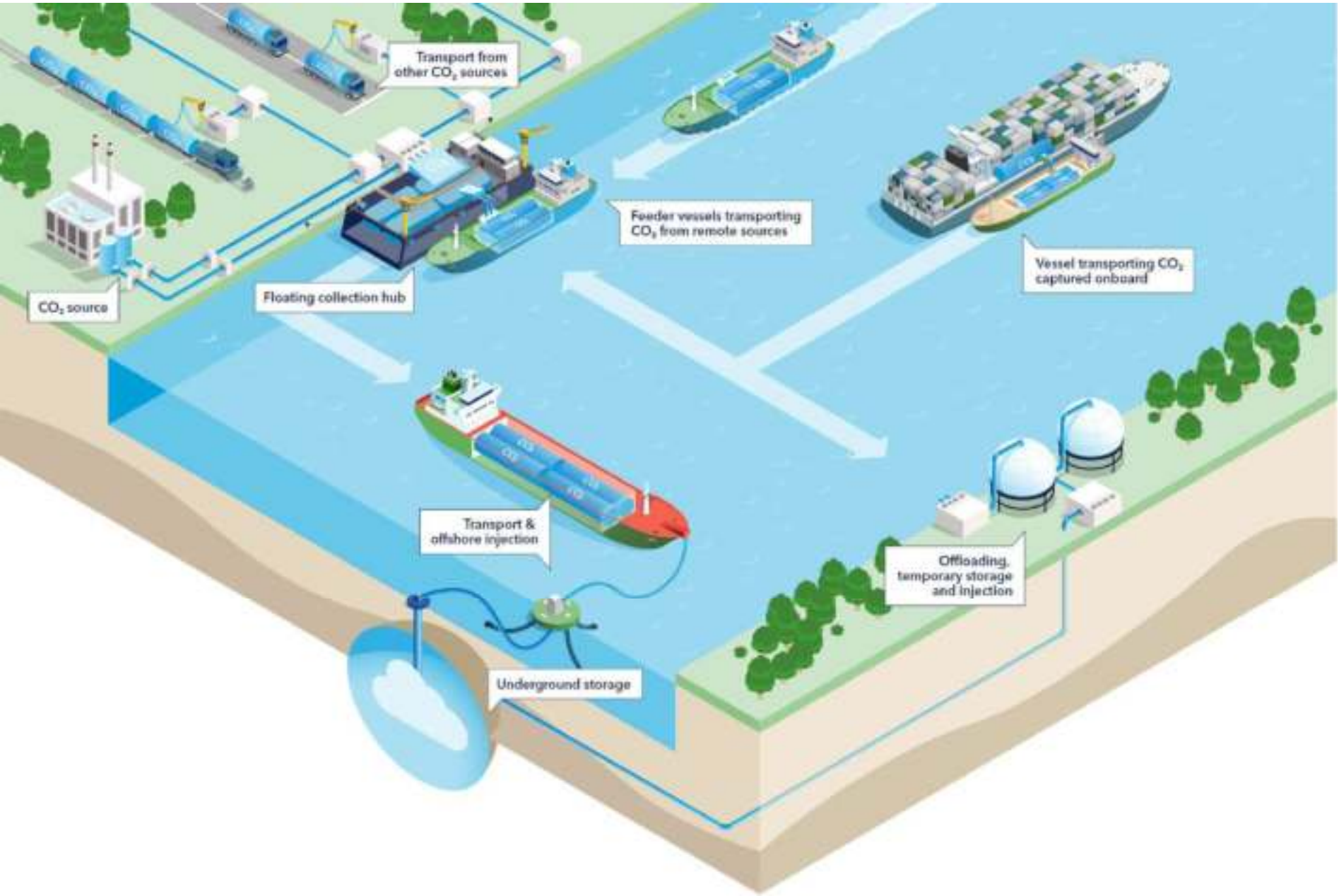


- El ritmo del Desarrollo del mercado aumentó significativamente a partir de 2020
  - El numero de proyectos en fase avanzada es un buen indicador
  - Notese el descenso en 2012-2015 debido a la crisis financiera, y el desplome del precio del CO2 (EU).
  - El transporte en buques del CO_2 es muy importante, pero todavía incierto a largo plazo

