

Inclusion of electrolysers in refineries

What REFHYNE 2 and Holland Hydrogen 1 have taught us about integrating renewable hydrogen into refining.

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Refineries must cut emissions while remaining competitive.

Reducing emissions

- Significant reduction of refinery emissions required by 2050
- Lower lifecycle carbon intensity of refinery products

Competitiveness

- Remain cost competitive with local refining peers
- Maintain profitability whilst investing in new technologies
- Manage increasing energy, carbon, and compliance costs

AVAILABLE PATHWAYS

Bio-feedstocks | CCS | Electrification | **Renewable hydrogen** | E-fuels

Renewable hydrogen can replace a feedstock that refineries already produce and use at scale.

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Refineries already use hydrogen at scale, so renewable hydrogen can cut emissions using existing demand and infrastructure.

HYDROGEN IS ALREADY ESSENTIAL FOR

- Hydrotreating and hydrocracking
- Sulphur removal
- Production of cleaner transport fuels

Refineries already produce and use hydrogen at scale, with the network and compression in place.

WHAT SWITCHING TO RENEWABLE HYDROGEN GIVES

Cuts refinery emissions

Replaces hydrogen made from natural gas

Uses existing infrastructure

Connects to the refinery hydrogen system

Has demand from day one

Supplies hydrogen already used in refinery processes

Supports RFNBO compliance

Creates value through the refinery route under RED III

> Renewable hydrogen also connects refinery operations more closely to the power system.

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Renewable hydrogen can replace hydrogen made from natural gas, but it requires a different operating model.

HYDROGEN FROM NATURAL GAS

Steam methane reforming



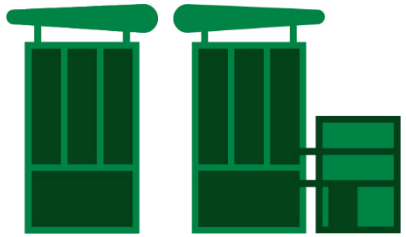
Natural gas + Steam → Hydrogen + CO_2

Produces hydrogen continuously

Produces CO_2 as part of the process

RENEWABLE HYDROGEN FROM ELECTROLYSIS

Water electrolysis



Water + Renewable power → Hydrogen + O_2

Can supply the same refinery hydrogen system

Output varies with electricity availability

> The hydrogen can be used in the same refinery system, but variable renewable power changes how production must be managed.

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Shell is demonstrating two ways to supply renewable hydrogen to a refinery at industrial scale, replacing a portion of fossil-based hydrogen.



DIRECT REFINERY INTEGRATION

REFHYNE 2

100 MW PEM	Brownfield	FID 2024	Operational 2027

Building on the 10 MW REFHYNE 1 project, REFHYNE 2 is expected to supply renewable hydrogen directly into the refinery's existing hydrogen system.



HYDROGEN NETWORK INTEGRATION

Holland Hydrogen 1

200 MW alkaline	Greenfield	FID 2022	Operational 2027

Holland Hydrogen 1 is expected to supply renewable hydrogen to the refinery through the public hydrogen network.

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MODEL ONE · DIRECT INTEGRATION

REFHYNE 2 is planned to supply renewable hydrogen directly into the refinery's existing hydrogen system.

