



Government of the Netherlands

A photograph of an industrial facility, likely a chemical plant, with several tall smokestacks emitting thick white plumes of smoke. The facility is situated behind a green field with a grassy embankment in the foreground. The sky is blue with some clouds.

Vision on sustainable carbon in the Dutch chemical industry

Summary

For the chemical industry, carbon serves as a fundamental building block in the production of products such as plastics, coatings, detergents and medical products. Most of this carbon currently comes from fossil raw materials, such as crude oil and natural gas. In order to secure future earnings potential and reduce strategic dependencies, the use of fossil raw materials must be phased out as far as possible. Using carbon from sustainable sources can help to achieve a climate-neutral and circular economy, boosting the Netherlands' strategic autonomy. Sustainable carbon can be sourced from secondary raw materials, sustainable biobased raw materials and CO₂. It currently remains unclear what a climate-neutral and circular chemical industry would actually look like and the route to achieving it is equally uncertain. This is why this vision and transition pathway for increasing the use of sustainable carbon in the chemical industry has been compiled.

In the future, the chemical industry is set to remain of strategic economic importance for the Netherlands because of its (geographic) position in Europe. As such, the sector has a key role to play in closing the carbon loop and achieving circularity. As a result of increasing circularity, global competition and the development of new value chains, the role of the basic chemicals industry in the Netherlands may potentially decrease, but it will no doubt continue to be a vital industry.

The raw materials transition will be challenging, because scaling the use of sustainable technologies will place a great demand on the sector, both in terms of time and resources. Operational costs will increase systematically. Meanwhile the sector's competitiveness faces pressure from high energy prices combined with excess production capacity worldwide. However, the transition to sustainable carbon also presents opportunities in terms of the Netherlands' strategic autonomy and future economic potential. Short-term interventions will therefore be required in order to trigger the transition and enable future prospects for the industry.

By 2050, the raw materials transition in the chemical industry will have made significant progress and the sector is set to look very different. New technologies will emerge across three main routes: **1) direct substitution:** transforming the existing petrochemical industry assets for the use of sustainable feedstocks; **2) alternative routes:** the development of new routes using sustainable feedstocks to produce existing output with wide-ranging applications; and **3) new chemistry:** the development of the production of new chemicals and plastics for improved carbon efficiency, energy consumption and functionality. This will mean a shift towards a more complex system with multiple routes and diverse feedstocks. The limited availability of sustainable raw materials, clean energy and space (both physical and environmental) will require high-value applications of sustainable carbon in the most efficient processes.

The pathway for this material transition is uncertain. By means of this vision, the Dutch government is providing direction and insight on what will need to happen, and when, in order to achieve the aims outlined above. As we head towards 2030, chemical companies and recyclers are facing a difficult market position. At the same time, the earliest 'first-of-a-kind' chemical plants are already under construction. After 2030, significant changes can be expected as a result of European product regulation on recycling and the establishment of the infrastructure needed to enable it. Renewable fuel production is set to be further developed. In this period, there will need to be clarity with regard to European policy interventions on sustainable carbon chemistry and product legislation if the transition is to be a success. The gradual phasing out of the use of fossil raw materials will create physical and environmental space for sustainable

production. As we move toward 2040 and beyond, new technologies will be upscaled and optimised, enabled by an increasingly standardised market and the availability of renewable energy.

To enable the transition to be successful, the Dutch government is committed to creating European demand and a market for (products made from) sustainable carbon, where secondary and raw materials have been harmonised and standardised for trade. At the same time, there will be investments in research and development for the sustainable carbon chemical industry to be developed in the Netherlands. Targeted government policy will also be essential in ensuring that energy costs in the Netherlands do not significantly differ from those in neighbouring countries, enabling Dutch companies to compete internationally and ensuring that the transition can also happen in the Netherlands. This will require sufficient affordable energy and energy infrastructure and a focus on the effective use of scarce (physical and environmental) space and sustainable raw materials.

