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ENABLING FUTURE FUELS – Infrastructure from Research to Deployment

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4TU+
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The energy system today

Reliable and mature, but dominated by molecules with a high carbon footprint



Centralised supply

Large production sites, terminals and long-distance transport.

Established assets

Pipelines, tanks and compressor stations built around known fluids.

Transition pressure

Decarbonisation changes the product, condition and duty of assets.

The emerging multi-energy economy

Electricity, hydrogen, CO_2, conventional fuels and other emerging fuels must operate as one connected system



Distributed supply

Wind, solar and electrolysers feed hydrogen, ammonia and CO_2 chains.

Reused and new assets

Existing pipelines and tanks are repurposed or joined by new build.

Integration challenge

Several fluids share corridors and sites, raising new safety questions.

Infrastructure is the transition enabler

Physical assets turn energy technologies into dependable services

Without qualified infrastructure, future fuels remain isolated technologies rather than dependable energy systems.



Connect

Link energy production, storage and end users across locations and sectors



Buffer

Balance variations in energy supply and demand through storage and system flexibility.



Scale

Transport and store large energy volumes safely, reliably and cost-effectively.



Derisk

Reduce technical and operational uncertainty through redundancy, monitoring and integrity management.

A lifecycle view of physical assets

Future-fuel readiness must be managed from concept to retirement

Plan

service, route, duty

Design

materials, safety, inspectability

Build / convert

quality and commissioning

Operate

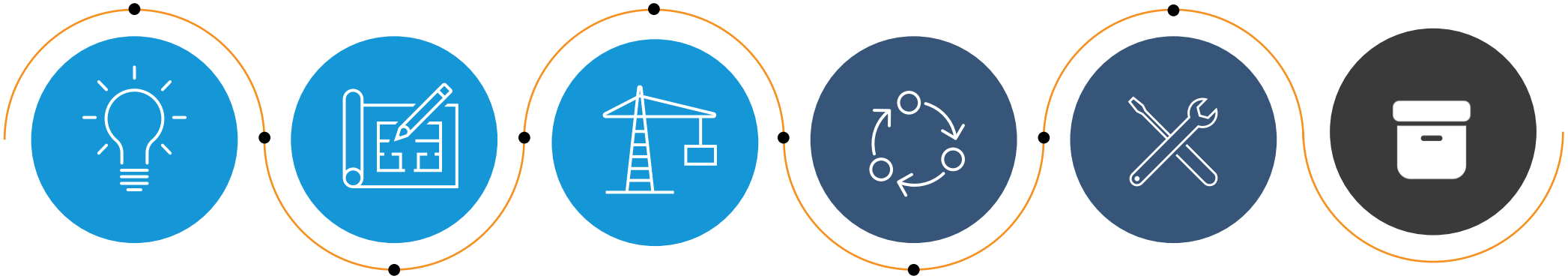
monitor, inspect, reassess

Intervene

repair, rehabilitate, uprate

Retire

isolate, reuse, decommission



Create: plan, design, build

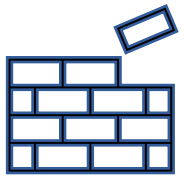
In service: operate, intervene

End of life

Build or reuse

Infrastructure for future fuels needs adaptation or new assets

Build new when the existing system cannot meet future requirements. Reuse when existing assets can be demonstrated to be fit for the new service.



To build?

Fit-for-purpose

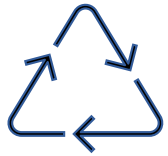
Designed specifically for the new fuel, pressure, capacity and operating conditions.

Higher confidence

Known materials, weld quality and condition, with modern safety and inspection requirements built in.

New capacity / corridors

Needed where existing infrastructure does not provide the required route, capacity or functionality.



To reuse?

Lower investment

Avoids replacing assets that may still be technically suitable.

Faster deployment

Existing pipeline corridors, facilities and connections can reduce the amount of new infrastructure required.