100 MW

PEM electrolysis in ten 10 MW modules

up to 44 t/d

Renewable hydrogen produced for use on site

On site

Direct connection to the existing refinery hydrogen system

30 barg

Hydrogen supplied at 30 barg, with existing refinery compression reused

WHAT MAKES DIRECT INTEGRATION POSSIBLE

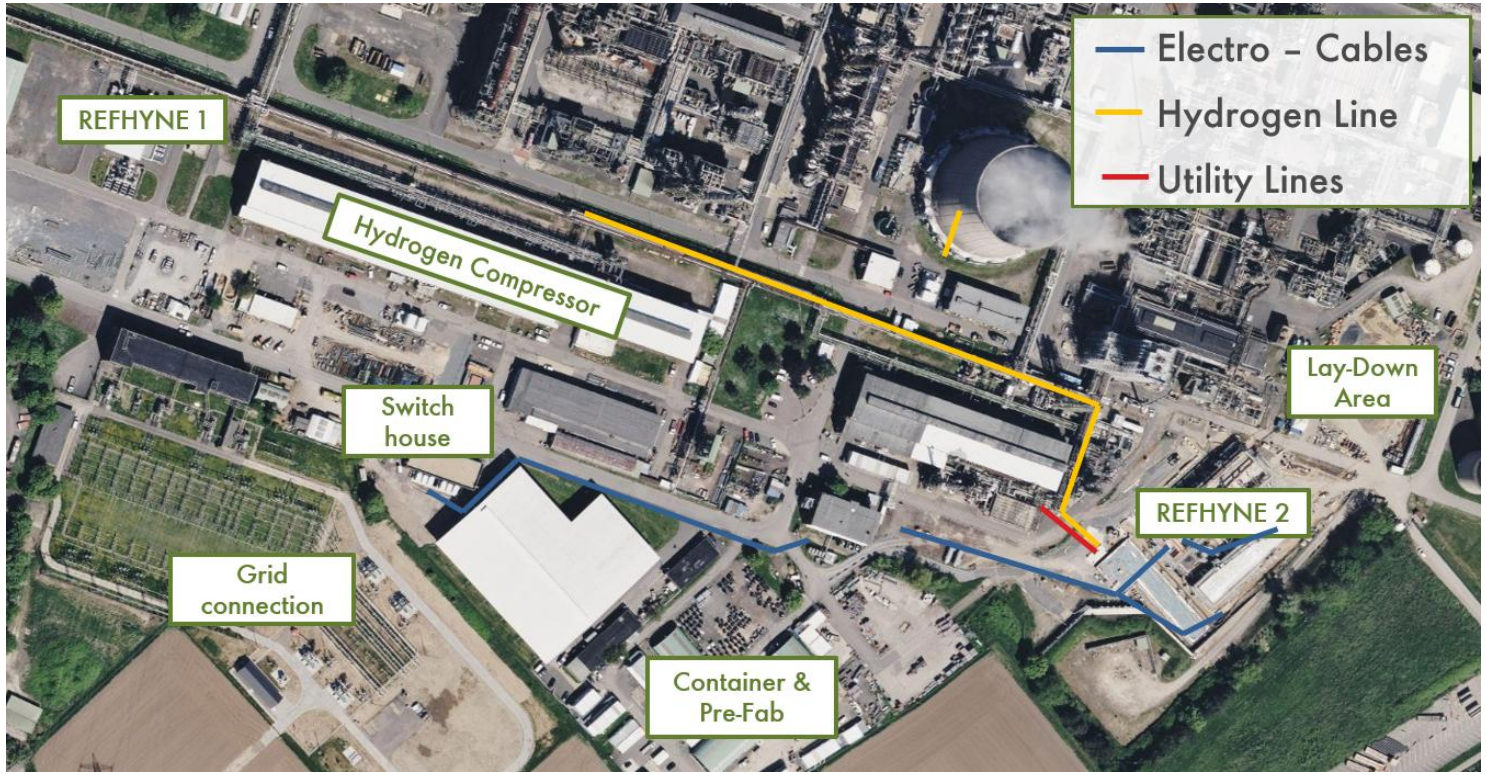
- Brownfield development within Shell Energy and Chemicals Park Rheinland
- Renewable power contracted through solar and wind PPAs, with a grid connection



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Most of the work was integrating the electrolyser with the refinery's existing systems.

Power, hydrogen, utilities and physical routing all sat on the critical path.



Cable, hydrogen and utility routing across a live refinery – plus lay-down space inside an operating plot



Switch house – grid connection



110/30 kV transformers (DSO)



30 kV switchgear

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Producing renewable hydrogen requires the power supply, water treatment, electrolyser and refinery hydrogen system to work together.