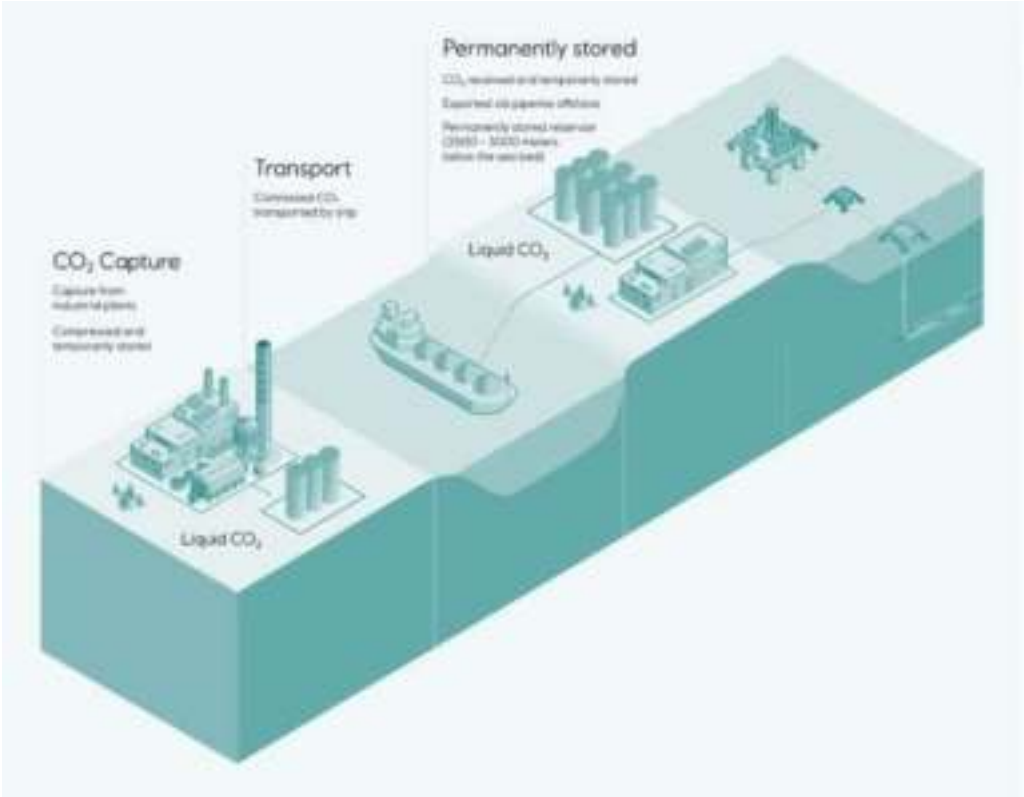
Zion market research:

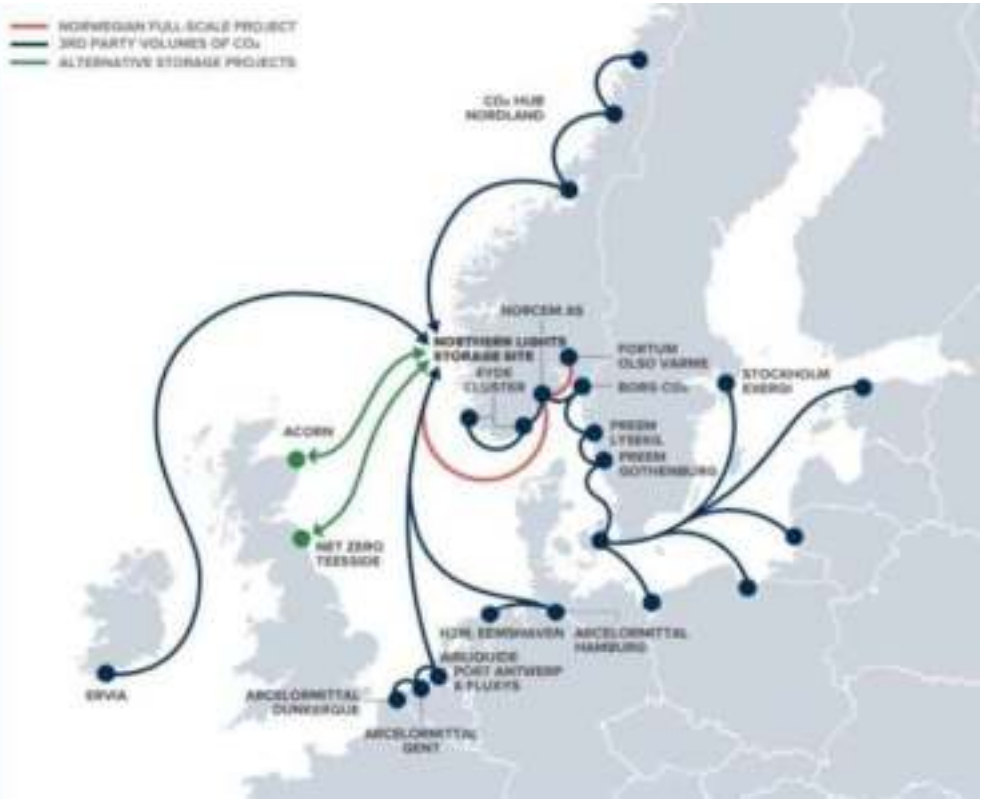
- Según Zion Market Research, el mercado de CCUS se va a triplicar entre 2022 y 2030

