Challenges and strategies for refiners in a decarbonising world

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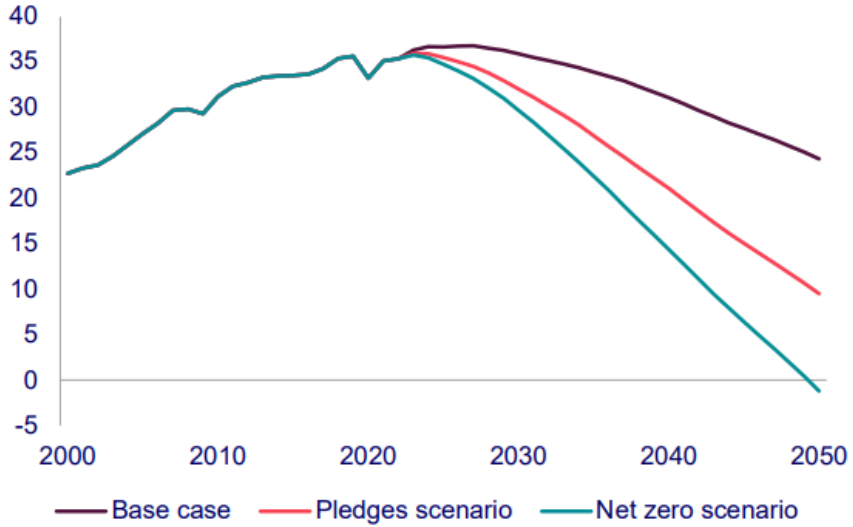
Energy Transition and Market Drivers

Wood Mackenzie

Wood Mackenzie's energy transition outlook base case is consistent with a 2.5 ºC global warming outcome by 2050, falling short of the Paris Agreement targets

The world needs to reach net zero before 2050 to meet the goals of the Paris Agreement

Global energy-related CO_2 emissions, Bt



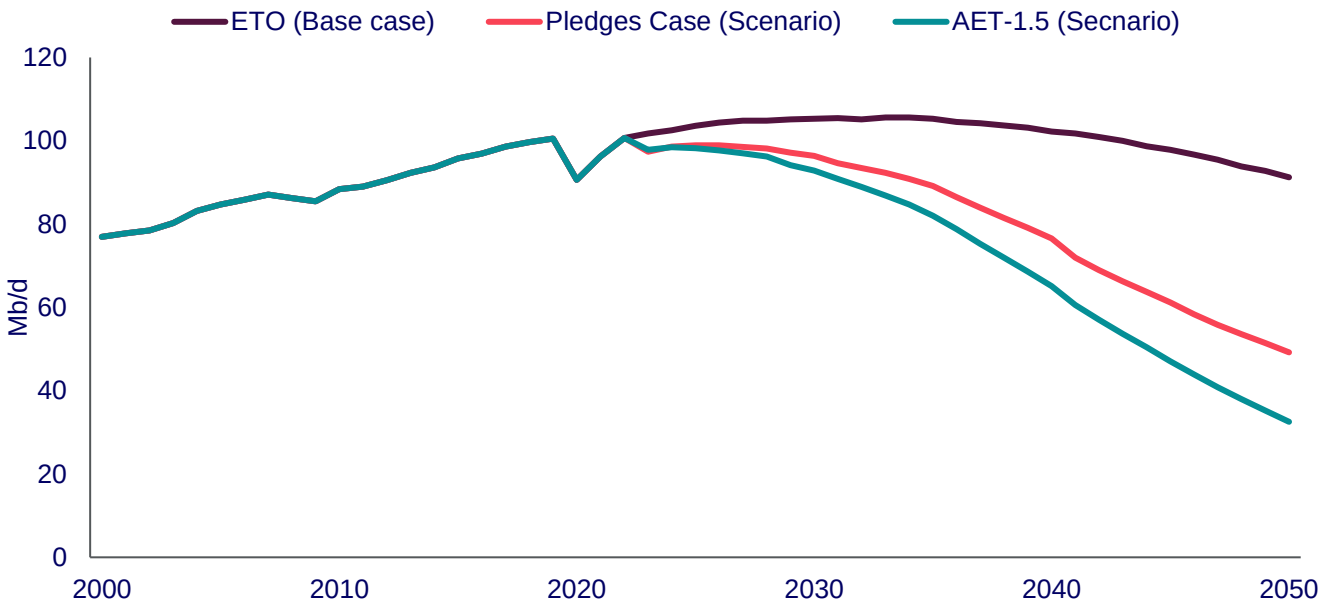
Outlook	Trajectory	Policy	Enabler
Base case	Consistent with 2.5 ˚C global warming	Evolution of current policies and aligns with the SPOs released in H1 2023	Steady advancement of current and nascent technologies
Pledges scenario	Consistent with below 2 ˚C warming (Global net zero by 2060)	Aligned with net zero pledges announced in the run-up to COP28	Incorporates policy response to the current energy crisis, and geopolitical challenges facing the global economy
Net zero 2050 scenario	Consistent with 1.5 ˚C warming (Global net zero by 2050)	Aligned with most ambitious goal of Paris Agreement	Immediate peak energy; rapid hydrogen and carbon removal deployment; consumer shift

