FutureBridge

EXECUTIVE REPORT

Future of Refineries

Contents

© 2025 FutureBridge. All rights reserved.

Executive summary

Global oil demand is rapidly declining, forcing refinery closures and upending the entire industry

Since 2020, more than 3 million barrels per day of capacity have been shut down. Refineries in Europe and North America could see up to 5 million barrels per day disappear by 2050, while even those in Asia and the Middle East may start cutting back by the 2040s. The refining industry must adapt quickly, or risk being left behind.

Refineries must pivot to high-growth petrochemicals and sustainable fuels to thrive in a transforming energy landscape

Petrochemicals, set to drive over a third of oil demand growth by 2030, offer a clear path to profitability. Leveraging advanced crude-to-chemical technologies, refineries can maximize high-value products like olefins and aromatics while reducing reliance on traditional fuels.

Refineries must future-proof operations to thrive in the transforming energy landscape

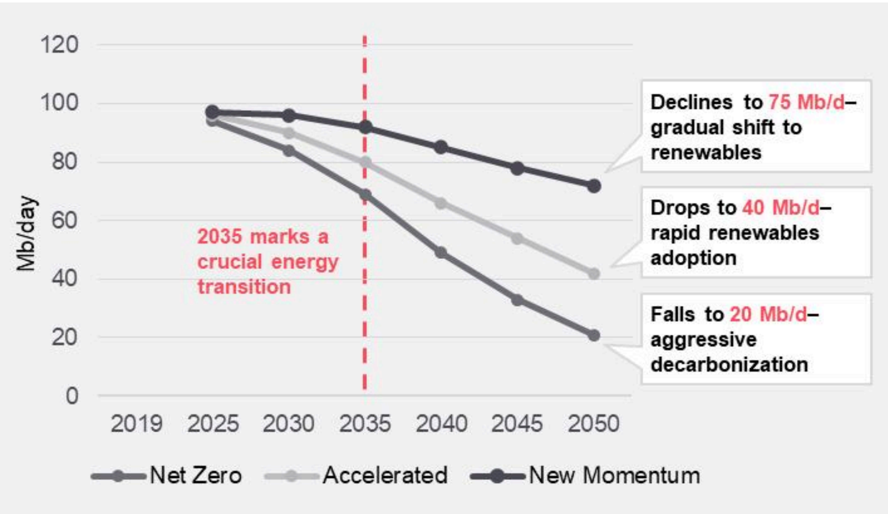
By adopting CCUS to capture CO_2 using renewable energy and leveraging feedstocks like municipal waste and used cooking oil, they can produce renewable fuels such as jet fuel and HVO.

E-fuels, synthesized from CO_2 and green hydrogen unlock additional opportunities for low-emission fuels like E-diesel, E-jet, and E-naphtha with minimal emissions to accelerate clean energy innovations.

Declining oil demand threatens existing refinery viability

The declining global oil demand is negatively impacting refinery margins, leading to closures and a shrinking refining capacity worldwide

Decline in oil demand



The rise of renewable energy and biofuels is reducing demand of crude oil for fuel production.

With governments incentivizing cleaner energy sources and consumers embracing electric vehicles (EVs), gasoline and diesel demand is plummeting, directly impacting refinery operations.

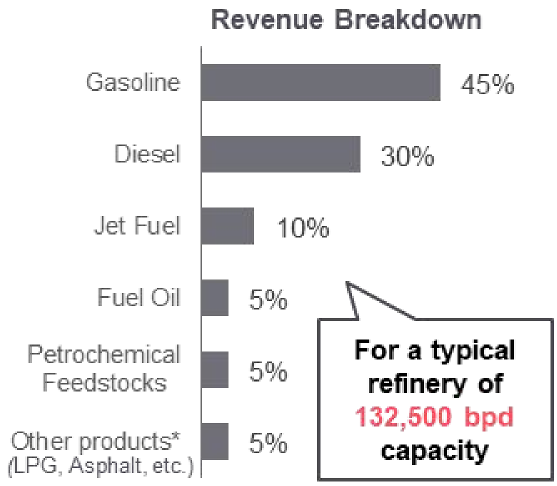
Source: BBC, Wood Mackenzie

Refining profitability at the mercy of global oil demand

Refineries produce a mix of products including gasoline, diesel, jet fuel, and petrochemicals