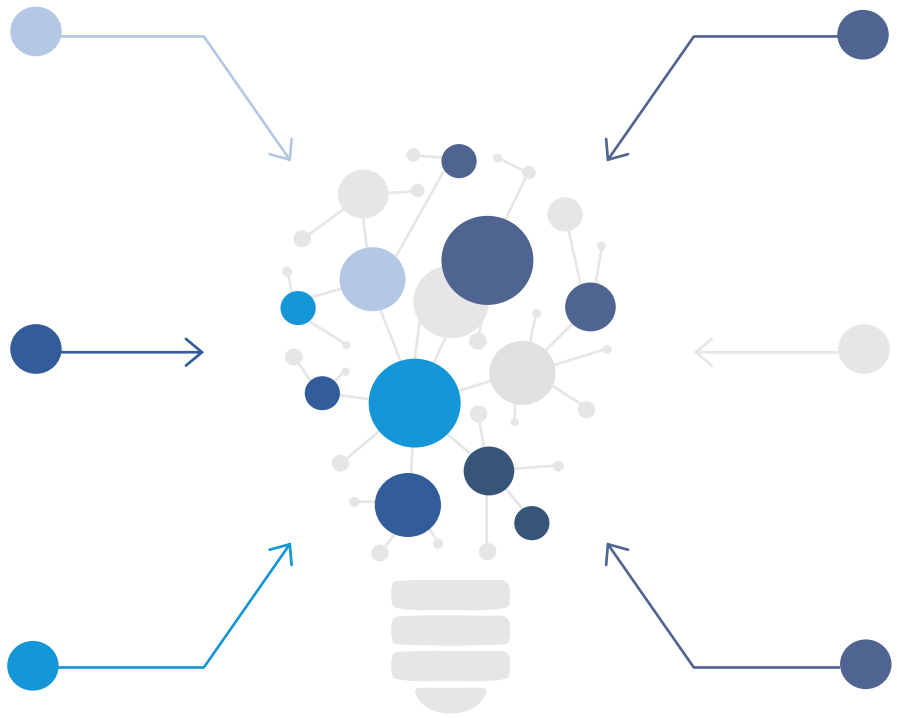
Lower environmental footprint

Extends the useful life of existing assets and reduces new construction and material demand.

Data supports the build-or-reuse decision

New-build defines what the future asset must be. Reuse must prove what the existing asset can safely become.

NEW-BUILD → RESEARCH & DATA ← REUSE



Materials

What materials are compatible with H_2 / CO_2 / future fuels?

Design

What pressure, loading and safety criteria are required?

Technology

How do we design for inspection, monitoring and repair?

Condition

What is the actual condition of the existing asset?

Compatibility

How will the material and existing defects behave in the new service?

Remaining Life

Can the asset operate safely, and what mitigation or monitoring is required?

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01

Challenges

Understanding the risks

02

Research and development

Finding solutions

03

Deployment

Operating and managing infrastructure

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Industry threats that already exist

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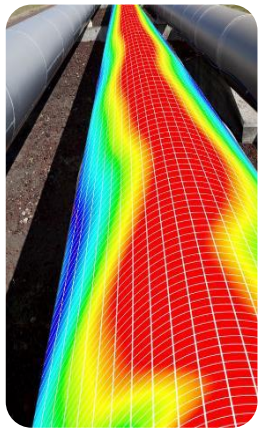


Emerging fuels introduce additional threats

New fuels like H_2, CO_2 and NH_4 change material behaviour, threats, consequences and operating requirements.