Source: Wood Mackenzie

Under the base case oil remains a major part of the energy mix, with global demand of ~ 90mb/d in 2050

The world needs to reach net zero before 2050 to meet the goals of the Paris Agreement

Oil demand by outlook, mb/d



Oil demand peaks circa 2035 at around 105 mb/d before declining to ~90 mbd/ by 2050

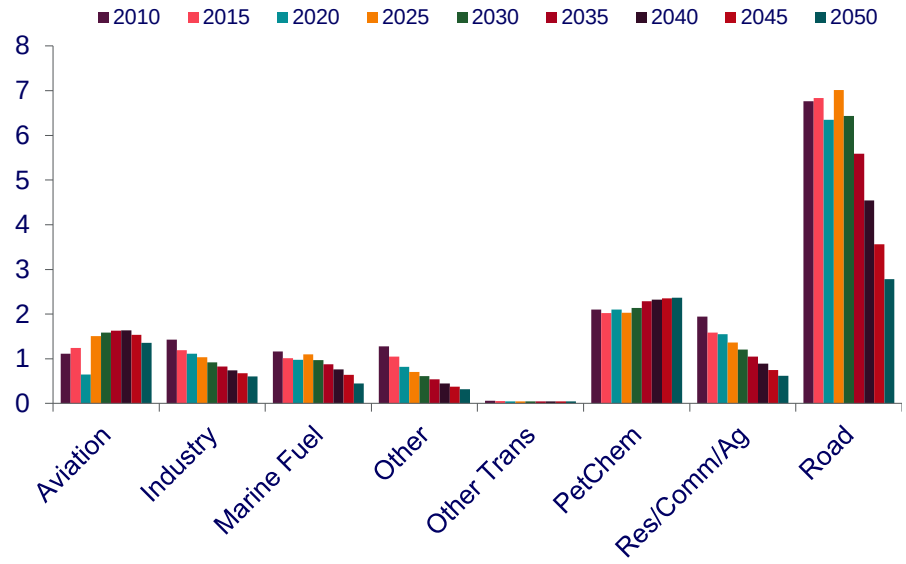
An accelerated energy transition scenario would see oil demand reduce to 65 mb/d by 2040 and 33 mb/d by 2050

Source: Wood Mackenzie

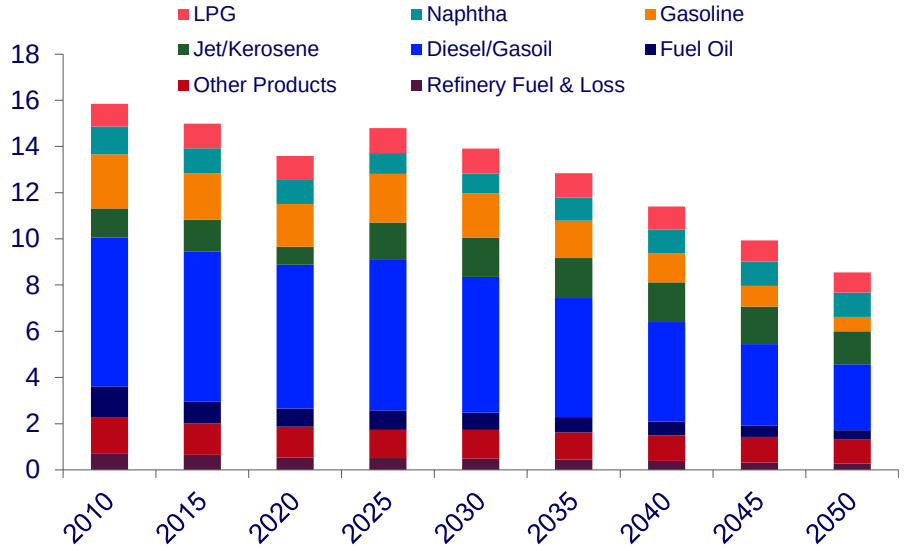
Oil product demand will continue to decline within Europe driven by improving energy efficiency and switching to alternative energy sources

