# Turning decarbonisation options into board-ready decisions

## A structured technical and economic screening process is vital for translating EU policy drivers into actionable investment choices

Andrew Last, Tracy Sadowski, and Scott Sayles
**Becht**

For European refiners, the past two decades have seen decarbonisation move from a policy discussion to an increasing direct operating cost. With a total annual emissions tax cost reaching billions of euros (*EEA*, 2025), emissions have shifted from a compliance item to a material factor in margin resilience and capital planning.

The challenge has evolved from identifying decarbonisation options to selecting the right ones. Refiners must evaluate competing technologies, infrastructure requirements, and capital intensity while maintaining operational reliability. A structured technical and economic screening process is essential to translate policy drivers into practical investment decisions.

The cost of emissions initially justified energy-efficiency improvements and is now a rising annual cost of tens of millions of euros for refining sites, driving margin and competitiveness decisions, large-scale project spending, and, for some sites, closure (*TCE*, 2025).

As project announcements have surged, particularly in biofuels and hydrogen, they must now contend with the practicalities of execution. The next phase will depend less on headline ambition and more on disciplined assessment of technology, configuration, and delivery risk.

The region's refiners face the challenge of selecting and implementing the right decarbonisation projects for their site's realities and market position to avoid eroding competitiveness or committing capital to the wrong long-term configuration.

Confidence in decarbonisation technology claims can outpace practical readiness; an independent third-party assessment can provide a structured counterweight. By evaluating technical feasibility, integration risk, Capex intensity, and schedule realism during scenario screening, a broad technology debate can be converted into a board-ready decision framework.

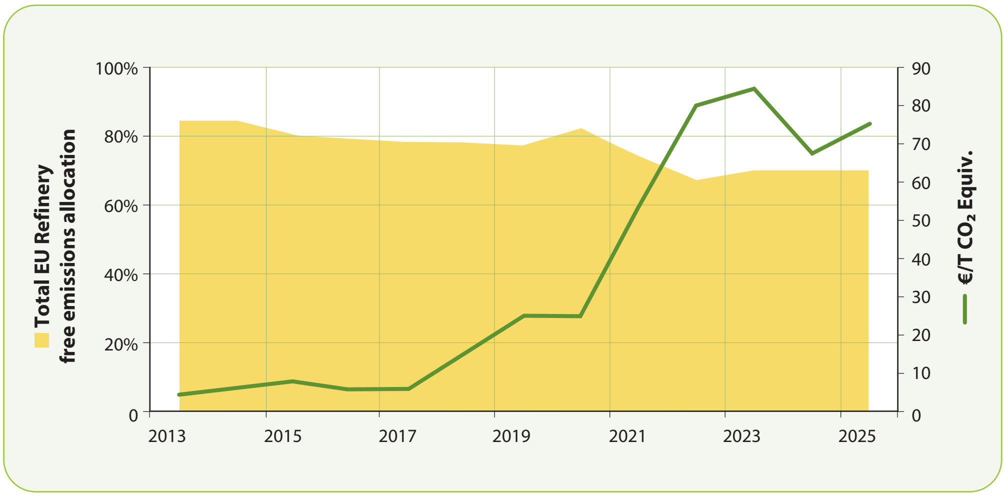


**Figure 1** Total EU refinery emissions (2013-2025) (*EEA*, 2025)

### European refinery decarbonisation drivers

Using the European Union's Emission Trading Scheme (EU ETS) as an example of a major decarbonisation driver, refineries each have individual emissions allocations, with a cost for any emissions beyond the annual cap. As the free allocation for each refinery has reduced, the cost of emissions in excess of the cap has risen.

Since 2013, total European refinery emissions have fallen 15% (*EEA*, 2025) (see **Figure 1**), with closures of 13 fossil refineries in the region (Concawe, 2025) contributing up to a third of the emissions reduction. Over the same time period, nine bio-refineries were added or converted from fossil refineries.

As the incremental cost of emissions has risen, this has incentivised adaptation and begun pruning the refining capacity base. The industry has pursued decarbonisation from:

- Pursuing quick wins and energy efficiency projects.
- Capital projects to decarbonise existing operations.
- Diversification into biofuels and alternative feedstocks or full conversion into bio-refineries.
- Capacity reduction and closures for those without the appetite for high-cost and long-timeline capital projects.

