Decarbonising assets: Key insights from Pernis refinery

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Whether it is power, steel, cement, or petrochemicals, we all recognise that it will not be easy to reduce the carbon footprints of our assets. But has it ever been easy? Heavy industry has a remarkable track record of solving challenges, and I believe this will be no different, especially because we all understand just how important it is that we do.

Decarbonisation is undoubtedly one of the most profound strategic issues that executives will face, so, in this article I discuss some of the actions that Shell is taking at one of its largest facilities: Pernis refinery in Rotterdam, the Netherlands, which will soon be Shell Energy and Chemicals Park Rotterdam. And the challenges for refiners are similar to the challenges facing all heavy industries as they grapple to untangle the pathways and options to navigate the energy transition.

The organisation that I lead, Shell Catalysts & Technologies, is supporting Shell as it transforms its business to meet its target of becoming a net-zero-emissions energy business by 2050 or sooner. We are also helping other companies to achieve their own net-zero goals. And when Shell Catalysts & Technologies provides that support, it tends to work through the three classic decarbonisation pathways (Figure 1).

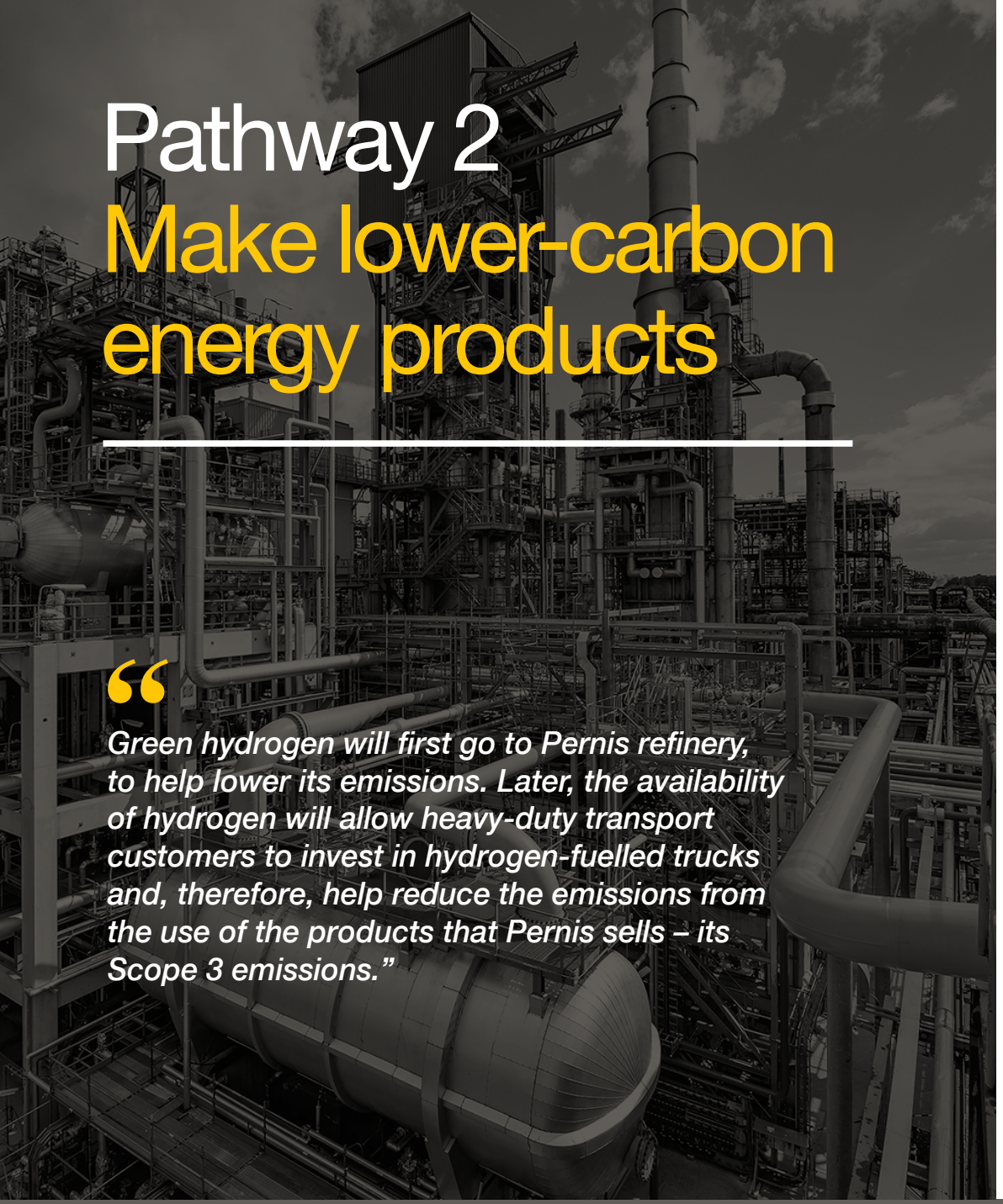
The first pathway involves looking at ways in which producers can reduce emissions from their own operations by increasing energy efficiency. Although energy efficiency is important, within a refinery, the facilities that bring an energy product to the customer are typically responsible for less than 15% of the greenhouse gas emissions associated with that product. Some 85% of the greenhouse gas emissions come from the product's end use: consumers driving their cars, for example. Therefore, the second pathway involves considering ways to make lower-carbon energy products such as biofuels. The third pathway encompasses capturing (or offsetting) any remaining emissions through carbon capture and storage (CCS) or nature-based solutions.