Road transportation will see the most rapid decline as EV's displace demand from ICE's

European Oil Product Demand (mb/d) by Sector



European Oil Product Demand (mb/d) by Product



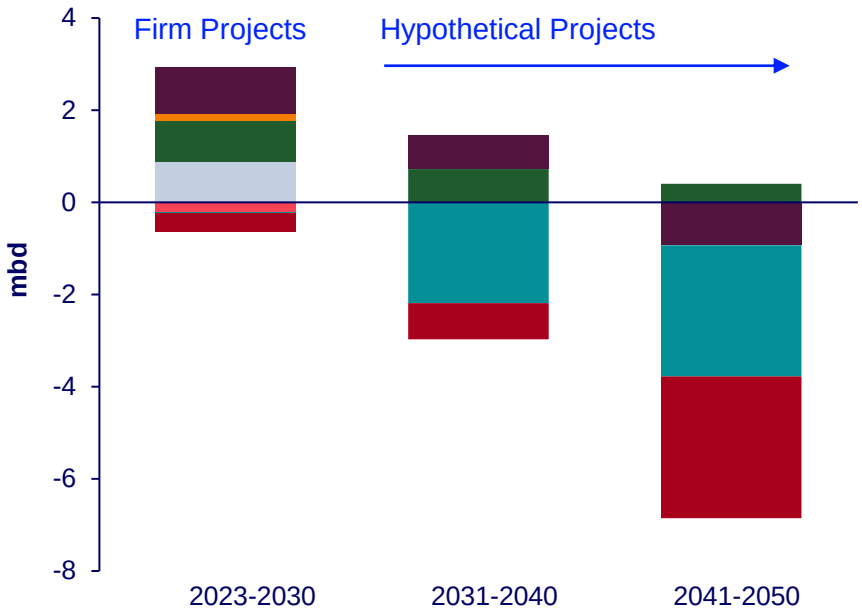
History: IEA Energy Statistics, National Statistics Forecast: Wood Mackenzie

Note: European Demand include Mainland European Countries

European refiners will face increased pressure from new refinery capacity being added in Asia and the Middle East

Further structural refinery capacity rationalisation will be expected within Europe beyond 2030

Incremental net regional refining capacity change, mb/d (2023-2050)



Source: Wood Mackenzie

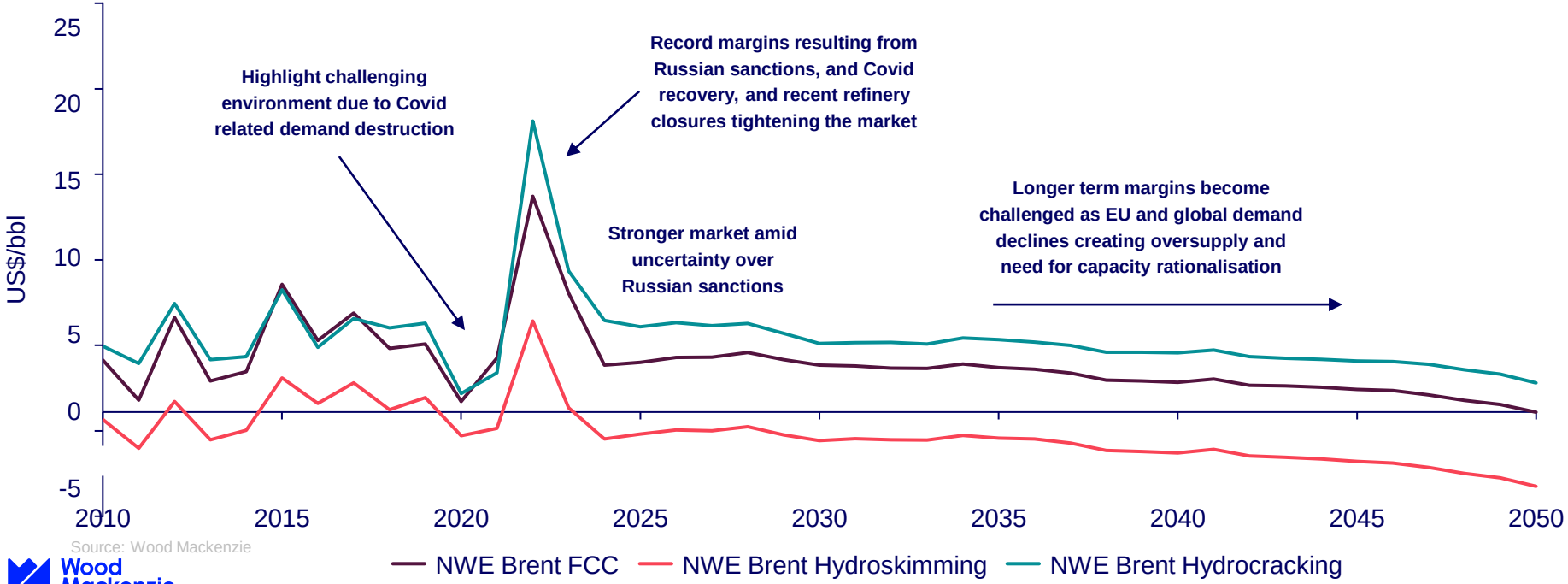
Asia Pacific	Adds 4.6 mb/d of capacity from large chemicals integrated sites in China and India. Indonesia and Vietnam are also expected to add capacity
Middle East	Large number of NOC refineries due online in next couple of years, with longer term large scale potential COTC projects
Sub-Saharan Africa	The 0.65 mb/d Dangote refinery towards end of 2023, with smaller projects in Angola, Congo and Uganda complete later in the decade
Russia & Caspian	No major net changes, some small additions / closures
Latin America	New refinery in Brazil and expansion of refinery in Peru
Greater Europe	**The pace of refinery closures and conversions to slows down during the 2020s** **Falling demand and margins force refinery closures from 2030 with the region losing 5 mb/d of capacity by 2050**
North America	Anticipated refinery closures, which continue after 2030 with the region losing 3.8 million b/d of refining capacity by 2050