This vision and transition pathway has been compiled based on an intensive stakeholder participation track, various studies into the feasibility, affordability and opportunities for minimising the use of fossil raw materials by 2050 and an independent expert advisory report on the future of sustainable carbon chemistry.

In order to implement this vision, a policy and implementation agenda will be compiled in 2026 including actions for the government and private parties for the next five years. An annual progress dialogue will be organised with the sector and value chains as a means of identifying any necessary adjustments in the vision. Progress will also be monitored and evaluated by means of the already existing Dutch policy frameworks such as the Energy System Monitor (*Monitor Energiesysteem*), the Energy Memorandum (*Energienota*) and the National Programme Towards Sustainable Industry (*Routekaart Nationaal Programma Verduurzaming Industrie*, NPVI). The vision will need to be evaluated and updated every five years.

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How to read this document

In order to achieve a climate-neutral and circular economy by 2050, the Dutch government has set out its goal of minimizing the use of fossil raw materials. How this will apply to the chemical industry, which largely makes use of fossil raw materials, remains unclear. This vision provides an initial picture of a future chemical sector in the Netherlands, based on sustainable carbon sources (secondary raw materials, biobased raw materials and CO₂) and the transition pathway towards its realisation.

It provides an insight into the steps that parties (both government and industry) can and must take in the short term in order to achieve the transition towards sustainable carbon chemistry. This vision has been developed within the wider framework of circular, climate, energy and environment policy as set out in the National Energy System Plan (*Nationaal Plan Energiesysteem*, NPE), the National Programme Towards Sustainable Industry (*Nationaal Programma Verduurzaming Industrie*, NPVI) and the National Circular Economy Programme (*Nationaal Programma Circulaire Economie*, NPCE).

The vision aims to provide insight in the challenges faced by the chemical industry in the material transition and identify the prerequisites, risks, but especially the opportunities, for creating a future Dutch chemical industry that is sustainable. It should also be noted however, that this vision was drafted at an economically difficult time for (the chemical) industry in the Netherlands and the rest of Europe. These circumstances only add to the importance of figuring out how a sustainable carbon chemical industry can be achieved in the Netherlands.

Chapter 1 describes the scope of this vision, starting with the rationale and objective. It includes a definition of sustainable carbon and sets forth why the transition towards sustainable carbon use is necessary.

Chapter 2 outlines a vision of the aspired chemical industry in 2050 and **Chapter 3** sets out the pathway that this transition could follow to achieve it. **Chapter 4** then sets out the policy strategy needed to achieve the transition, detailing the government's efforts required and the key principles on which policy will need to be based.

Chapter 5 outlines the context of carbon chemistry. It starts by describing the current situation of the chemical industry. This is followed by the international context facing the chemical industry. Finally, the chapter details how the transition to sustainable carbon can contribute to the transition towards a climate-neutral, circular and healthy and safe environment by 2050.

Chapter 6 then explores how demand for chemicals and materials is expected to develop. Based on three different sustainable carbon sources, it also describes potential technological opportunities for scale up, the role that different sustainable carbon sources could play in the Netherlands and what will be needed to enable that to happen. It also takes a brief look at the supply side of these carbon sources.

Chapter 7 looks closer at public and private funding; an essential ingredient in making the transition possible.

Finally, **Chapter 8** focuses on how this vision can be implemented and embedded in policy.

Note; This document was originally drafted in Dutch and translated to English after its publication. Certain sentences, technicalities or Dutch policies might not have been translated accurately. When you have doubts or questions regarding certain phrasing, please reach out to your contact at the Ministry of Infrastructure and Waterworks or the Ministry of Climate and Green Growth.

1 Scope and objective

1.1 Rationale and objectives

Fossil raw materials, such as crude oil and natural gas, are used for energy and fuel production, but also as feedstocks in the chemical industry. These raw materials are used to make products that we use on a daily basis, such as plastics, coatings, detergent and medical products. As fossil raw materials use for chemicals is roughly equal to their use in domestic mobility¹, the chemical industry is a large-scale consumer of fossil raw materials. Declining levels of production in the chemical industry in the Netherlands and Europe mean that it is more important than ever to outline a vision of a future-proof and sustainable chemical industry. Increasing competition from outside Europe and rising energy and raw material prices put pressure on the existing fossil carbon chemistry and this is only expected to continue. A transition towards sustainable production methods will therefore be needed to ensure increased strategic autonomy and future earnings potential.