Existing threats do not disappear. Emerging fuels add new mechanisms, interactions and risks that must be understood before assets are built or reused

Operational requirements of the network





Flow Rate



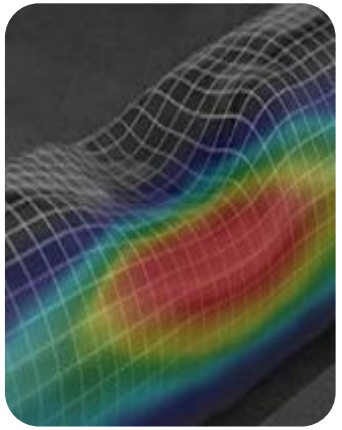
Pressure

Consequences and risk assessment



Effects of new fuels on material properties

Toughness, ductility and fatigue resistance



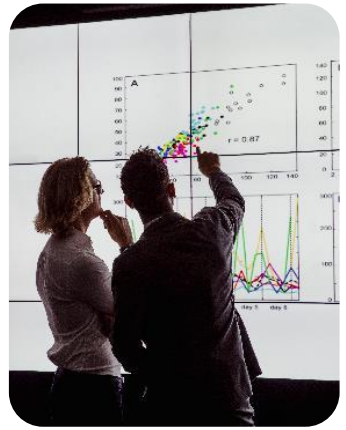


Loading



Material Specification

Impact of new fuels on implied safety factors

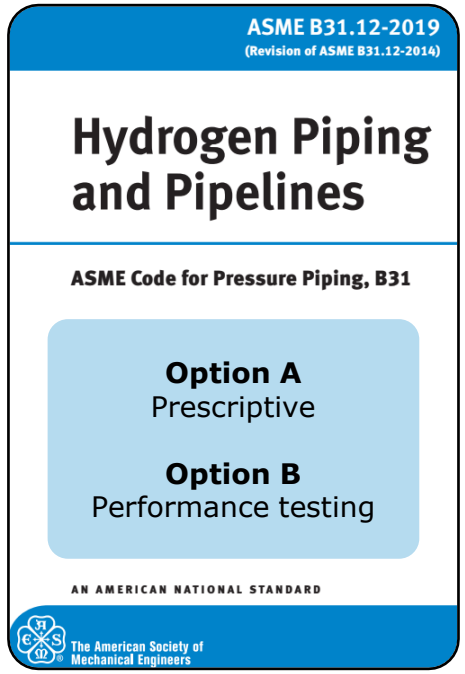




New fuel specific Asset Integrity Management Plan

Current codes may become over/under conservative

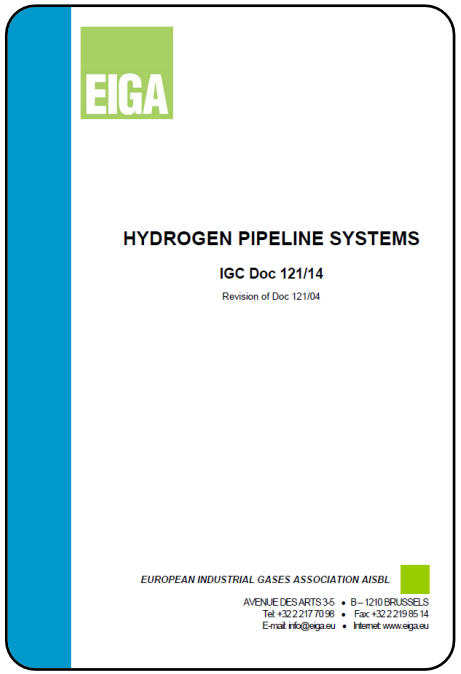
Limited evidence can lead to generic requirements that may not be proportionate to the condition of an asset.



A minimum of one sample per 1.6 km (1 mi) should be examined."

It is recommended that only **lower strength API 5L grades (X52 or lower) be used**..

Design factor of 0.4 - 0.5 is recommended



If original material data reports for the pipeline are missing, internal inspection is required to supplement data obtained from samples.

The process of determining and assessing defects is defined in ASME B31.8S, titled, "Managing System Integrity of Gas Pipelines".

Metallurgical notches may result in even more severe stress concentrations than a mechanical notch and shall be prevented or eliminated in all pipelines intended to operate at hoop stress levels of 20% or more of the SMYS.