INPUTS

Renewable electricity and purified water

POWER CONVERSION

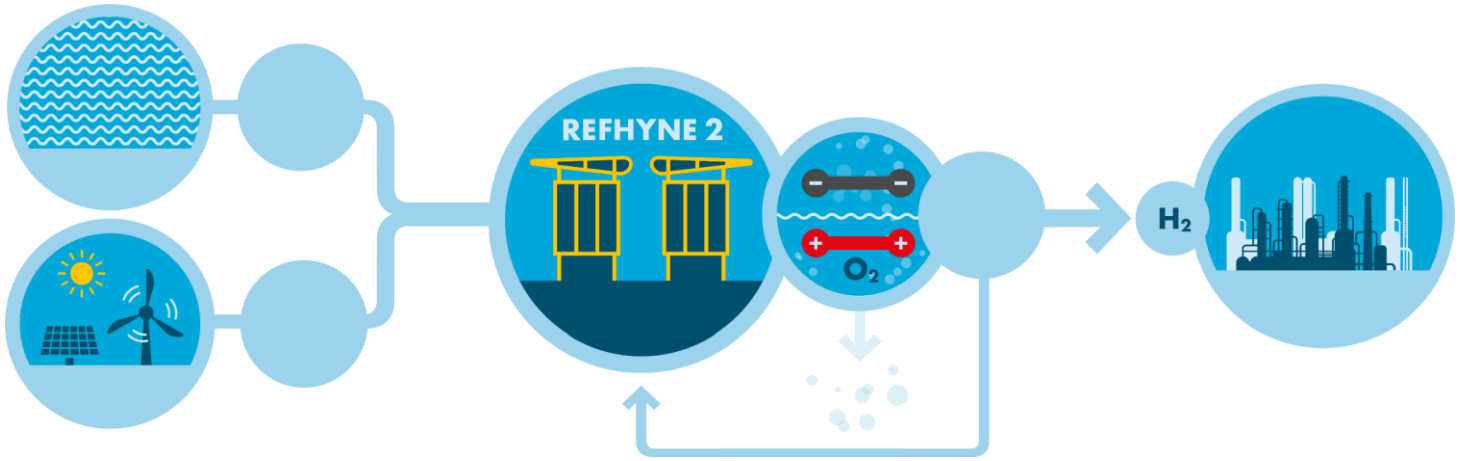
Transformers and rectifiers convert grid AC power for use by the electrolyser

HYDROGEN PRODUCTION

PEM electrolysis produces hydrogen, supported by cooling and water-treatment systems

REFINERY SUPPLY

Hydrogen is supplied into the refinery system for use in production



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MODEL TWO · NETWORK INTEGRATION

Holland Hydrogen 1 is planned to supply renewable hydrogen to the refinery through a public hydrogen network.