Wood Mackenzie

Benchmark refining margins are expected to fall back from recent highs, but remain relatively attractive through the 2020's in a tight global products market

Complex hydrocracker margins remain advantaged driven by middle distillate strength. FCC margins weaken more significantly as global gasoline demand declines accelerates

NWE gross refining margins forecast, US$/bbl real 2023 (2010-2050)



Source: Wood Mackenzie

Carbon Emissions Perspectives for Refiners

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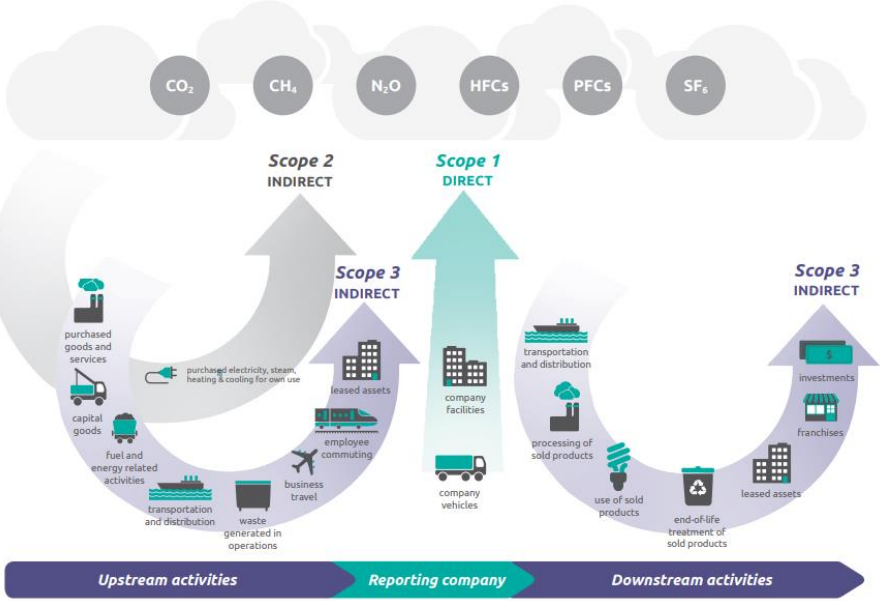
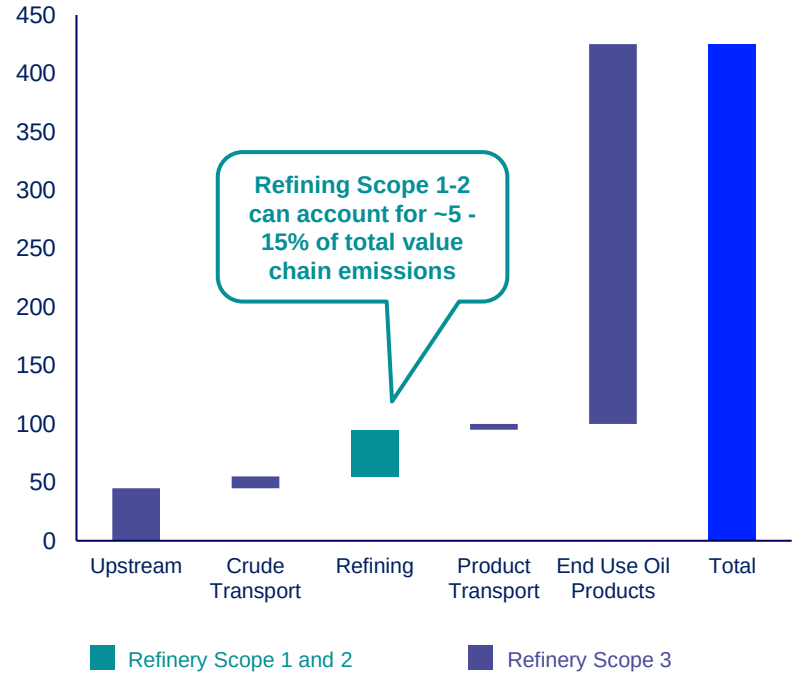
The Greenhouse Gas Protocol's definition of carbon emissions as Scope 1, 2, and 3 is used by companies across many industries