Practicality and cost-effectiveness are questionable

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Research Enabling Safe Design & Installation

Design practices developed for conventional fuels cannot always be transferred directly to new fuels

The design and construction challenge is not simply moving a new fuel. It is understanding how the new service changes the requirements for materials, equipment, layout, safety and operation.

MultHyFuel

Safe integration of hydrogen refuelling stations into multi-fuel stations

*Experimental research and regulatory analysis to develop best-practice guidance for **design and operation**, safety recommendations and permitting.*

tunnel HP

CO_2PipeHaz

Mechanism on releases, dispersion, fires and explosions

Investigated ventilation strategies and the effectiveness of conventional safety installations, including prevention and mitigation measures

CO_2 Europipe

Designing safe large-scale CO_2 transport infrastructure

Research covering transport network design, CO_2 standards, pipeline risk management, offshore pipeline design and opportunities for reuse of existing pipeline infrastructure.

Research Enabling Safe Operation & Integrity

Operational practices established for conventional fuels must be adapted for future fuels

Multiple research initiatives are supporting the evolution of operational and integrity practices for hydrogen and CO_2 service.

PilgrHym

groen vermogen nl

HyTROS

H2 PORTS

Encase

Hydrogen Underground Storage in Porous Reservoirs HyUSPRe

HIGGS Hydrogen in Gas Grids

HyDelta

“Can we operate, inspect and maintain it safely throughout its life?””

Research spans the entire infrastructure chain:

- Production and storage
- Processing
- Transport
- Terminals
- Inspection, operation and integrity management

Research partnerships advancing future-fuel infrastructure

Research partnerships are developing the evidence required for safe future-fuel infrastructure.













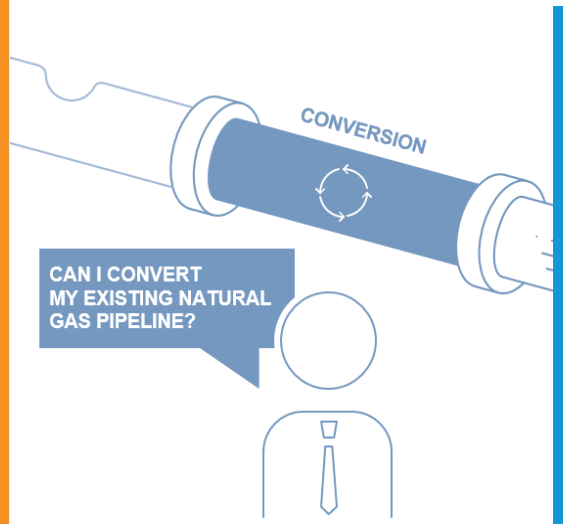




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Research partnerships advancing future-fuel infrastructure

ROSEN translates research into practical solutions for the safe reuse and operation of future-fuel infrastructure.



Pipeline repurposing

Assessing whether existing natural-gas pipelines can be safely reused.



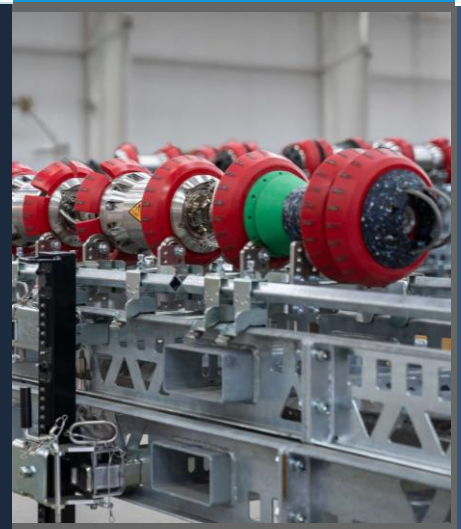
Integrity management

Developing assessment methods, operating limits and mitigation strategies.