By phasing out the use of fossil raw materials as much as possible and scaling up the use of sustainable raw materials in chemical industry production, a climate-neutral and circular economy can be achieved. The key building blocks, hydrogen and carbon, currently taken from fossil sources, will need to come from sustainable sources in the future². The National Hydrogen Programme (*Nationaal Waterstof Programma*)³ provides a vision for hydrogen, but so far there has been no vision on the use of sustainable carbon in chemistry.

The National Circular Economy Programme (NPCE) 2023 – 2030⁴ states the ambition of being completely circular by 2050. The NPCE describes a fully circular economy as one in which the environmental effects of the use of raw materials by all Dutch production and consumption remain within the planetary boundaries⁵. The National Programme Towards Sustainable Industry (NPVI)⁶ endorses this while also emphasising that the use of fossil raw materials needs to be reduced. The National Energy System Plan (NPE) sets out the aspiration to minimise the use of fossil raw materials as far as possible by 2050. A climate-neutral energy system still permits the use of fossil raw materials, when this is offset by the capture of CO₂. It currently remains unclear what a climate-neutral and circular chemical industry would actually look like and the route to achieving it is equally uncertain. With contributions from a large group of stakeholders, the government has therefore set out a vision and transition pathway for the use of sustainable carbon in the chemical industry.

This vision builds on the development pathway for the carbon supply chain set out in the NPE and takes a closer look at the effects and consequences of the raw materials transition in the chemical industry. It outlines a vision for the future use of carbon in the chemical industry and provides an insight into the challenge involved and the steps that parties – both government and industry – can and must take in the short term in order to achieve this transition.

1 [Energiebalans; aanbod, omzetting en verbruik | CBS.](#)

2 This vision focuses on organic chemistry, in which hydrocarbons play a central role, with a view to defossilising carbon sources. Although inorganic chemistry, such as steel production, is not based on carbon, it is closely linked to organic chemistry. In the follow-up to this vision, interaction with inorganic chemistry and other sectors will need to be taken into account.

3 [Home | Nationaal Waterstof Programma.](#)

4 [Nationaal Programma Circulaire Economie 2023 - 2030 | Beleidsnota | Rijksoverheid.nl.](#)

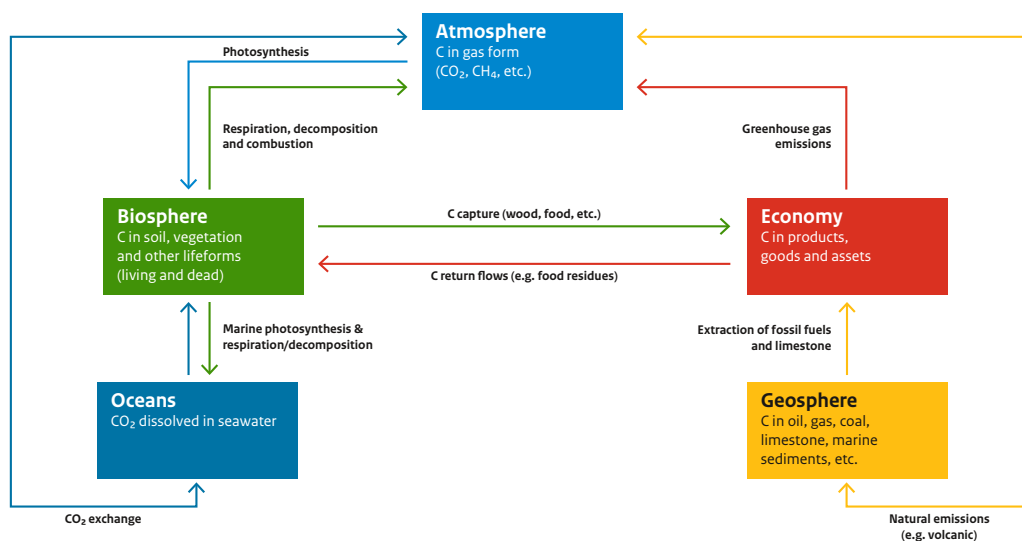
5 The government is currently updating the NPCE and the targets for a circular economy. The aim is to share the updated NPCE with the House of Representatives in the autumn.