Scope 1 and 2 emissions are **regulated** under the EU ETS, Scope 3 emissions reporting is currently **voluntary**

The GHG Protocol defines Scope 1, 2, 3 emissions



Crude Oil Value Chain Emissions – Example (kgCO2e/bbl)

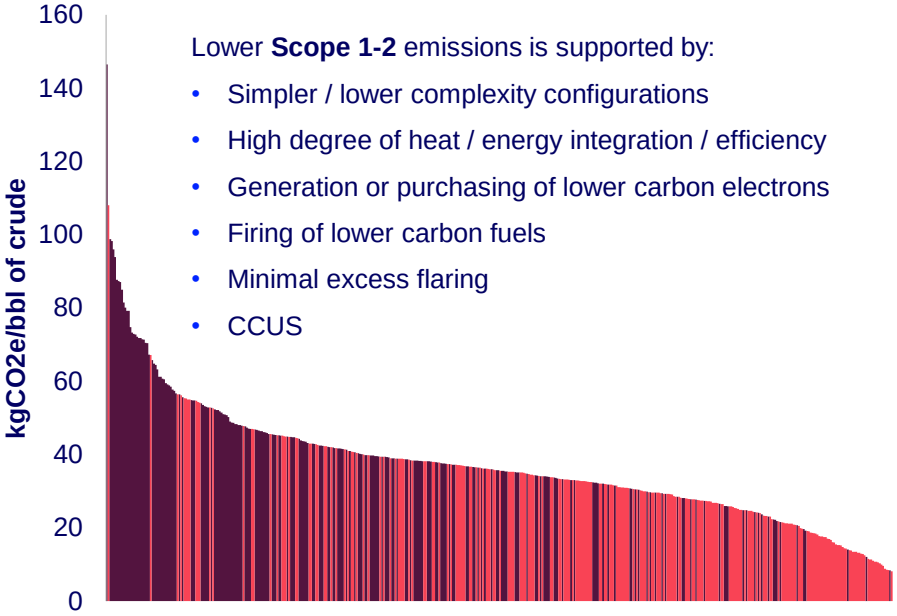


Source: GHG Protocol, Wood Mackenzie

Carbon emissions intensity from refinery operations can vary significantly by asset based on a range of factors

Scope 3 carbon intensity is largely driven by crude slate, logistics, and most importantly product yield

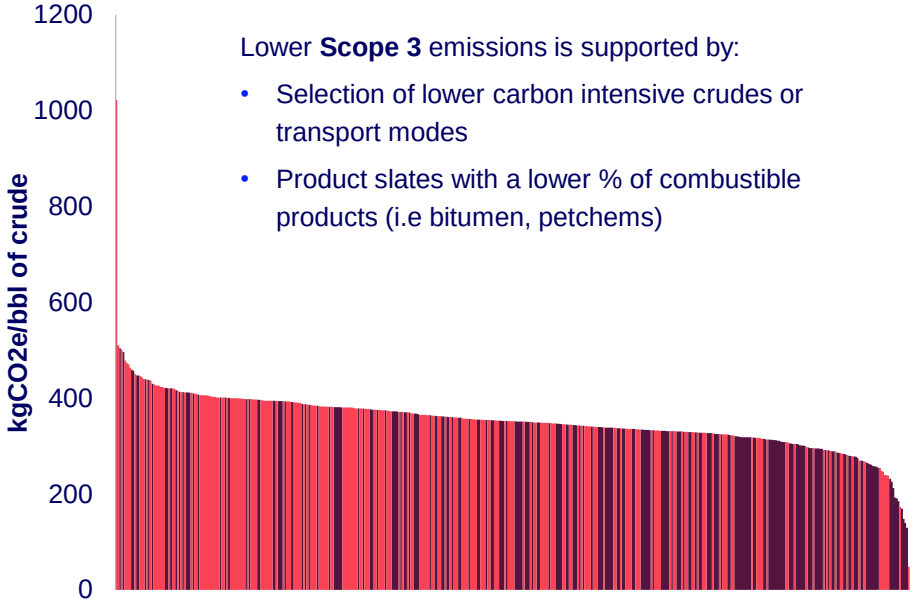
Refinery Scope 1 & 2 emissions intensity, 2022