A typical 150 KBD fossil refinery in Europe currently faces a €30 million annual emissions cost, climbing to more than €100 million in the next decade as the free allocation further reduces and the unit cost of emissions rises. This is illustrated in **Figure 2** on a euro-per-barrel basis.

For refiners factoring the price of decarbonisation into their future business cases, utilising an independent third party to assess options for capital projects, configuration changes, and new technologies can quickly develop robust board-level decision-ready strategies.

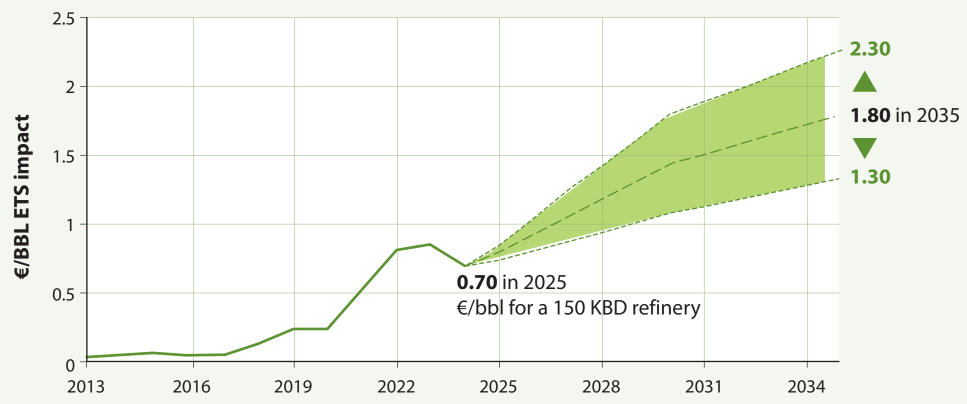


**Figure 2** EU ETS forecast scenario

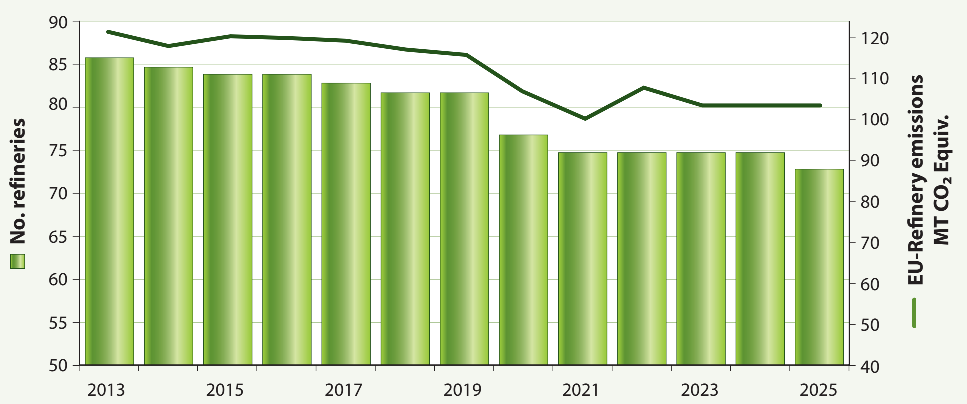


**Figure 3** European refinery count and total annual emissions (Concawe, 2025) (*EEA*, 2025)

Understanding the emissions cost impact of optimisation and project assessments is moving from a secondary screening check to a primary project driver. Ensuring the technical and economic representations of emissions in decision-making tools are correct should be part of cold-eyes review processes.

## Refinery capacity and configuration shifts

Capacity changes and closures have delivered additional throughput reductions in the region, with Europe's decarbonisation wave reshaping portfolios alongside cutting $CO_2$ intensity (see **Figure 3**).