The profitability of individual refineries depends on market demand for these products

For example, gasoline-dominant refineries may struggle as electric vehicles reduce gasoline demand



Weakening margins and demand collapse signal more refinery shutdowns

>3.2 Mb/d

Global Refining Capacity closed since 2020

Europe is projected to lose up to 5 million barrels per day (Mb/d) of refining capacity by 2050, with North America following a similar downward trajectory.

In contrast, the Asia-Pacific and Middle East regions are expected to experience net capacity growth during the 2030s, driven by the launch of large, integrated sites focused on chemical production.

However, even Asia is anticipated to begin reducing the refinery capacity by 2040s as global demand patterns shift and the energy transition progresses.

Future-proofing refineries in a transforming energy landscape

Empowering refineries to thrive profitably, sustainably, and at scale in the era of energy transformation

Petrochemicals production

Expanding petrochemical production helps offset the impact of declining transportation fuel demand

Bio-refineries

Ensure supply chain sustainability by tapping into renewable feedstocks like agricultural residues, algae, and municipal waste

E-Fuel production

Positions refineries at the cutting edge of scalable, renewable fuel alternatives

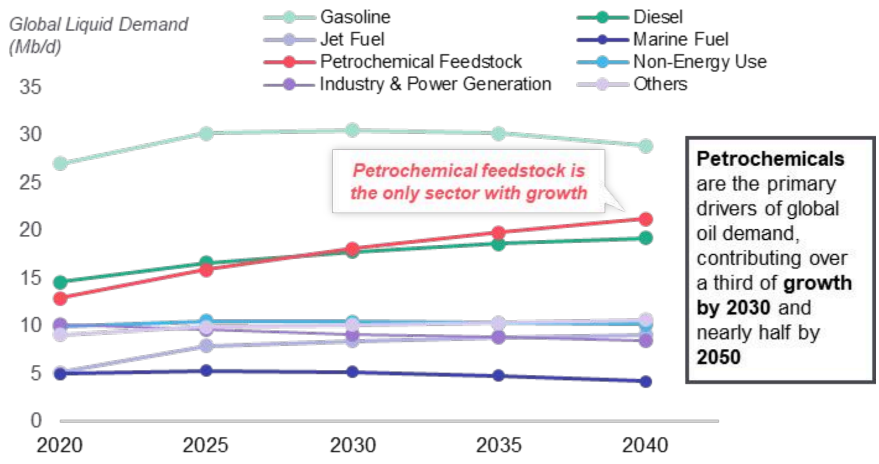
FutureBridge

Focus on Petrochemicals to futureproof refinery margins

Petrochemicals and their undervalued influence on Energy's future

Petrochemicals are a significant blind spot in the global energy debate, especially considering the influence they will have on future energy trends

Petrochemical feedstock: The sole driver of growth in a declining oil market



The shift towards petrochemicals is a major factor contributing to the continued demand for oil, even as overall oil consumption declines

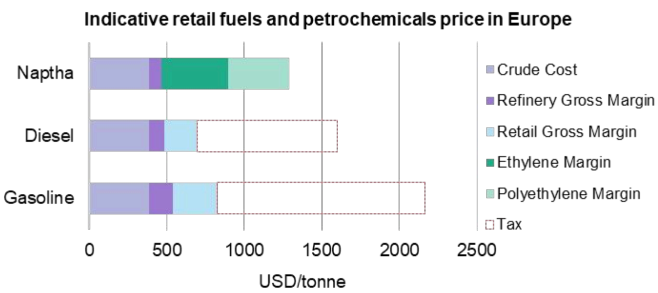
Petrochemicals are essential components in a wide range of products, including plastics, synthetic fibers, detergents, and pharmaceuticals

Source: IEA, GPCA

For integrated refineries, the petrochemical path can offer higher margins than fuels