200 MW

Atmospheric alkaline electrolysis

up to 60 t/d

Renewable hydrogen production

35 km

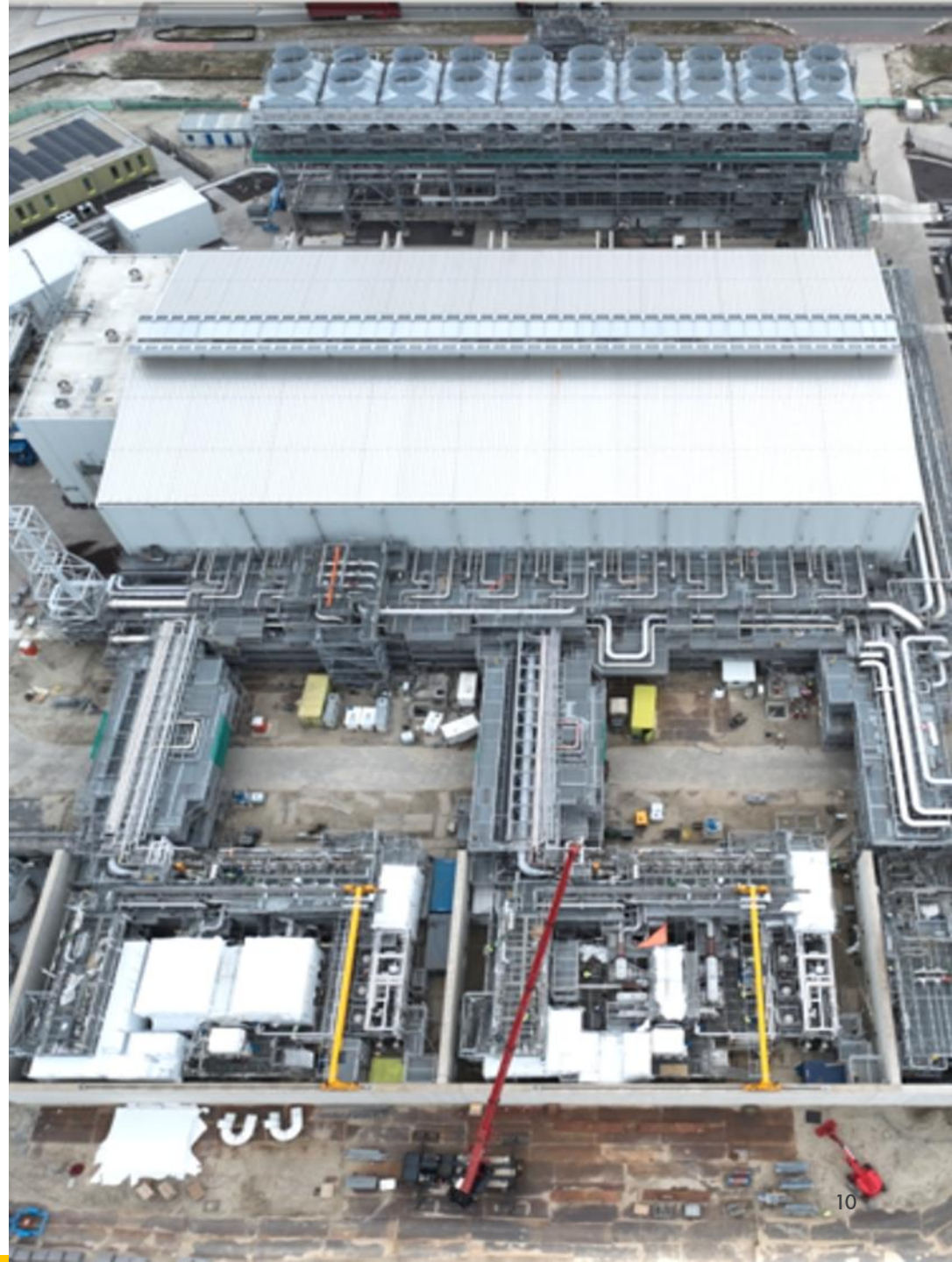
Public hydrogen network connecting the plant to Pernis

Dedicated

Compression required for network delivery

WHAT MAKES NETWORK INTEGRATION POSSIBLE

- Greenfield development at Maasvlakte in the Port of Rotterdam
- Renewable electricity supplied from offshore wind
- Public hydrogen network connecting the plant to Pernis



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Holland Hydrogen 1 connects offshore wind to the Pernis refinery through a 35 km public hydrogen network.