Lower **Scope 1-2** emissions is supported by:

- Simpler / lower complexity configurations
- High degree of heat / energy integration / efficiency
- Generation or purchasing of lower carbon electrons
- Firing of lower carbon fuels
- Minimal excess flaring
- CCUS

Refinery Scope 3 emissions intensity, 2022



Lower **Scope 3** emissions is supported by:

- Selection of lower carbon intensive crudes or transport modes
- Product slates with a lower % of combustible products (i.e bitumen, petchems)

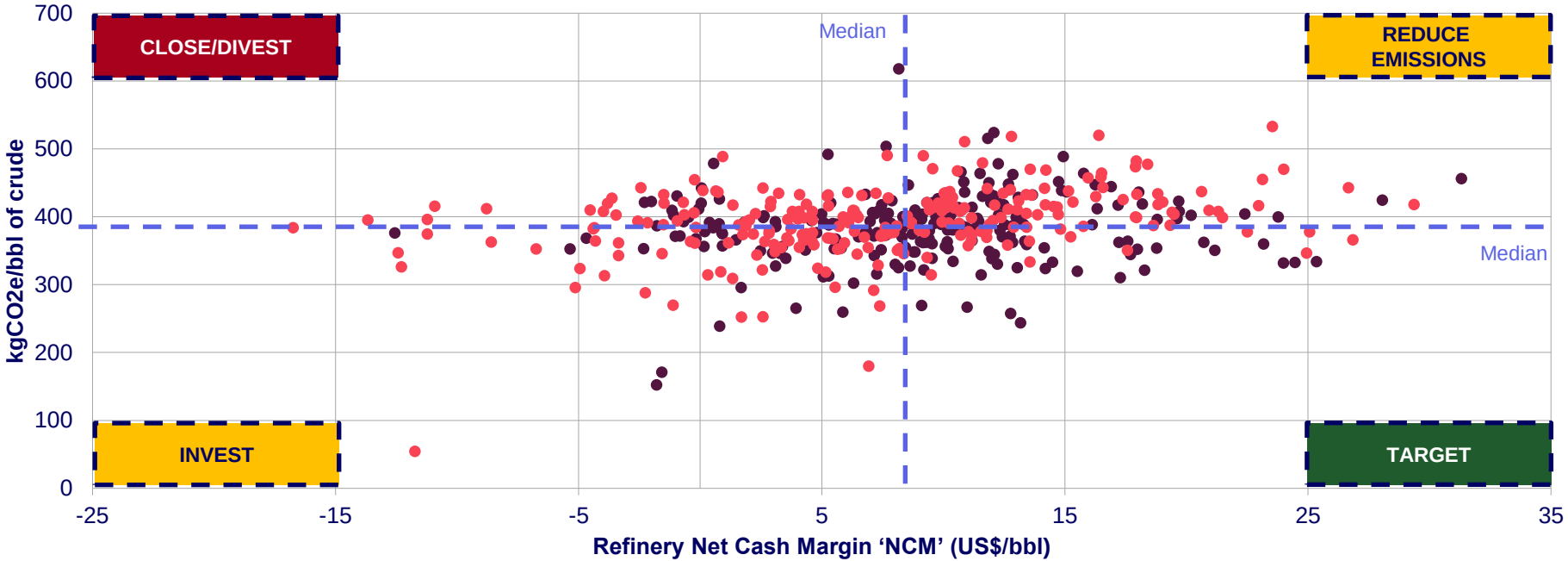
Source: Wood Mackenzie

■ Integrated site ■ Refining-only site

Refiners that have lower carbon intensity and stronger relative competitive position will be better positioned for the energy transition

Refiners will need to increasingly consider carbon intensity in addition to margins