Over 30% of global refineries are integrated with petrochemical production, allowing for diversified product portfolios and improved efficiencies

Lower tax rates on petrochemicals in Europe are primarily driven by the industries and the need to maintain competitiveness amid global market pressures



> You can sell fuels for $550 a ton or convert them further to petrochemicals and get around $1400 a ton
>
> **Senior Director, HONEYWELL UOP**

Crude-to-chemical refining: A strategic path forward

Refineries are opting for advanced modifications to maximize the production of olefins and aromatics by optimizing crude oil conversion, reducing traditional fuel yields, and meeting the growing petrochemical demands

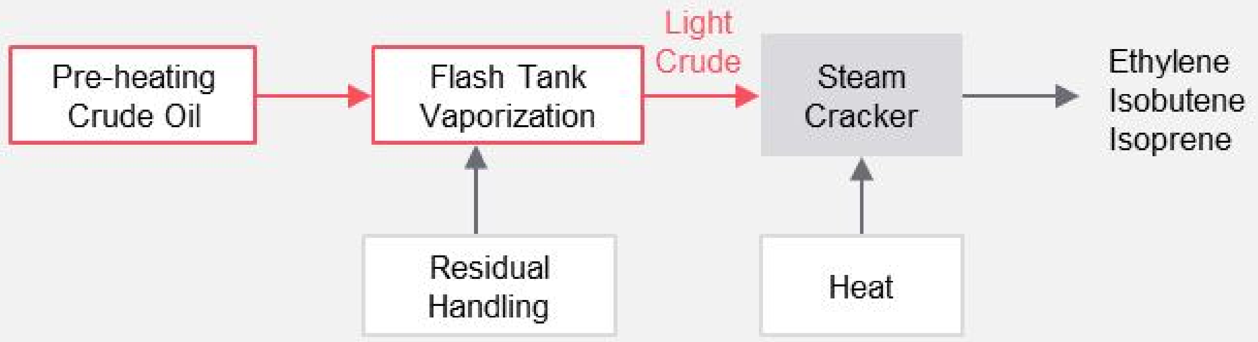
Direct processing of crude oil in steam cracking

Direct Conversion

Light crude oil is pre-heated, vaporized in a flash tank, and fed directly into a steam cracker to produce petrochemicals

Key Modification

Traditional distillation steps are bypassed, enabling crude-to-chemical conversion with reduced infrastructure and costs



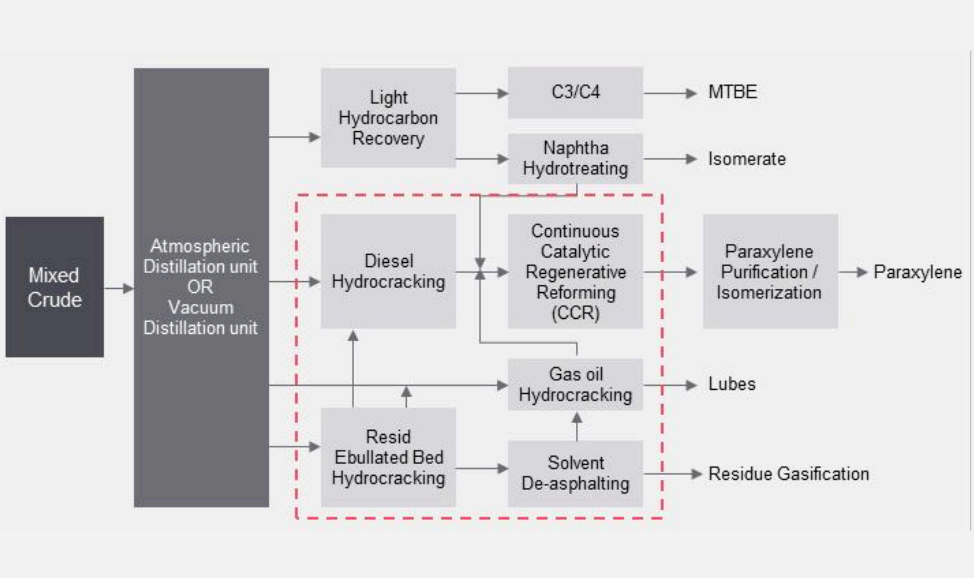
Using light crude oil with low residue content reduces heavy components that drive coke buildup during thermal cracking