6 [Routekaart NPVI: Van grijs naar groen.](#)

1.2 Definition of sustainable carbon

While the carbon used currently is mainly of fossil origin, the carbon of the future will need to come from sustainable sources. Sustainable carbon covers all sources of carbon that either avoid or replace the use of extra fossil carbon from the geosphere. This means that sustainable carbon can originate from the biosphere, atmosphere or the economy. Sustainable carbon circulates between the biosphere, atmosphere or economy, thereby creating a circular carbon cycle, see [Figure 1](#).⁷

Figure 1: A country's carbon economy and the interactions between the reservoirs



Through the use of secondary raw materials (recycling), raw materials remain in the economy, avoiding the use of extra carbon. Secondary raw materials may originate from fossil sources (from the geosphere) or may be of non-fossil origin (from the biosphere or atmosphere). References in this vision to secondary raw materials refer to materials that contain carbon, such as recyclate originating from plastic waste. Both post-industrial and post-consumer recyclates are important sources of secondary raw materials.

Alongside secondary raw materials, sustainable biobased raw materials and CO_2 are the other two sustainable carbon sources that can replace the use of fossil carbon. Biobased raw materials encompass all material originating from vegetable or animal sources. Biobased raw materials can originate from crops, trees and plants, algae and animal products. Biogenic primary, residual and waste streams will all have a role to play in the transition. The production of biobased raw materials can have adverse environmental effects. It is therefore important to encourage the use of sustainable biobased raw materials only (see also [Chapter 5.3](#)).

CO_2 can be captured in industrial processes, from the atmosphere or from surface water, thereby replacing the need for extra fossil carbon. In addition to CO_2 , CO can also be captured in industrial processes. CO and CO_2 from industrial processes can be of fossil or biogenic origin. At the start of the transition, CO_2 from fossil sources plays a larger role, as fossil CO_2 is still more available and affordable than biogenic or atmospheric CO_2 and can therefore enable the necessary scale up in technology to occur. The more the transition progresses, the more the use of CO_2 from fossil sources will be replaced by CO_2 of atmospheric or biogenic origin.

⁷ [De koolstofboekhouding van Nederland | CBS](#).

1.3 The need for sustainable carbon

Some 15% of the global demand for oil and 5% of the global demand for gas is used for applications in materials.⁸ Greenhouse gases are released across the value chain: the extraction of oil involves emissions; CO₂ is emitted in the refinery, cracker and in processing; emissions may be released during the consumption or use of the products and, finally, in waste incineration, carbon stored in the products is released as CO₂. Some of these emissions (scope 1) can be reduced through the energy transition that has already been initiated, but this does not apply to the (fossil) emissions that are released during the use of the products or in the waste phase. There are also other adverse environmental effects of the use of fossil carbon, such as environmental pollution caused by crude oil extraction. The use of sustainable carbon will not necessarily cancel out all of the adverse environmental effects (such as plastic soup, litter, micro-plastics, etc.) but the transition also offers opportunities for smarter product design or other design innovations, ensuring that products are reusable, recyclable and safe for people and the environment (see [Chapter 5.3](#)).