Hollandse Kust Noord

Offshore wind supplies renewable electricity →

380 kV grid connection

Transmits electricity to Holland Hydrogen 1 →

Holland Hydrogen 1

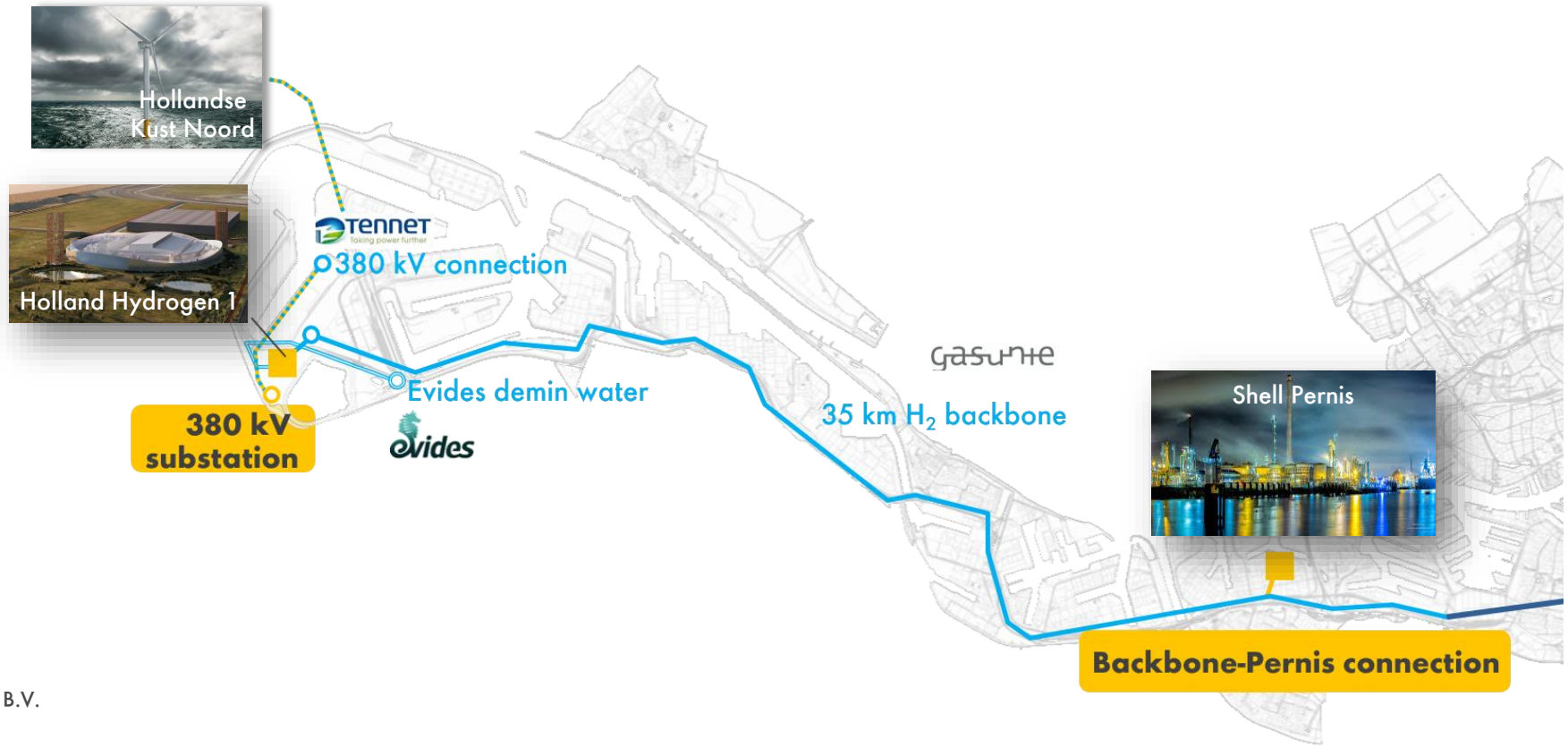
Uses electricity and purified water to produce hydrogen →

35 km hydrogen network

Transports hydrogen from Maasvlakte to Pernis →

Pernis refinery

Uses renewable hydrogen in its existing processes



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Direct integration creates complexity inside the refinery, while network integration shifts it to external infrastructure.