Vaporizing lighter fractions and limiting hydrocarbon exposure to high-temperature surfaces, decreases the need for frequent decoking, ensuring continuous production and reducing downtime

ExxonMobil has deployed this direct crude conversion technology. In January 2014, the company inaugurated a novel steam cracker at its Singapore complex, capable of producing olefins directly from crude oil

Source: IHS Markit1 , IHS Markit2 and FutureBridge Report

Processing of middle distillates and residues using Hydrocracking technology



This type of processing involves hydrocracking of diesel and products from the vacuum distillation unit to produce naphtha range stream, which can later be processed to produce aromatic compounds

Hydrocracking converts 90% of vacuum residue into valuable products, reducing waste

Proven at scale by Hengli Petrochemical, producing 4.43 million tons per year per unit

Adds economic value by upgrading low-value residues to high-value chemicals

Produces 45% naphtha yield, which is crucial for petrochemical feedstocks

Refineries are enhancing conversion efficiency by adopting resid hydrocracking and advanced cracking technologies to maximize the transformation of crude oil into high-value petrochemicals

Strategic technology choices for crude oil-to-chemicals using Hydrocracking

Shift from Carbon Rejection to Hydrogen Addition

Hydrogen addition, via hydrocracking, achieves higher conversion rates and improved chemical yields compared to carbon rejection methods like coking

Implication: Hydrocracking enables the production of lighter, higher-value products such as naphtha and olefins, crucial for petrochemicals. It also reduces the sulfur content and increases flexibility in crude feedstock selection

Catalyst Development for Naphtha Maximization

Hydrocracking requires advanced catalysts optimized for light and heavy naphtha production rather than middle distillates or diesel, which are less relevant in Crude oil-to-chemical configurations

Implication: These catalysts ensure high hydrogen efficiency and conversion rates, making hydrocracking central to achieving the 72-80% crude-to-chemicals yield

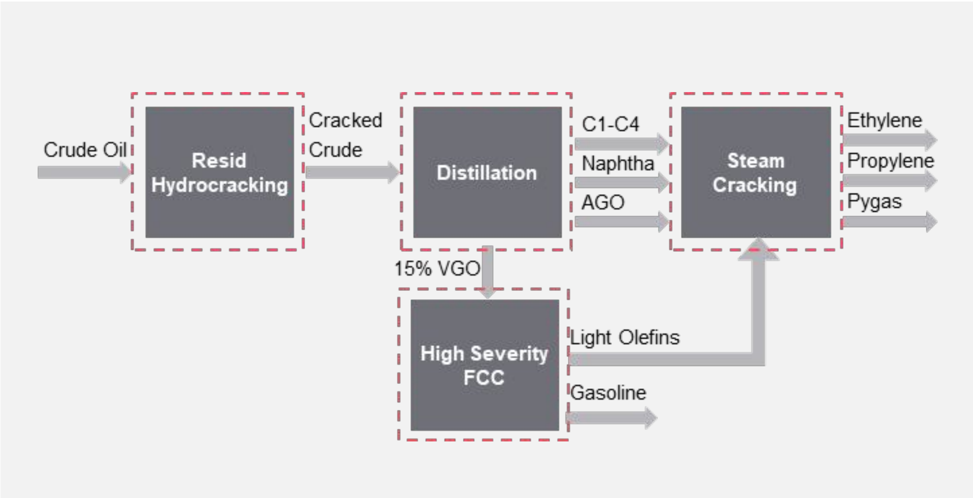
Cost and Efficiency Trade-offs

Hydrocracking demands higher capital investment and operational costs due to its reliance on hydrogen and high-severity conditions. However, it enables integrated processing, reducing downstream complexity