The current economic situation also accentuates the importance of focusing on the use of sustainable carbon in the chemical industry. The existing European chemical industry based on fossil carbon is losing competitiveness (see [Chapter 5.2](#)) and is expected to continue to remain under pressure. The future of the European chemical industry will involve a switch to sustainable production methods. Moreover, the availability of fossil raw materials in the chemical industry, such as naphtha, is strongly linked to the use of fossil raw materials for fuel production. This means that phasing out fossil fuels will also have effects on the future availability (and affordability) of naphtha. Additionally, new platform molecules will emerge that can be used both for fuel and as a feedstock in the chemical industry, such as methanol, for example. This will result in further integration of fuel production and the chemical industry.⁹ Investing in sustainable production will prepare the industry for a future in which sustainable products are the standard. However, there is currently only a very limited market for green products because buyers and consumers are not yet sufficiently willing to pay the premium for sustainable products, causing investments to stall (see [Chapter 7.2](#)). Investing in sustainable carbon contributes to our future earnings potential: it spans various growth markets for the Netherlands, such as the innovative and high-grade materials in the process industry, Carbon Capture & Utilisation (CCU) and circular materials.¹⁰ In addition, the circular use of a wider range of raw materials has the potential to reduce risky geopolitical dependencies and improve the country's strategic autonomy.

In the autumn, the Ministries of Climate and Green Growth (KGG) and Infrastructure and Water Management (I&W) commissioned the DRIFT research agency to conduct an investigation into the transition pathways towards a sustainable carbon chemistry. The report, conducted in partnership with TAUW and Rebel, describes four potential transition pathways and the lessons that can be learned from them. The four transition pathways describe a future in which:

- European policy focuses more strongly on improving the sustainability of industry;
- In the face of geopolitical tensions, European policy focuses more strongly on strategic autonomy;
- Society turns its back on plastics;
- A technological breakthrough causes an acceleration in the transition.

As reality is changing fast, these transition pathways no longer seem inconceivable and should therefore be considered to be serious scenarios in the context of future policy.

⁸ [Use of natural gas and oil as a source of feedstocks \(Energy Economics 2020\).](#)

⁹ [kranenburg-2025-circulaire.pdf.](#)

¹⁰ [Dialogic Groeimarkten voor Nederland.](#)

Textbox 1: Investments required for the transition towards a fossil-free, versus a climate-neutral energy system, source Publieke Zaken, Energy Research Strategy and QuoMare¹¹, PBL¹², TNO¹³

As set out in the National Energy System Plan, the Dutch government aims to minimise the use of fossil raw materials by 2050.

In its exploration of pathways towards climate neutrality (*Trajectverkenning Klimaatneutraal*), the Netherlands Environmental Assessment Agency (PBL) concludes that the complete phasing out of fossil fuels and raw materials by 2050 will significantly increase costs and will only be possible if there is sufficient availability of biobased raw materials and hydrogen. Assumptions about the price and availability of CCS capacity are a key factor. A report published by Publieke Zaken reaches a similar conclusion. In a recent study [Fossil-free energy system and the chemical industry in the Netherlands – TNO 2025], the Netherlands Organisation for Applied Scientific Research (TNO) concludes that the use of fossil raw materials in a climate-neutral scenario will have been substantially reduced, but still remain significant. A fossil-free energy system calls for rapid and major upscaling of clean electricity and hydrogen and significant amounts of available biomass. This will also lead to €7.7 to €12.8 billion per year in additional system costs in and beyond 2050.

These studies suggest that complete phasing out of fossil resources presents an additional challenge and places even greater pressure on scarcely available sources than climate neutrality alone. Moreover, feasibility will very much depend on the international market and policy context. At the same time, minimising the use of fossil raw materials also has important advantages (see also the NPE). In choices about policy, it is important to carefully take account of all of the climate, environmental, energy, economic and societal effects of a fossil-free industry compared to one that is climate neutral. Further research will be needed to determine the appropriate level of phasing out of fossil raw materials

¹¹ [070824-Grote-kostenverschillen-in-keuzes-klimaatbeleid-PZ-ERS-Quo-Mare-1.pdf](#).

¹² [Trajectverkenning Klimaatneutraal 2050](#).

¹³ [Fossil-free energy system and the chemical industry in the Netherlands - TNO 2025](#).