Operators are paring back throughput on older trains, with many closures of ageing, mid-scale plants with heavier ETS exposure. Since 2013, the average characteristic of an EU refinery facing closure was 65 years old and 115 KBD capacity, while the remaining stock

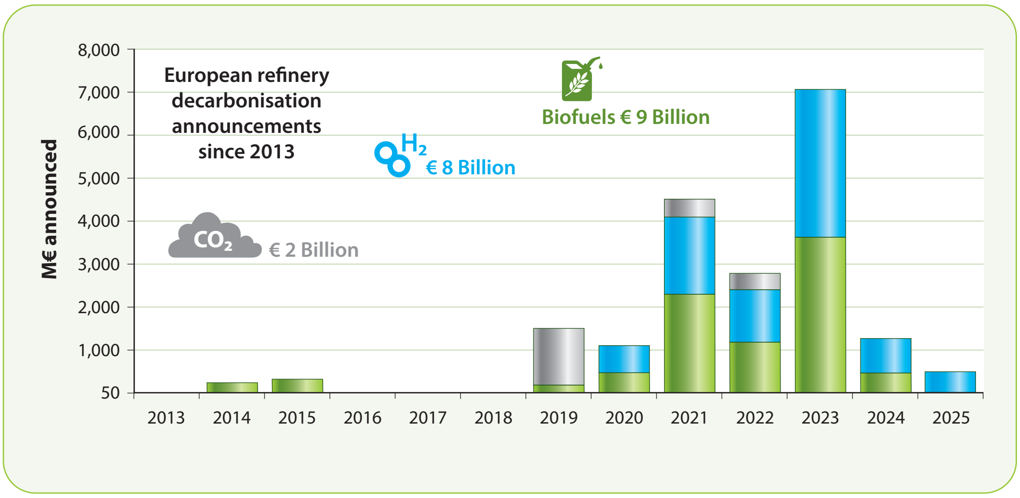


**Figure 4** European refinery decarbonisation announcements (2013-2025)

is on average 50 years old and 150 KBD crude capacity.

Conversions to biofuels or lubes still incur emissions costs if fossil energy or grey hydrogen remains in use. Meanwhile, redundant assets are being converted to terminals, with imports meeting demand whilst exiting ETS obligations.

## Decarbonisation projects from announcement to execution

In practice, successful decarbonisation strategies rarely rely on a single flagship technology. Instead, they combine near-term efficiency improvements, mid-term process upgrades, and longer-term infrastructure investments. From a review of annual company announcements by European refiners of decarbonisation projects, a wave of initiatives was announced primarily between 2019 and 2025, peaking at an annual total of €7 billion in 2023 (see **Figure 4**).

From 2013 to 2018, refiners likely focused on low-Capex energy efficiency projects executed within existing turnaround cycles and did not warrant public announcement. Meanwhile, as market impetus grew amid low borrowing costs and policy funding support from 2021 to 2023, a range of carbon capture, hydrogen production, and biofuels projects were announced by refiners.

Biofuels have dominated announcements, accounting for almost half of signalled capital from 2020. Hydrogen projects accelerated sharply from 2021, often paired with renewable or blue hydrogen supply schemes.

The concentration of projects in 2021 to 2023 signals a strategic pivot from compliance-driven decarbonisation to wider portfolio adoption within European refining. A reduction in new announcements, alongside a series of cancellations, highlights a market moving into the realities of execution. With many refiners relying on a single flagship project to reduce vulnerability to future increases in emissions costs, a rigorous assessment of technology options is a crucial step to reduce project risk.

As the licensor market develops and establishes a variety of decarbonisation technologies, an independent external market-wide technology readiness assessment ensures that the right solution for each location, process, budget, and scale is identified. In a cost-pressured market, projects that are expensive, delayed, or highly sensitive to operating conditions can quickly undermine the underlying business case.

## Case study: sequencing renewable fuels investment decisions

A European refinery facing structurally weak margins engaged Becht to assess conversion to a renewable fuels configuration, comparing full conversion against phased co-processing within existing hydroprocessing assets. A rapid, multidisciplinary screening integrated technical feasibility, feedstock availability, product market access, and incentive exposure, alongside repurposing constraints on in-flight capital projects. The analysis moved beyond headline economics to identify practical delivery risks, including pretreatment requirements, hydrogen balance, product routings, and sensitivity to policy-driven credits.