GCCSI: Global Status of CCS 2023


Transport from other CO_2 sources
Feeder vessels transporting CO_2 from remote sources
Vessel transporting CO_2 captured onboard
CO_2 source
Floating collection hub
Transport & offshore injection
Offloading, temporary storage and injection
Underground storage

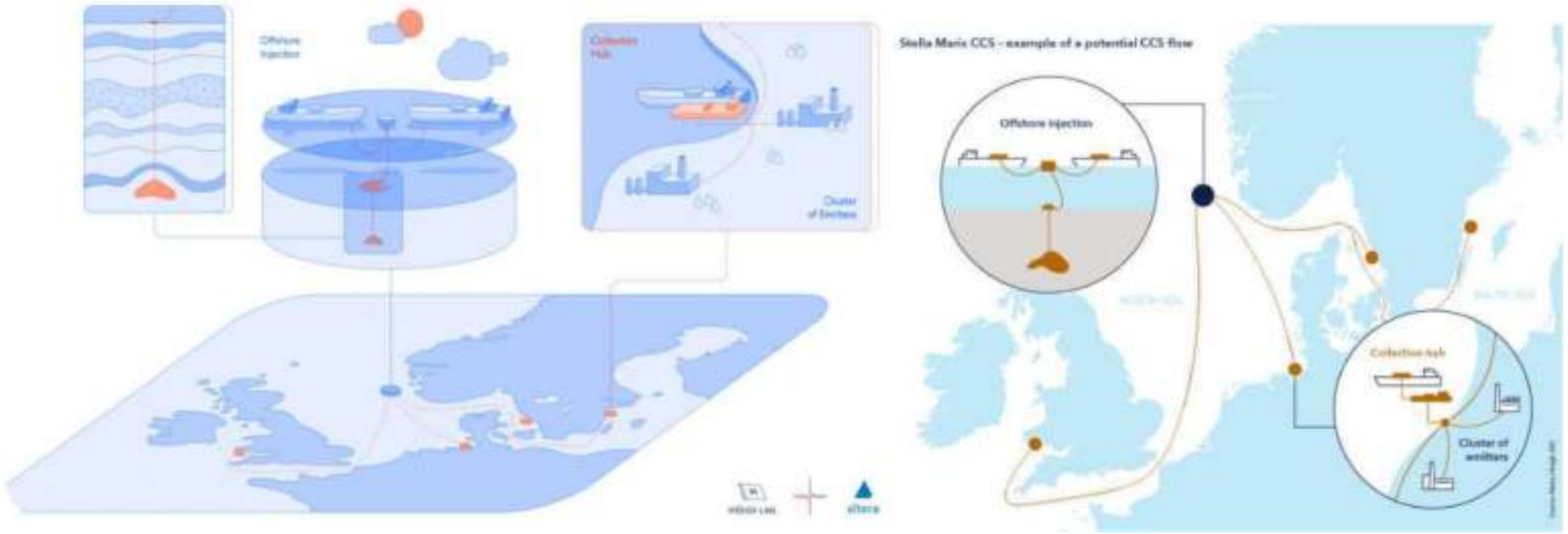
Northern Lights



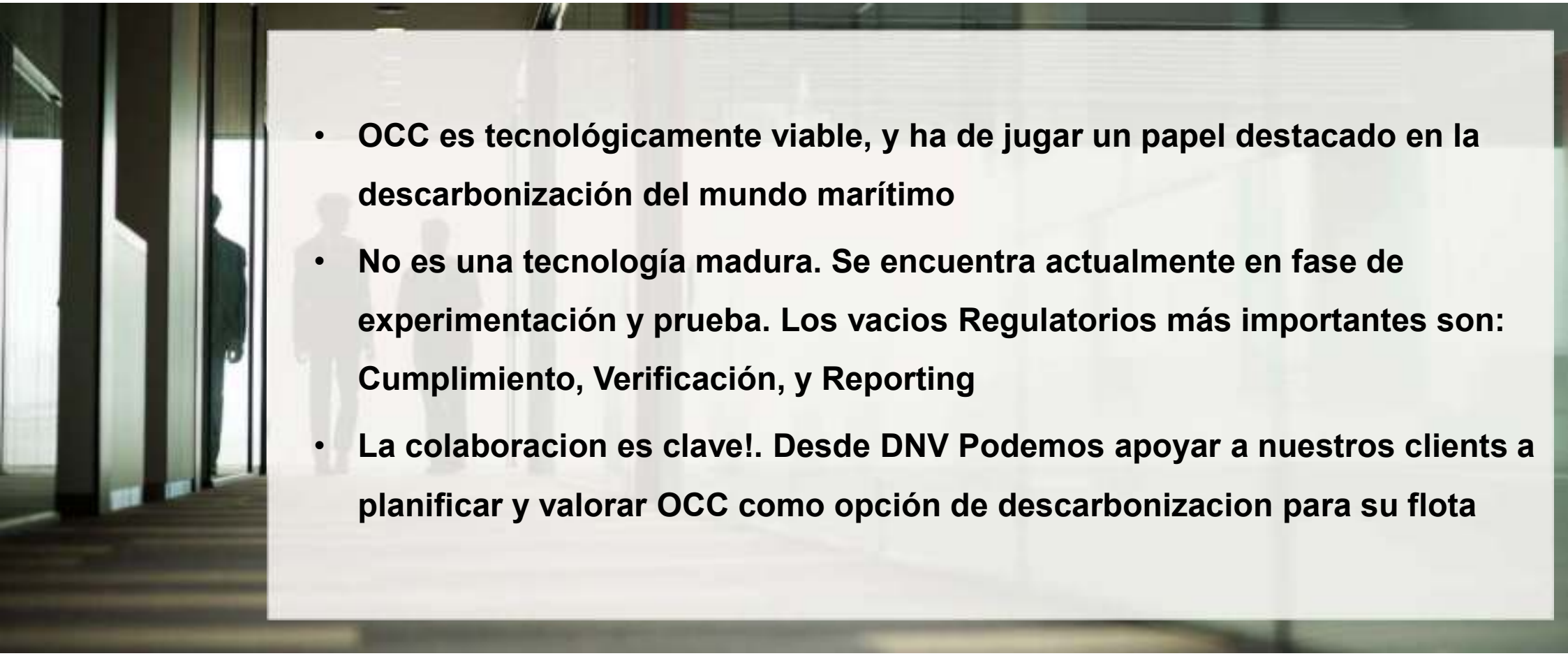


Courtesy of Northern Lights

Stella Maris
Altera Infrastructure and Höegh LNG



En resumen:



- **OCC es tecnológicamente viable, y ha de jugar un papel destacado en la descarbonización del mundo marítimo**
- **No es una tecnología madura. Se encuentra actualmente en fase de experimentación y prueba. Los vacios Regulatorios más importantes son: Cumplimiento, Verificación, y Reporting**
- **La colaboracion es clave!. Desde DNV Podemos apoyar a nuestros clients a planificar y valorar OCC como opción de descarbonizacion para su flota**

WHEN TRUST MATTERS

Muchas gracias

Jose Allona, BDM

Jose.allona@dnv.com

+34 607 517305

www.dnv.com

Important physical properties affecting CO_2 transportation

- Current maritime transportation of CO_2 is exclusively for commercial trade (food and beverage, cleaning, chemical). Limited volumes, served by a fleet of handful smaller ships with cargo capacities in the range of 1200 to 1850 m3
- Transported in liquid form at operating pressures of 13 to 15 barg at temperatures between -22 to -28°C, often referred to as medium pressure conditions
- As a larger transportation demand/quantities of CO_2 is expected to increase in the future (e.g., related to CCS), it is likely that the cargo will be transported at lower operating pressures (e.g., at about 7 to 8 barg and temperature of -50 to -55°C). This is often referred to as low pressure conditions
- This implies that the CO_2 is transported in a state closer to the triple point, which is expected to increase the risk of solid CO_2 formation (dry ice), clogging of pipes, valves, etc.