Implication: The higher upfront costs are offset by long-term benefits of superior product yield and reduced environmental impact, aligning with global sustainability goals

Refineries are enhancing conversion efficiency by adopting resid hydrocracking and advanced cracking technologies to maximize the transformation of crude oil into high-value petrochemicals

Maximizing conversion efficiency through Hydrocracking in crude-to-chemical integration



Hydrocracking to FCC Integration

Hydrocracking is optimized to produce lighter fractions (naphtha and lighter hydrocarbons) fed directly into high-severity FCC units, maximizing olefins and aromatics output

Enhanced Chemical Yield

Advanced catalysts and severe FCC conditions boost light olefins and aromatics production, achieving a 72% chemical yield (14.3 MTPA from 20 MTPA Arab Light crude)

Aramco and SABIC's partnership is developing a cutting-edge Crude oil-to-chemicals facility based on this model. This facility is set to produce 9 MT of chemicals annually —four times the capacity of the current steam cracker— beginning operations in 2025

Source: IHS Markit and FutureBridge Analysis , SPJGlobal

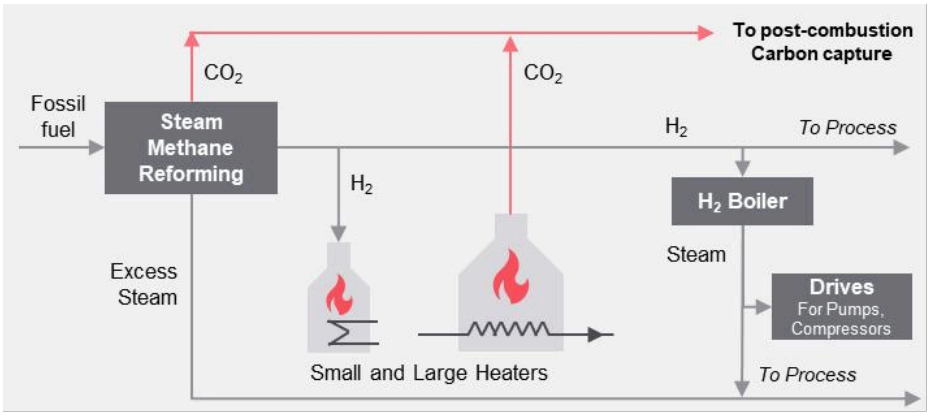
FutureBridge

Conversion to Green refineries is the key to a sustainable future

Paving the way for a green refinery

Many existing refineries can be converted into future biorefineries following a phased approach – removing carbon from fired sources and replacing fossil feedstocks with bio-feeds. Carbon emissions can be minimized by integration of hydrogen-CCUS or electrification technologies

Integration of carbon capture technologies

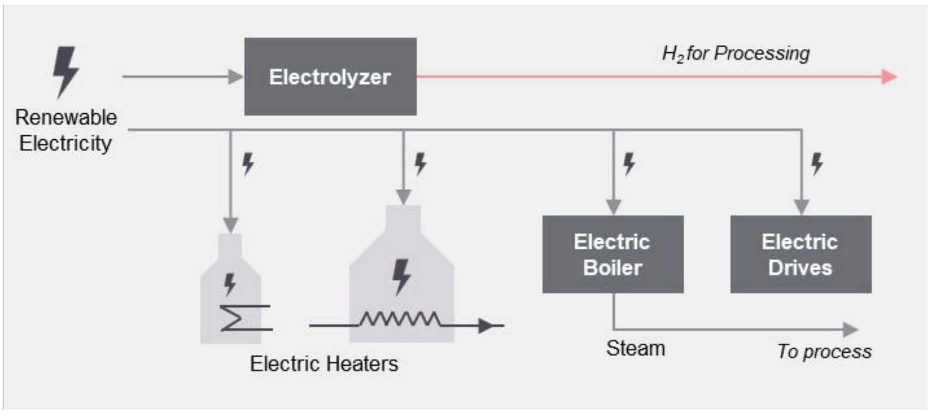


SMR-based hydrogen can power essential refinery equipment, reducing reliance on fossil fuels