Emissions intensity versus Integrated NCM, Global, 2021-2022



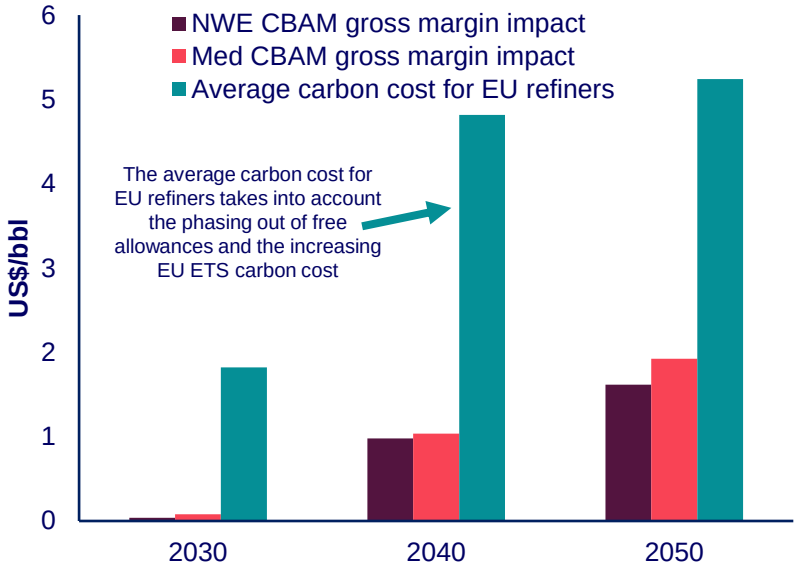
Source: Refinery Evaluation Model (REM), REM-Chemicals, PetroPlan

Note: Average of 2021's and 2022's integrated NCM and emissions (Scope 1, 2 and 3)

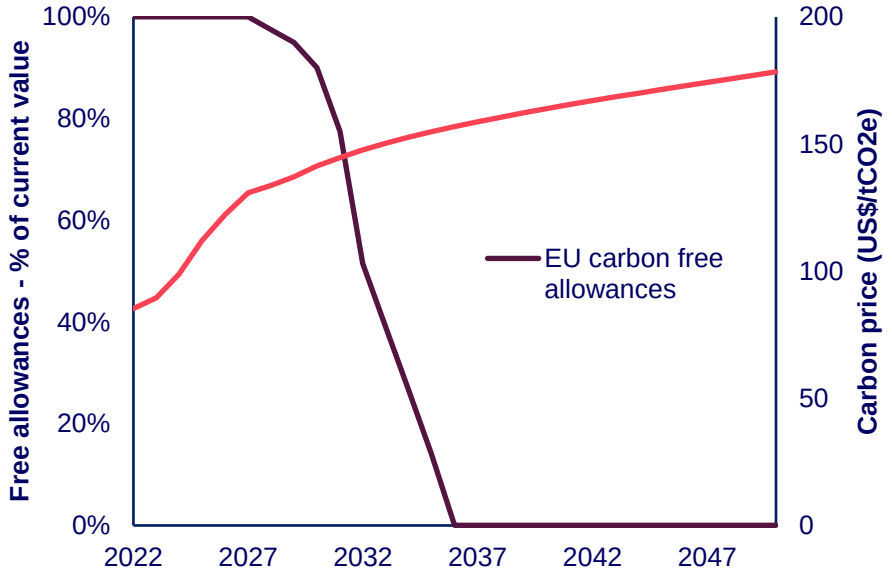
Increasing carbon costs will place a greater cost burden on EU refiners, the CBAM will provide some support but not fully level the playing field

As EU ETS price increases and free allowances phase-out, the average cost of carbon for EU refiners reaches nearly 5 US$/bbl in 2040 – with CBAM providing only ~1 US$/bbl of margin support

Impact of CBAM on European gross refining margin, and average carbon cost for EU refiners, US$/bbl (2030-2050)



Assumed free allowances phase-out profile and EU ETS carbon price, %, US$/tCO$_2$e (2022-2050)



Source: Wood Mackenzie

Refining companies will need to develop and implement strategies to manage carbon and adapt to the energy transition market changes while growing margins

The downstream / refining sector is at the forefront of the **energy transition**. Balancing the need to continue to effectively supply the market with fuels while reducing carbon impact