Pipeline Inspection

Inspection technologies to detect and size fuel-specific defects.



Material testing

Generating data on material compatibility under representative service conditions.

ASME
SETTING THE STANDARD

EPRG

Standardization

Translating research findings into validated methods, recommended practices, codes and standards.

01

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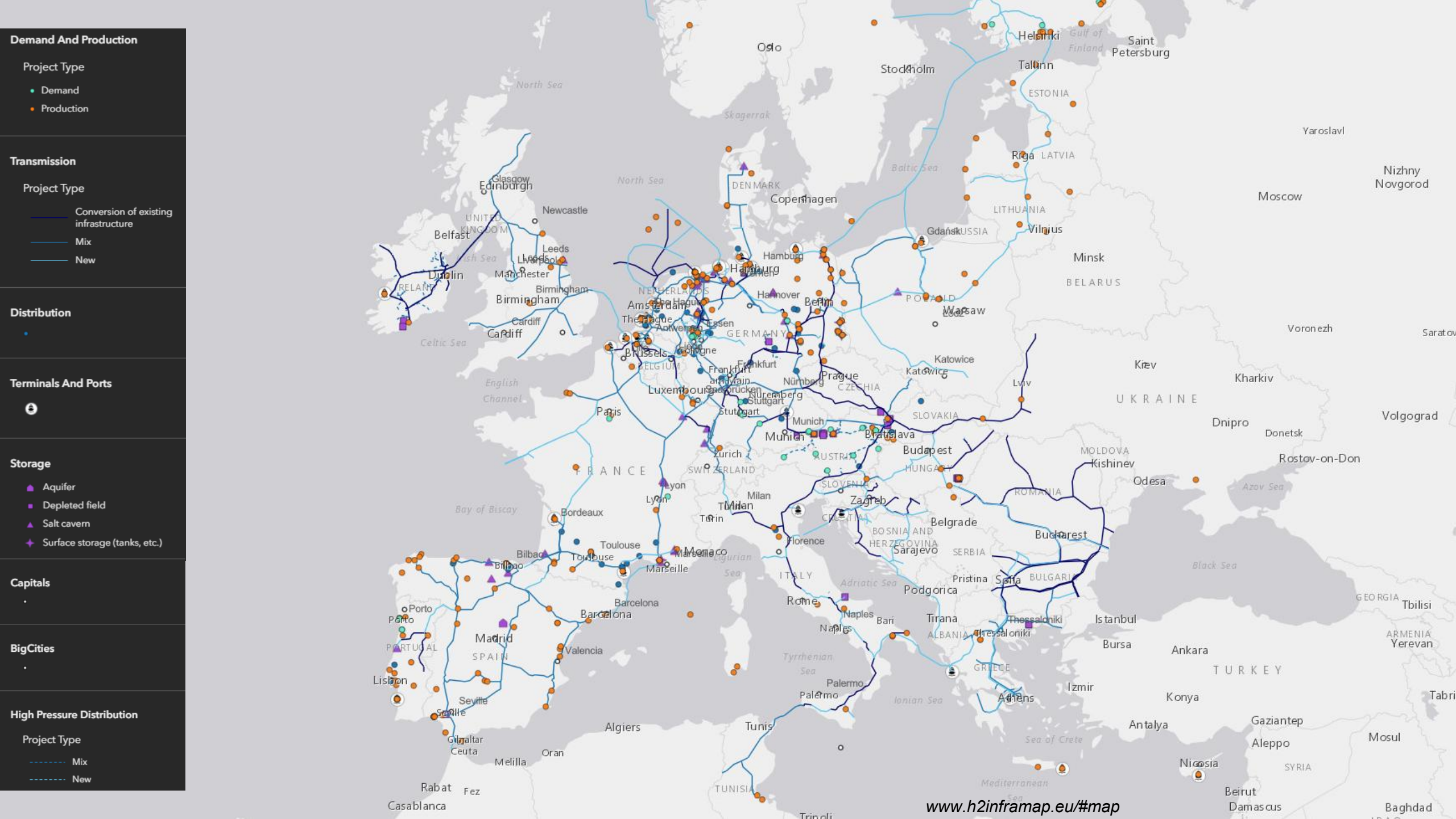
Research and development