Figure 1: The three classic decarbonisation pathways.

Pathway 1
Increase energy efficiency

At all of Shell's downstream assets, teams are working to continue improving utilisation, energy efficiency and carbon intensity. Carbon dioxide (CO_2) and energy management plans are in place, and the sites are investing in cogeneration units and upgrades for equipment and technology. Pernis refinery is no exception. Here, a recent energy-efficiency programme helped to cut CO_2 emissions by the equivalent of the annual emissions of 50,000 cars.

An interesting initiative that has helped to further improve Pernis refinery's energy efficiency is an innovative project in which waste heat from the refinery is used to heat local homes. The site has installed specialised technology to capture and store residual heat from operations, which was previously considered a waste product, that has the capacity to heat more than 16,000 households in Rotterdam.



Pathway 2
Make lower-carbon energy products

“Green hydrogen will first go to Pernis refinery, to help lower its emissions. Later, the availability of hydrogen will allow heavy-duty transport customers to invest in hydrogen-fuelled trucks and, therefore, help reduce the emissions from the use of the products that Pernis sells – its Scope 3 emissions.”

The site’s emissions will fall further when the Rotterdam Clean Energy Hub is completed, which is expected to be in 2023. This is an industry collaboration that will see up to 60,000 kg/d of green hydrogen produced through electrolysis using renewable electricity from the Hollandse Kust Zuid wind farm.

Initially, this green hydrogen will go to Pernis refinery to help lower its emissions. But there is another important aspect to this: the availability of hydrogen will encourage heavy-duty transport customers to invest in hydrogen-fuelled trucks. So, in this way, Pernis refinery will play a crucial role in helping that sector to lower its emissions. This will also help the refinery to reduce the emissions that come from the use of the products it sells – its Scope 3 emissions.

Pernis refinery is also pursuing an ambitious biofuels strategy and recently announced a final investment decision to build an 820,000-t/y low-carbon fuels facility. The new plant, which will feature the Shell Renewable Refining Process, plans to convert low-carbon oils and fats such as used cooking oil, waste animal fat and other industrial and agricultural residual products into sustainable low-carbon road and aviation fuels.

The Shell Renewable Refining Process is a hydroprocessing or hydrotreated vegetable oil technology for producing renewable fuels from vegetable oils, fats and greases, and is licensed by Shell Catalysts & Technologies. Pernis refinery selected it following an extensive assessment of the numerous available technologies. Shell Catalysts & Technologies is also working with several other refiners around the world to help them to evaluate the technology’s process economics and its robustness to future demand and regulatory scenarios.