However, hydrogen production from natural gas through SMR and H2 combustion releases a lot of CO_2 so the need for retrofitting and modifications in the process becomes crucial

Additionally, capturing CO_2 from fired heaters and using it for CCUS further minimizes the refinery's carbon footprint while maintaining its energy output

The electrification pathway



Electrolyzers can generate green hydrogen using renewable electricity. This hydrogen can be used for processing

Electric boilers and drives can replace fossil-fuel-powered systems, ensuring a carbon-free heat source. This fully electric approach positions the industry for a net-zero future

Retrofitting refineries to install electrolyzers, electric boilers, and electric drives is capital-intensive, and the success of this model depends heavily on access to low-cost green electricity and reliable grid infrastructure

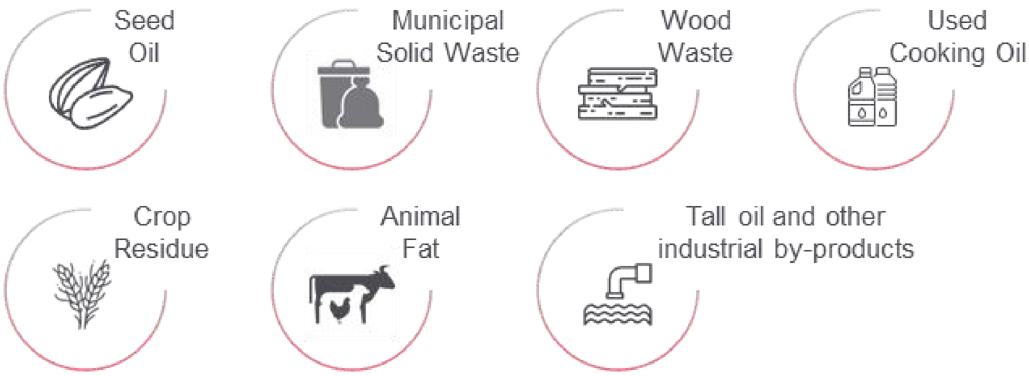
While the hydrogen-CCUS pathway offers a smoother transition but retains some carbon management complexity, electrification provides near-zero emissions but requires extensive retrofitting and reliable access to green electricity

Source: Decarbonisation Technology and FutureBridge Analysis

Bio-refineries

Different configurations exist for integrating renewable feeds into refineries. The two-train system maximizes liquid yield, while the integrated system minimizes capital costs. The gasification approach offers high-quality jet and diesel but lower overall liquid yield

Alternative feedstocks



The process line-up must be redesigned according to feedstock types, as the feedstock defines the processing limitations for each unit

While edible oils like seed oils are easier to process, they compete with food production. Non-edible feeds like wood waste and municipal waste offer a more sustainable solution but require advanced upgrading techniques

Building dedicated renewable processing facilities near refineries can streamline the supply chain and leverage existing infrastructure

Refineries will need separate processing trains for fossil and renewable feeds due to their incompatibility

Renewable feeds must be processed to reduce oxygen content before blending with fossil streams. This requires separate feed tankage but shared product tankage to meet existing fuel specifications

The more complicated the refinery complex, the easier the conversion becomes

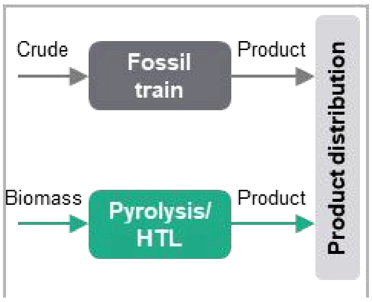
Routes to integrate bio-feed

Different configurations exist for integrating renewable feeds into refineries. The two-train system maximizes liquid yield, while the integrated system minimizes capital costs. The gasification approach offers high-quality jet and diesel but lower overall liquid yield