2 Vision on carbon chemistry

By 2050, we will have made major progress towards a fossil-free chemical industry, a transition to which the whole of society will contribute. The public will be careful with their product use and consider it important that their waste is recycled as much as possible. A mature sustainable raw materials market will have developed, involving close collaboration between raw material suppliers and the chemical industry. The chemical industry will supply sustainable building blocks for strategic sectors, such as energy and defence, as well as for products used by consumers on a daily basis, ranging from plastics to medical products. Companies will design high-grade products that have a long lifespan and can easily be recycled. Within Europe, the Netherlands will benefit from its leading position and will supply other member states with safe and sustainable chemical products. Thanks to its strategic position as a maritime nation, its infrastructure and innovation driven culture, the Netherlands will have a flourishing chemical sector, characterised by a high level of activity in the industrial clusters. The local community will benefit from a healthy environment and good opportunities for employment.

The chemical industry can and must play a key role in the transition toward circularity. After all, high-grade recycling, the reuse of raw materials and substitution by new, less environmentally-harmful materials are impossible without innovative chemical processes. The Netherlands has the knowledge and technology to improve sustainability. In addition, because of its strategic position logistically, access to wind energy and the size of the Dutch chemical industry and the ARRRRA (*Antwerp-Rotterdam-Rhine-Ruhr-Area*) cluster, the Netherlands has a crucial role to play in closing the carbon loop within Europe. By seizing this role, we can guarantee our future earnings potential and use fewer but a wider variety of raw materials. This will also be important for our future strategic autonomy, as critical sectors, such as defence and pharmaceuticals, are part of the chemicals value chain.

By maintaining its strong chemical sector, the Netherlands will be able to fulfil its responsibility in terms of improving the sustainability of its consumption. All of this means that the Netherlands will need to develop a sustainable chemical industry with new and existing companies. The recycling of products alone will not be sufficient to meet all of the future demand for chemicals and materials. Additionally, sustainable biobased raw materials and CO₂ will be needed to meet the demand for carbon. This use of sustainable biobased raw materials in the chemical industry will provide new business models for farmers, without undermining food security. Although much remains uncertain, we need to consider a shift towards partial import for the most energy-intensive process stages at the start of the supply chain¹⁴. Sustainable raw materials or platform molecules, for example in the form of pyrolysis oil and biomethanol or synthetic methanol, will partly be produced domestically and partly imported from neighbouring countries and processed here. Many of the technologies for processing these raw materials require further development and scale up. This represents a huge challenge, especially at a time when the very same industry faces enormous economic pressure. Nevertheless, the transition also offers many opportunities for the Dutch chemical industry to do business in new growth markets¹⁵, improve its international competitiveness and reduce dependencies.

By 2050, the use of fossil raw materials will as much as possible have been replaced by the use of sustainable raw materials. The extent to which it will be possible to phase out fossil raw materials will depend on the international market and policy context. By 2050, sustainable technologies will have been substantially upscaled. New value chains will have taken shape between players and these will continue to develop after 2050. For the chemical industry, CCS is an important route towards climate-neutral operation.

¹⁴ See Letter to Parliament: Dutch Senate, 2024-2025, 36169.

¹⁵ [The-Carbon-Managers-iC2050.pdf](#).

The infrastructure developed for this will also benefit CCU. The chemical industry even has the potential to become climate negative through the increased use of sustainable biobased raw materials and the related potential for achieving carbon removals.

The market for products will look different in 2050. Europe's total demand for carbon is expected to decline since the demand for (liquid) fuels will fall with the rise of electrification and the use of hydrogen.¹⁶ European demand for products is expected to remain stable¹⁷, but long-term demand for chemicals will decline as circularity increases. Increasing worldwide competition could result in the import of (sustainable) products further up the supply chain. Apart from these trends, there is an expectation that the raw materials transition will be less advanced outside of Europe. A European internal market for sustainable products and raw materials will create demand and strengthen the industry's resilience to imports of non-sustainable products from outside Europe. Compared to those in other European countries, Dutch chemical plants have historically been regarded as efficient, although the climate for investment is under severe pressure, see [Chapter 5.2](#). By taking advantage of these assets, the Netherlands will be able to continue to produce for the European market. In addition, as a trailblazer in this field, the Netherlands can export knowledge and technology as well, while also ensuring that production remains within Europe for reasons of strategic autonomy.