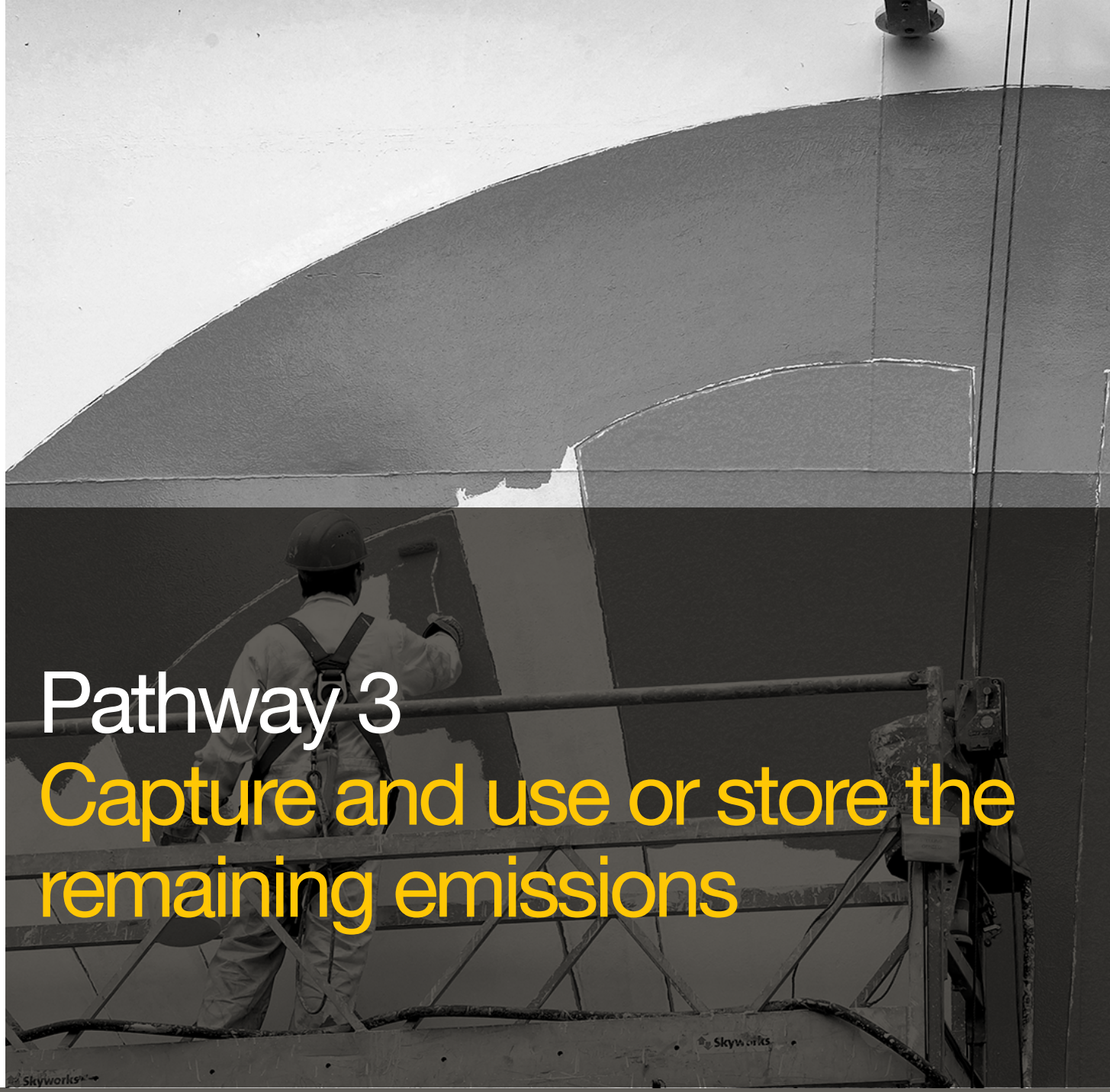
This technology would enable these refineries to process 100% biofeeds. For many refiners, the easiest way to start producing lower-carbon energy products is through co-processing. In this way, they can add up to 10% renewable feedstock to an existing hydroprocessing unit, often without any capital expenditure. There are some risks to manage with co-processing, but it is a well-established technique.

For many years, Pernis refinery has been routing 40% of the CO_2 its Shell gasification hydrogen unit produces to local greenhouses, where it is used to accelerate crop growth and reduce the need for horticulturalists to generate their own CO_2.

The high purity of the CO_2 not only benefits the crops, it also makes it ideal for CCS. By the end of 2023, Pernis refinery expects the remaining CO_2 to be routed to the North Sea and stored in depleted gas reservoirs deep beneath the seabed.

This would be through Porthos, a project that will also involve three neighbouring plants: the ExxonMobil refinery and Air Products and Air Liquide's hydrogen plants.

For Pernis refinery, which would route emissions from the gasification plant and the Shell Renewable Refining Process unit, this would reduce the site's emissions by some 25%. CO_2 from the new unit would be captured using ADIP ULTRA, Shell Catalysts & Technologies' solvent technology for capturing CO_2 from high-pressure process streams, which is also used at Shell's Quest CCS project in Canada.



Pathway 3
Capture and use or store the remaining emissions

Key learnings

One of the key takeaways from all this, for me, is that there is a wide range of decarbonisation solutions that can be applied across all of industry, from power to steel to cement. And the scale of the challenge is that most businesses will need to apply nearly all of them.

But I also think that Pernis refinery demonstrates something else: that companies and governments are increasingly willing to collaborate to solve these major challenges. Whether it is sending CO_2 to greenhouses and heat to homes, developing infrastructure or working with other companies to develop green hydrogen networks and CCS projects, most of these initiatives involve working with others – and momentum is building.

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