Finding solutions

03

Deployment

Operating and managing infrastructure


Demand And Production
Project Type
Demand
Production
Transmission
Project Type
Conversion of existing infrastructure
Mix
New
Distribution
Terminals And Ports
Storage
Aquifer
Depleted field
Salt cavern
Surface storage (tanks, etc.)
Capitals
BigCities
High Pressure Distribution
Project Type
Mix
New
Oslo
Stockholm
Helsinki
Saint Petersburg
Tallinn
ESTONIA
Riga
LATVIA
Yaroslavl
Nizhny Novgorod
Moscow
Vilnius
LITHUANIA
Minsk
BELARUS
Gdańsk
RUSSIA
Copenhagen
DENMARK
Edinburgh
Glasgow
Newcastle
Belfast
Dublin
Leeds
Manchester
Birmingham
Cardiff
Hamburg
Hannover
Berlin
Amsterdam
The Hague
Antwerp
Essen
Cologne
Brussels
Frankfurt
Nürnberg
Stuttgart
Prague
Katowice
Warsaw
Łódź
Lviv
Kyiv
Kharkiv
Voronezh
Saratov
Volgograd
Dnipro
Donetsk
Rostov-on-Don
Luxembourg
Paris
Munich
Zurich
Bratislava
Budapest
Kishinev
Odesa
Azov Sea
Black Sea
Lyon
Milan
Turin
Zagreb
Belgrade
Bucharest
Florence
Sarajevo
Pristina
Sofia
Podgorica
Rome
Naples
Bari
Tirana
Thessaloniki
Istanbul
Bursa
Ankara
Izmir
Konya
Antalya
Athens
Gaziantep
Aleppo
Mosul
Nicosia
Beirut
Damascus
Baghdad
Tbilisi
Yerevan
Bordeaux
Toulouse
Bilbao
Marseille
Monaco
Barcelona
Porto
Madrid
Valencia
Lisbon
Seville
Gibraltar
Ceuta
Melilla
Oran
Algiers
Tunis
Palermo
Rabat
Fez
Casablanca
Tripoli
North Sea
Baltic Sea
Skagerrak
Celtic Sea
English Channel
Bay of Biscay
Ligurian Sea
Adriatic Sea
Tyrrhenian Sea
Ionian Sea
Sea of Crete
Mediterranean Sea
Gulf of Finland
FRANCE
BELGIUM
NETHERLANDS
GERMANY
SWITZERLAND
AUSTRIA
CZECHIA
SLOVAKIA
HUNGARY
SLOVENIA
ROMANIA
MOLDOVA
UKRAINE
BULGARIA
SERBIA
BOSNIA AND HERZEGOVINA
ALBANIA
GREECE
TURKEY
SYRIA
TUNISIA
PORTUGAL
SPAIN
IRELAND
UNITED KINGDOM
www.h2inframap.eu/#map