Not only will the market change, the chemical industry itself will also look different in 2050.¹⁸ First of all, a circular economy means reduced demand for new products and more recycling further up the supply chain, reducing the demand for basic (fossil) chemicals. Moreover, as new production chains develop, it is possible that the most energy-intensive processes in production of easily transportable intermediate products will shift to other regions within and beyond Europe. All of this means a smaller and more diverse basic chemicals industry. There is expected to be a partial shift from the classic refinery-cracker complex with integrated processing to production sites that operate on a smaller scale and are spread across (and beyond) the clusters of industry. During this transition, it will be vitally important to ensure a balance in terms of developing new and phasing out old (fossil based) processes within these clusters, in order to prevent the loss of valuable knowledge and infrastructure.

Three main routes have been identified for developing a sustainable carbon chemistry, see [Figure 2](#).¹⁵ It is expected that the existing petrochemical industry will be adapted for processing sustainable carbon in the production of existing platform molecules, for example through the use of lignin oil or pyrolysis oil instead of fossil oil (**direct substitution**). In order to close the loop and ensure autonomy in production of the building blocks for critical supply chains, it will be essential for a more sustainable bulk chemical industry (in slimmed down form) to be maintained in the Netherlands. In addition, **alternative routes** will also develop, with potential for widespread application, both in terms of input and output. Gasification will allow production of conventional products from sustainable raw materials via new routes. This route will give renewable platform molecules, such as methanol and ethanol, a more significant role as fuels and raw materials for the chemical industry. These could be produced in the Netherlands, but could also be imported. It will be possible for these new platform molecules to be used for further processing within existing supply chains. Relatively new technologies that produce new products (**new chemistry**) will also play a role, offering potential advantages in terms of carbon efficiency, energy consumption and functionality. Although many of these technologies require further development, there are already some examples of successfully upscaled products within this route, such as PLA and PHA. These new technologies will not (necessarily) make use of the refinery-cracker route. Close collaboration between (bio)refineries and crackers will however remain important in view of the synergy with the routes that do use them. As a result of these two trends, the chemical industry will shift from an optimised system based on homogeneous fossil raw materials (natural gas and crude oil) to a complex system in which different sustainable raw materials are converted by means of different technologies into partially existing, but also new products, see [Table 1](#).

¹⁶ Nationaal Plan Energiesysteem | Rapport | Rijksoverheid.nl.