The outcome was not a binary 'convert or not' decision, but a sequenced strategy: near-term co-processing to capture available margins and de-risk operations, combined with defined triggers for deeper conversion aligned to feedstock security and incentive stability. This provided management with a viable investment pathway, grounded in asset-level constraints and market realism, rather than relying on optimistic assumptions about future policy or technology readiness.

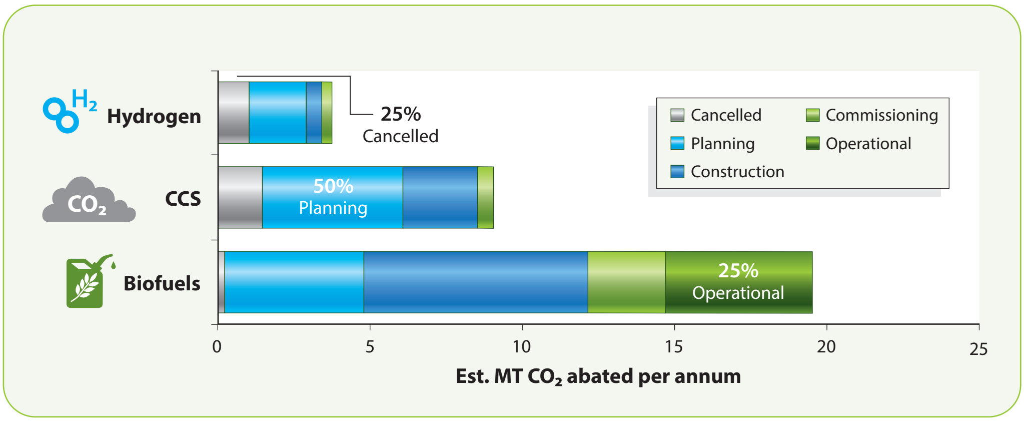


**Figure 5** European refinery decarbonisation announcement status (2025)

## Case study: readiness assessment for a green hydrogen project

A further example highlights a different dimension of decarbonisation project risk: overall project readiness. The offtaker for a new European green hydrogen facility was preparing to receive hydrogen from a project led by a first-time developer. As commissioning approached, concerns emerged around whether the facility could deliver hydrogen safely, reliably, and on schedule. An independent production assurance review by Becht assessed readiness across technical systems, operations, safety, and governance through document review, site visits, and stakeholder interviews. The assessment identified gaps in procedures, roles, and system maturity that would likely have impacted start-up performance. By surfacing these issues early, the offtaker was able to pause integration planning and require corrective actions, enabling the developer to address deficiencies prior to start-up and improving the likelihood of stable operation.

## Sustaining momentum

Publicly announcing a project is no guarantee of execution, and tracking the latest status of the announcements highlights challenges in each of the three key technology categories in progressing from concept to operation.

Each technology route has faced differing challenges and timescales for execution, with biofuels projects demonstrating the highest success rate in progressing to operation, while the majority of carbon capture projects remain in the planning stage. Furthermore, the recent wave of hydrogen projects has been beset by cancellations.

Flexibility in feedstock and technology, and the ability to co-process in existing operations, have resulted in the rapid adoption of biofuels projects, further incentivised by additional policy support through the Renewable Energy Directive III and ReFuelEU Aviation policies. By enabling integration into ongoing profitable operations and being scalable to individual sites' capital appetites, robust conversion of biofuels projects into operation can be expected to continue.

The scale of hydrogen and carbon capture projects often necessitates the right local combination of supply, offtake, and government support, favouring regional energy hubs with involvement of multiple industrial partners and often coming with a significant logistics component. Projects frequently face challenges across:

- Grid connection capacity.
- $CO_2$ and $H_2$ transport and storage infrastructure.
- Lack of offtake partners for $CO_2$ and $H_2$.
- Permitting and approval timelines.
- Policy support and subsidies.

As the pipeline has shifted to execution, with more than 55% of projects progressing beyond planning, leveraging experienced independent input from the conceptual, feasibility, planning, and implementation phases reduces execution risk while enabling site resources to focus on stable, profitable operation and upcoming maintenance periods.

Accelerating emission costs shorten the decision timeline for refiners to select, plan, and implement their chosen decarbonisation route. By tailoring the project to the unique needs of each refinery, rather than the most optimistic licensor estimates, and by pursuing a pragmatic approach, technical and economic uncertainty can be reduced in the early stages of the project.