Waterstofnetwerk 2030 en verder

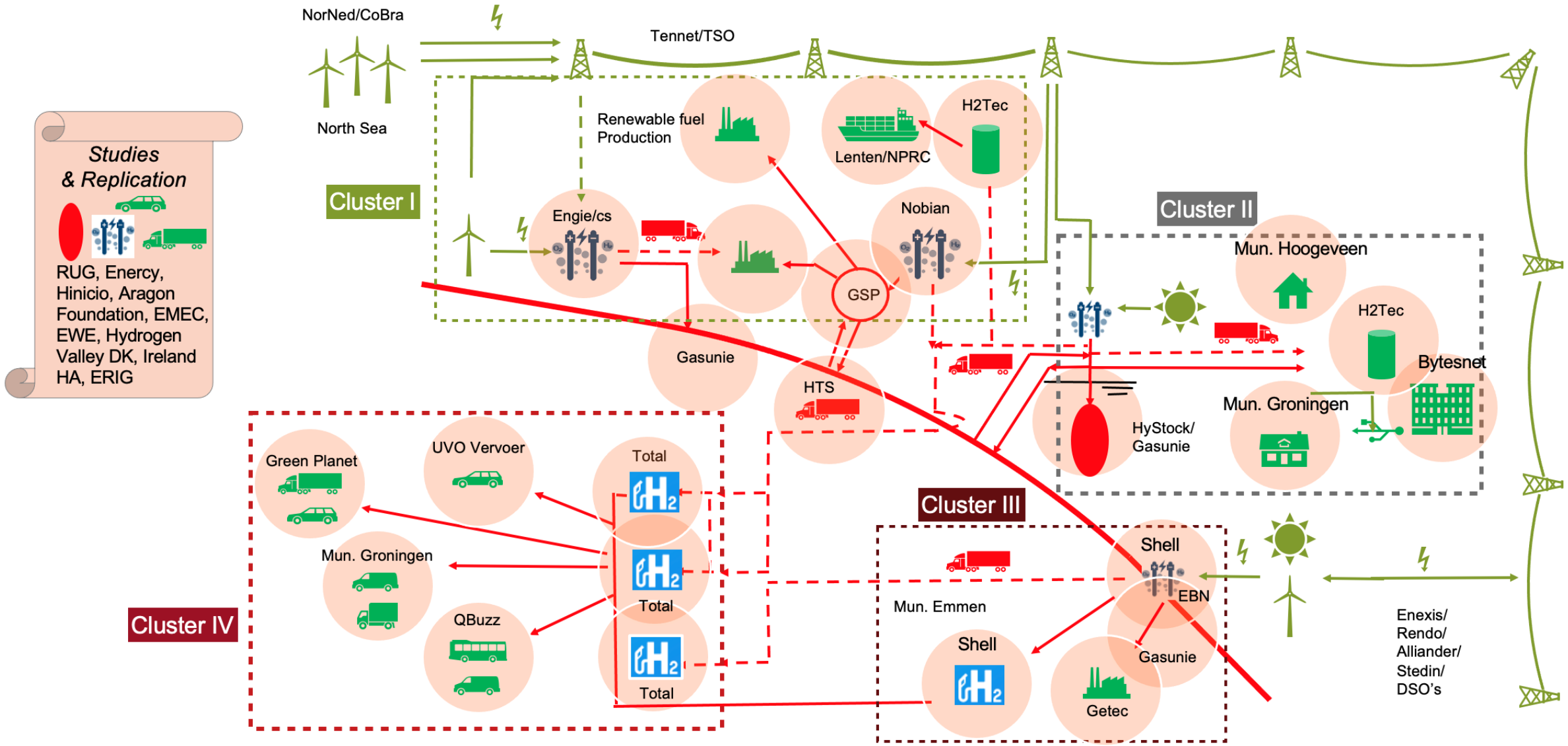


- Waterstofnetwerk
- Potentieel (offshore) waterstofnetwerk
- Industriecluster
- Import
- Waterstofopslag (zoutcaverne)
- Importterminal