Routes to integrate bio-feed

PATHWAY I

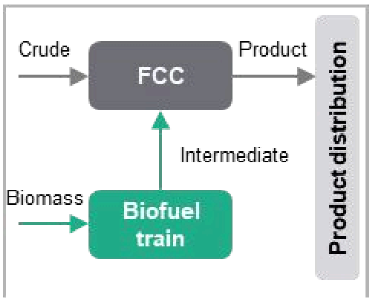
Separate fossil & biomass trains



Fossil and bio-crude from biomass feedstocks are processed independently in parallel trains, with separate distribution of their products

PATHWAY II

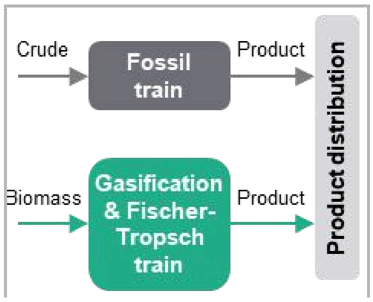
Integrated System



Biomass-derived intermediates from the biofuels train are integrated into the FCC unit, enabling co-processing with fossil feedstocks for unified product output

PATHWAY II

Fossil train with biomass gasification



Biomass is converted into syngas through gasification and processed into synthetic crude via the Fischer-Tropsch route alongside fossil processing, with joint product distribution

Yield comparison with base 100% crude oil refinery

Gasoline	Base
Jet	-
Diesel	-
Renewable Jet	All
HVO	All

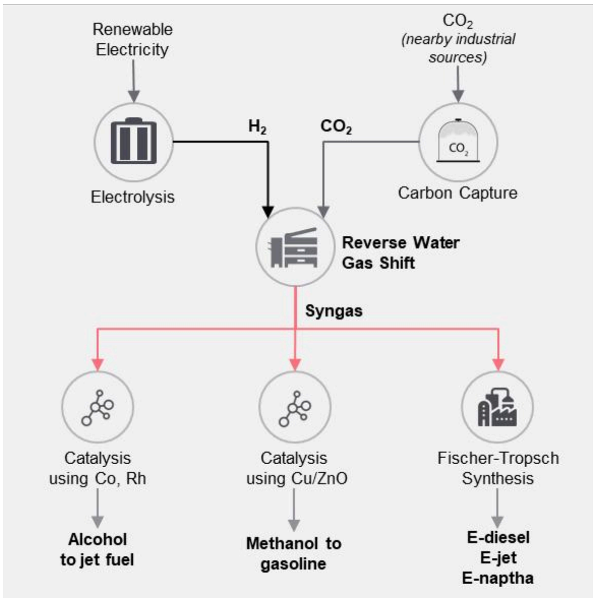
Gasoline	Base
Jet	-
Diesel	-
Renewable Jet	Higher than 2 train
HVO	

Gasoline	Base
Jet	-
Diesel	-
Renewable Jet	All
HVO	All

Source: Decarbonisation Technology

Transitioning refineries to E-fuels production

By utilizing captured CO_2 from nearby industrial sources, refineries can integrate synthetic hydrocarbon fuels and chemical production into the refinery space



No need for desulfurization

No hydrotreatment required

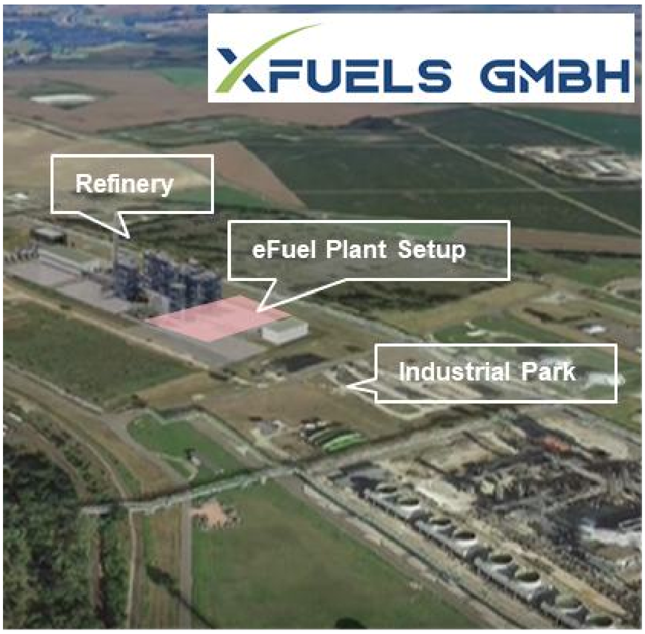
Minimal-to-zero emissions

Need for green H2 and captured CO_2

High costs due to low efficiency

Limited global demand

XFuels GmbH integrated SAF and green naphtha production with DOW's refinery operations