## Case studies: screening carbon capture for site-specific reality

Many refiners and upgraders are evaluating carbon capture as part of their decarbonisation strategies. However, the technical questions involved vary widely from project to project. In some cases, the primary challenge is selecting the most appropriate capture technology among competing licensors. In others, the key issue is whether the existing refinery configuration can physically accommodate the changes required by carbon capture without compromising reliability or emissions performance.

Two recent project assessments illustrate how independent technical screening helps refine these decisions:

> "Independent technical screening helps ensure that investment decisions reflect the realities of the host refinery rather than optimistic assumptions about technology performance"

### Technology screening for carbon capture integration

A European refinery facing rising EU ETS compliance costs required a technology-neutral assessment of $CO_2$ capture options for its hydrogen plants. The objective was to identify a capture configuration that could deliver meaningful emissions reductions while maintaining refinery reliability and economic competitiveness.

An independent review was undertaken to evaluate multiple capture licensors and configurations. The study normalised capital and operating costs, assessed process integration with existing utility systems, reviewed plot space limitations, and evaluated operability considerations across several technology options. A structured scoring framework was developed to compare six licensors using technical, operational, and economic criteria.

The assessment identified clear technology and configuration leaders suited to the refinery's specific operating environment. By integrating engineering constraints with financial modelling, the refinery was able to move forward with confidence toward the next phase of engineering using a defensible, data-driven selection.

### Operational constraints in hydrogen plant $CO_2$ capture

A separate evaluation for a refinery illustrates a different type of decarbonisation challenge: operational integration. The operator was exploring the feasibility of adding $CO_2$ capture to an existing hydrogen production unit. Early project concepts assumed that removing $CO_2$ from pressure swing adsorption (PSA) tail gas would not significantly affect reformer operation.

A rapid technical screening revealed that the proposed configuration would substantially alter the reformer heat balance. Removing $CO_2$ from the fuel stream increased combustion temperatures and air demand, creating potential constraints on the forced-draft and induced-draft fan systems. The changes also raised the possibility of increased NOx formation, depending on the resulting combustion conditions.

By identifying these interactions early, the refinery avoided progressing with a configuration that could have created operability challenges and emissions risks. Instead, the findings allowed the project team to refocus subsequent engineering studies on realistic operating ranges, delivery, and commissioning risk.

These two studies highlight a broader lesson for decarbonisation planning. The key question is rarely whether a carbon capture technology can work in isolation, but whether it can be integrated into a specific refinery configuration at an acceptable cost and operating risk. Independent technical screening helps ensure that investment decisions reflect the realities of the host refinery rather than optimistic assumptions about technology performance.

## What successful decarbonisation projects have in common

The wave of decarbonisation announcements across European refining peaked between 2021 and 2023, driven by policy incentives, lower borrowing costs, and rising EU ETS prices. As projects move from concept to execution, clear patterns are emerging: some initiatives progress successfully, while others struggle to move beyond the planning stage.

Biofuel conversion projects have generally advanced most rapidly. Their success reflects several advantages: compatibility with existing refinery infrastructure, scalable investment levels, and the ability to integrate renewable feedstocks into profitable operations. Policy frameworks such as Renewable Energy Directive III and ReFuelEU Aviation have further strengthened the commercial case.

Hydrogen and carbon capture projects face more complex development pathways. These projects typically depend on multiple external factors, including hydrogen supply, $CO_2$ transport infrastructure, permitting approvals, and government support mechanisms. As a result, many announced projects remain in planning stages while developers address process integration challenges and commercial risk.

Across all technology pathways, successful projects share a common characteristic: alignment among technology choice, site constraints, synergies with existing infrastructure, and economic reality. Projects that rely on optimistic assumptions are far more likely to stall during development.

Projects that progress successfully blend technology with the specific configuration and operating environment of the refinery. In a market defined by rising carbon costs and constrained capital, competitive advantage will come from combining innovative technologies with disciplined engineering and integration planning.

VIEW REFERENCES


Andrew Last
alast@becht.com

Tracy Sadowski
TSadowski@becht.com

Scott Sayles
ssayles@becht.com