Juni 2023

HYNETWORK
SERVICES

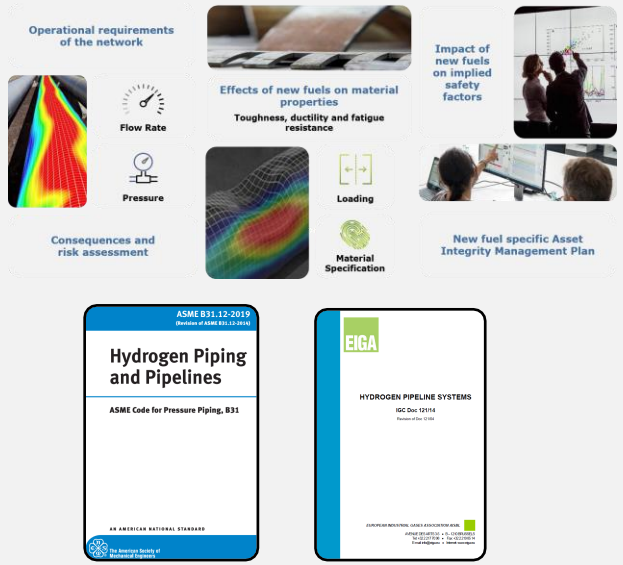
H2 Energy Applications in Valley Environments for Northern Netherlands




CO_2 HUB ROTTERDAM
Gateway to the North Sea
P18-4 STORE
P18-2 STORE
ARAMIS
Q16-FA STORE
Porthos
CO2NEXT
OCAP PIPELINE
CO_2 TRANSPORT BY SHIP
CO_2-SYSTEM MAASVLAKTE
EVOS/VALUE CARBON
CHANE CO_2 TERMINAL
DELTA RHINE CORRIDOR
MOERDIJK
DELTA SCHELDE CO_2NNECTION
gasunie
crossing borders in energy
ebn
Port of Rotterdam

Challenges

01



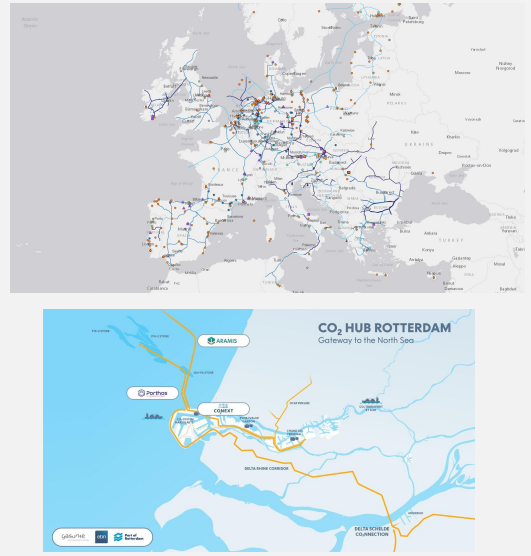
Research & Development

02



Deployment

03



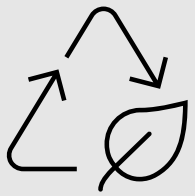
Final words

Infrastructure is where the energy transition becomes physical

The question is not only whether a new fuel can be produced.

The question is whether it can be transported, stored and operated SAFELY at scale.

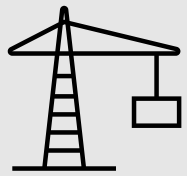
01



REUSE

where evidence supports it

02



BUILD

where uncertainty or constraints dominate

03



LEARN

Through continuous monitoring

ROSEN Group – At a Glance

We are a global technology group. We enable asset owners to make the best decisions for the performance, integrity and lifetime extension of assets. For over **40 years**, we have delivered insights, innovative solutions and outstanding services based on our expertise in multiple technology areas, combined with our advanced digital and AI-based capabilities.

ROSEN worldwide



4000+	Employees worldwide
75+	Nationalities working together
25+	Locations worldwide
110+	Countries in which we operate

Our Customers

Operators of industrial assets who aim to safely and reliably transport large volumes of fluids, such as oil and gas.

Our Markets

Our market includes more than 2,000,000 km of oil and gas and pipelines worldwide as well as many other assets (storage tanks, pressure vessels, etc.).

Key Facts

- **40+** years of experience
- **1M+** miles of inspected pipelines
- **26T+** pipelines are stored in our database
- **10** UN Sustainable Development Goals (SDGs) are in our focus