Source: Topsoe, xFuels GmbH, FutureBridge Analysis

Location:
Böhlen-Lippendorf Industrial Park, Germany

Capacity:
50,000 tons SAF, 14,000 tons of green naphtha, and 1,000 tons of green hydrogen annually

Operating Year:
2027

XFuels GmbH's HyKero Plant demonstrates a scalable and sustainable approach to synthetic fuel production, effectively combining renewable inputs with established refinery techniques

Key Differentiators:

- Xfuels GmbH uses captured CO_2 and green hydrogen from renewable electricity to produce synthetic fuels
- Green hydrogen lowers emissions compared to traditional refineries

FutureBridge

About FutureBridge Energy practice

FutureBridge offerings across the 8 pillars of energy transition

CCUS & carbon trading

- Industrial carbon capture
- Carbon dioxide removal including BECCS and DACS
- Carbon storage and transportation
- Carbon utilization & sequestration
- Carbon offsets and credits

Electricity

- Renewable energy options: Wind, solar, geothermal
- New sources of energy (ocean/ tidal)
- Low carbon energy: Nuclear
- 24/7 Carbon free electricity
- Energy storage
- Flexible generation
- EV charging

Heating & cooling

- Waste heat recovery
- Renewable heating & cooling

Future of oil & gas and energy utilities

- Decarbonization of assets
- Energy intensity reduction
- Industrial revolution 5.0
- Adjacent sector technologies

ENERGY TRANSITION INITIATIVES

Hydrogen & its derivatives including E-fuels

- Hydrogen (Green, Blue, Turquoise, Pink…)
- Offshore & onshore Green hydrogen
- Hydrogen value chain including last mile connectivity
- E fuels – E-Methanol, E Ammonia, E-methane, E-SAF

Biofuels

- Biofuels : Renewable & biodiesel
- Bio-methane
- Waste to fuels
- SAF

Digitalization

- Digital readiness assessment
- Digital solution discovery
- Digital partner selection

Scope 1-2-3 emissions reduction for hard to abate sectors

- SBTi targets & GHG emissions
- Lifecycle assessment
- Energy intensity reduction
- Process & equipment optimization

Our energy team

Our Energy team is rather unique in the research and insight space. We're a team of Business Consultants, researchers, patent experts, and industry specialists. **Over 100 years** of combined experience in Energy sector at global level.

Mukesh Dhiman

Practice Head

With **23+ years of experience,** Mukesh guides global energy clients through transition, innovation, and growth strategies across emerging domains.

Devay Gupta

Senior Director

With **18+ years of experience,** Devay drives growth and transformation for global energy clients across oil, gas, and emerging green fuel domains.

Saurabh Jain

Director

With **21+ years of experience,** Saurabh leads energy transition and decarbonization strategies for global clients across the US, Europe, and Asia.

Saurabh Uniyal

Associate Director

With **15+ years of experience,** Saurabh leads strategic advisory and management consulting initiatives for global energy clients with a focus on new energies & sustainable solutions.

Continue the conversation

Our addresses

North America

55 Madison Ave, Suite 400,
Morristown, NJ 07960, USA

Europe

WTC Utrecht, Stadsplateau 7,
3521 AZ Utrecht, The Netherlands

United Kingdom

Holborn Gate, 330 High Holborn,
London, WC1V 7QH, UK

Asia-Pacific

Millennium Business Park, Sector 3,
Building 4, Mahape, Navi Mumbai, India

FutureBridge is a techno-commercial consulting and advisory company. We track and advise on the future of industries from a 1-to-25-year perspective.

www.futurebridge.com