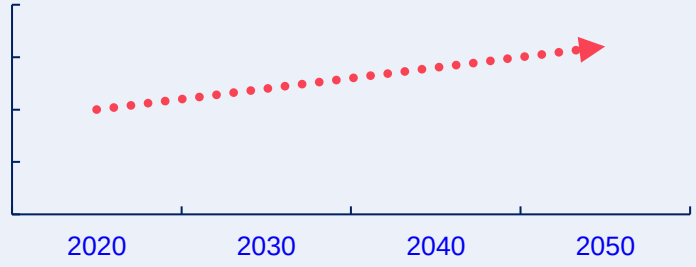
Companies will need **devise strategies** and long-term implementable plans to meet a range of key objectives:

- **Grow revenue and margins** (in a sector where the core market is declining)
- **Reduce carbon / impact** (where core product is highly carbon intensive)

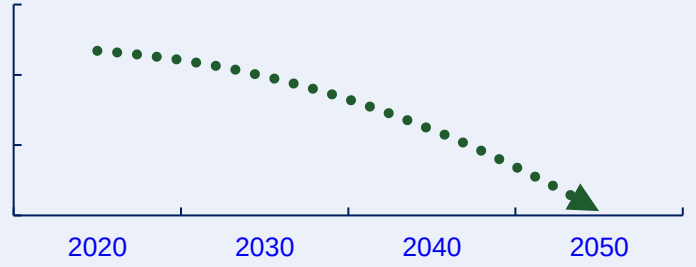
There are a range of different **strategic pathways** refiners could take, and no one solution will work for all businesses – examples:

- High-grade portfolio
- Alternative / low carbon liquid fuels
- Diversity offering (new energies)
- Cost and efficiency
- Retrench to advantaged market
- Industrial cluster integration
- Focus on non-transport liquids
- Reduce carbon emissions (CCUS)
- Circular production

Revenue / EBITDA



Carbon Emissions / Intensity



Refiners will need to identify which decarbonisation options may be viable and attractive for them, many will have high cost or margin impacts

Reducing absolute scope 3 emissions will require a reduction in production of fossil-based fuels, diversification into new areas over time may make this more feasible

Refinery Integrated Options

Scope	Scope 1 & 2	Scope 3
Energy efficiency improvement	↓↓	
CCUS	↓↓	
Fuel switching (lower carbon)	↓	
Renewable power integration	↓↓	
Flaring reduction	↓	
Integrate green hydrogen (displace grey)	↓↓	↓
Yield shift from combustible products		↓↓
Co-process bio/sustainable fuels*	↑	↓↓
Petrochemical integration*	↑	↓↓
Integrate E-fuels production*	↑	↓
Lower carbon crude selection		↓
Lower carbon transportation		↓

Portfolio Options

Scope	Scope 1 & 2	Scope 3
Capacity rationalisation	↓	↓
Refinery sale	↓↓↓	↓↓↓
Refinery site closure	↓↓↓	↓↓↓

There are a range of low carbon diversification options

- E-mobility
- Renewable power production and sale
- Green/blue hydrogen production and sale
- Site conversion (bio/sustainable fuels)
- Standalone bio/sustainable fuels production
- Standalone e-fuels production
- CCUS as a service
- Carbon offsets – EUA's for scope 1 and 2
- Carbon offsets – voluntary / un-regulated market for scope 3

Note:* Adding net additional production can increase overall scope 1 and 2, while reducing scope 3 intensity. If production is used to offset fossil-based processing, absolute reductions in scope 1,2,3 could be achieved

↓ Relative scale estimate

Appendices

Chris Barry

Vice President, Head of EMEA Downstream Consulting

Biography

Chris leads Wood Mackenzie's EMEA Downstream Consulting team and is based in London.

Since joining Wood Mackenzie Chris has managed a range of projects covering the refining, renewable fuels, petrochemicals, and storage sectors. This has included buy and sell side due diligence / transaction support, government advisory, strategy development, feedstock and product market analysis, greenfield development studies, and competitiveness and opportunity screening

Chris has conducted a number of studies covering refining, petchems, competitiveness and carbon analysis and has led on various biofuels studies including new greenfield investments, pricing and market outlooks, valuations of existing biofuels production businesses, and feasibility of conversion of a refinery to sustainable fuels.

Chris has worked with a broad range of clients including oil majors, NOC's, financial institutions, EPCs, and government ministries predominantly focusing on Europe, Africa, and the Middle East

Prior to joining Wood Mackenzie Chris gained experience within the downstream industry, working for BP and Petroplus at the Coryton Refinery in the UK.

During this time Chris worked in the process engineering team holding a range of technical, operational, and project development roles. He also worked in the commercial planning team providing commercial co-ordination between trading, marketing, and operations teams

Chris holds a First Class honours degree in Chemical Engineering from the University of Bath, and is a chartered member of the Institute of Chemical Engineers.

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