	REFHYNE 2	Holland Hydrogen 1
Site	Brownfield refinery site	Greenfield production site
Hydrogen route	Direct connection to the refinery hydrogen system	Public hydrogen network to Pernis
Compression	Existing refinery compression reused	Dedicated compression required
Power supply	Solar and wind PPAs, plus grid connection	Offshore wind through a dedicated 380 kV connection
Main integration challenge	Interfaces within the refinery	External infrastructure and interfaces

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Electrolysers can respond quickly, but the wider hydrogen system determines how flexibly they can operate.

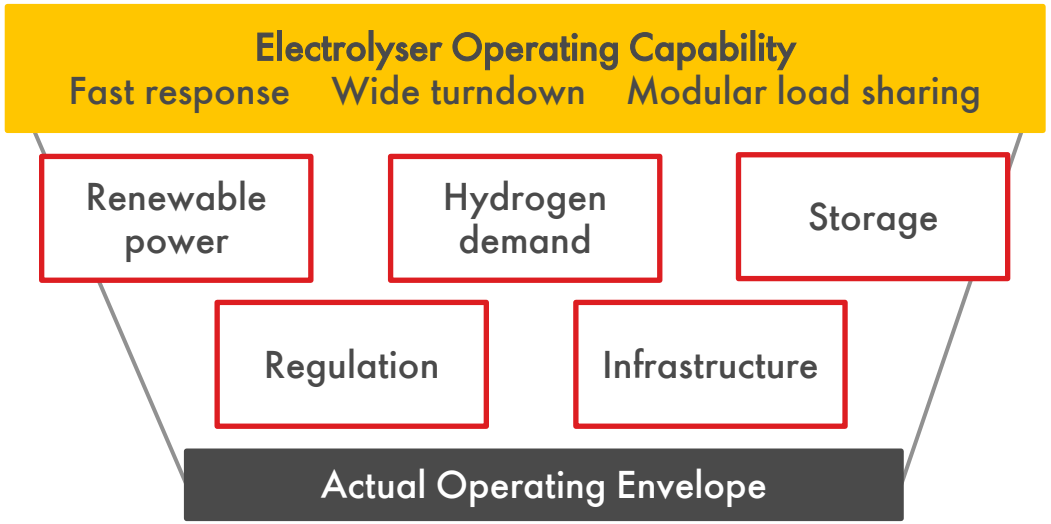
CONVENTIONAL REFINERY HYDROGEN

Steady input and continuous production

RENEWABLE HYDROGEN



Variable power input and flexible production



WHAT HAS TO BE DECIDED AT DESIGN STAGE

- Minimum operating load and turndown
- Ramp rates and load sharing across modules
- Effects of flexible operation on equipment life and safety
- How hydrogen supply is maintained when electrolyser output falls

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Across both projects, the electrolyser was only one part of the challenge; integration and infrastructure were just as important.

THE VISIBLE ASSET	**Electrolyser**			
THE WIDER PROJECT SCOPE	Site integration and interfaces	Power, utilities and control systems	EPC delivery and operating procedures	Permitting and external infrastructure

WHAT WE EXPECTED		WHAT WE LEARNED
The vendor and electrolyser would be the main challenge	→	Refinery integration, EPC capability and interface management were equally important
Operational flexibility would come naturally	→	Operational flexibility had to be designed into the system
Hydrogen production would be the main focus	→	The entire hydrogen value chain had to work as one system
Technology would be the main barrier	→	Commercial, regulatory and infrastructure constraints were more significant

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IN SUMMARY

Switching to renewable hydrogen changes the whole refinery system, not only how hydrogen is produced.

01 Refineries must cut emissions while remaining competitive.

02 Renewable hydrogen can replace hydrogen made from natural gas, using demand that already exists.

03 REFHYNE 2 and Holland Hydrogen 1 demonstrate two integration models at industrial scale.

04 Most of the challenges lie in integration, infrastructure, commercial delivery and regulation, rather than the electrolyser technology.

Scale-up depends not only on the electrolyser, but also on competitive power, timely infrastructure and stable regulation.

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