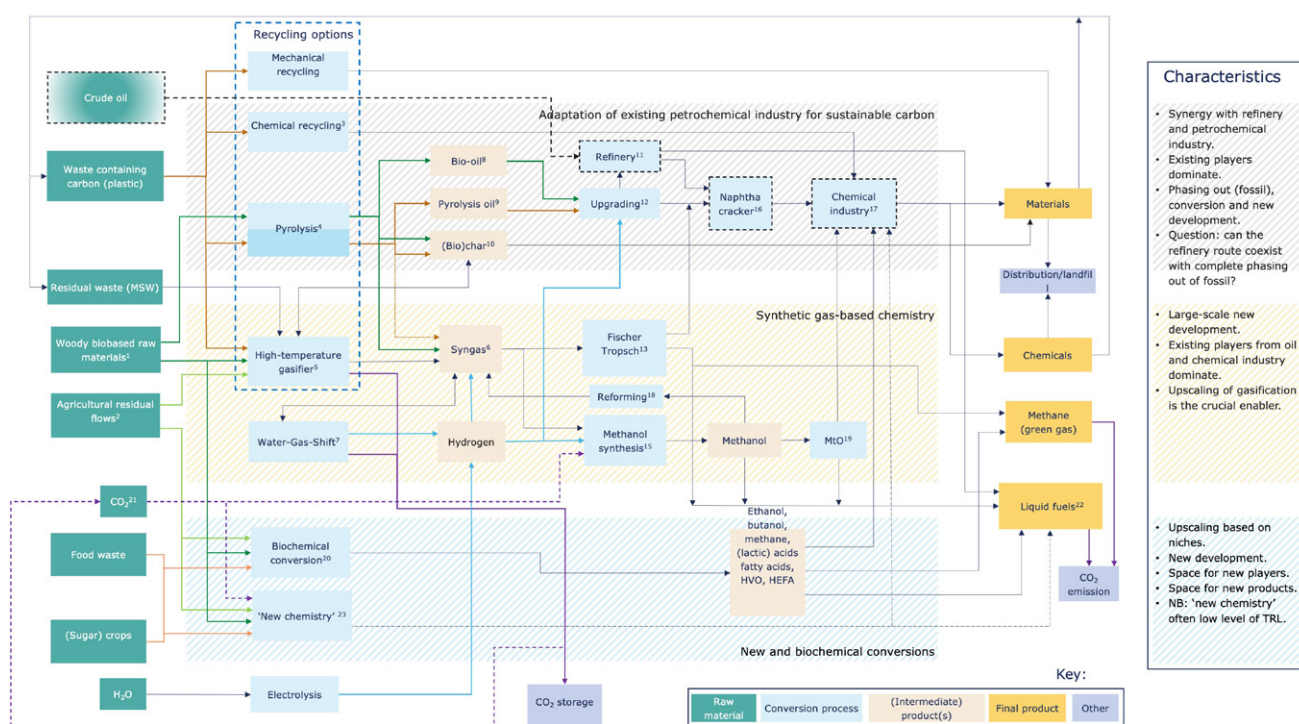
¹⁷ The-Carbon-Managers-iC2050.pdf.

¹⁸ De toekomst van duurzame koolstofchemie in Nederland – Expertadvies.

Table 1 The three main routes and use of sustainable carbon sources

Main route & Characteristics	Direct substitution	Alternative routes	New chemistry
New sustainable raw material	Secondary and Biobased raw materials	Secondary, Biobased raw materials and CO ₂	Biobased raw materials and CO ₂
New routes and assets	✗	✓	✓
New products	✗	✗	✓

Figure 2: Main routes for sustainable carbon for fuels and chemical industry (De toekomst van duurzame koolstofchemie in Nederland - Expertadvies)



3 Transition pathway to 2050

With this vision, the government is outlining a roadmap towards a sustainable chemical industry, for which the final vision was described in [Chapter 2](#). The use of fossil carbon will gradually be phased out and new routes developed towards a sustainable carbon chemistry.

There are five key uncertainties in the transition that are linked and, for each of these, the level of uncertainty varies according to the phase. Firstly, the current and future international *economic situation*, creates real uncertainty about the competitiveness of the chemical industry in the Netherlands and Europe. This is slowing investments in more expensive circular products at the same time as competition with fossil products from other parts of the world is increasing. Another important uncertainty is the *trend in volumes*. The demand for new products is expected to decline as a result of improved durability, lifespan expansion and recycling, but the extent to which this will happen is uncertain. In addition, there could be a partial shift towards import of intermediate and final products from outside Europe, reducing demand for production in Europe. Thirdly, it is uncertain how quickly and to what extent *sustainable carbon sources* will be available that can replace the existing demand for fossil carbon. Finally, *technological development* is another important factor. This technological development relates both to new production processes and the variety of product groups that can be produced using sustainable carbon. The *time horizon* is also a source of uncertainty. It is difficult to predict when new technologies will become scalable, both technically and economically, and it is also hard to foresee how they will develop in terms of their economic relationship to each other. This will very much depend on the availability of funding for scaling up these technologies, market demand and the facilitating framework, such as the availability of infrastructure and space. Finally, it is still unclear how (European) *policy interventions* are set to develop.

Against the backdrop of these uncertainties, the government outlines below the intended transition pathway towards the final vision for the Dutch chemical industry. This provides direction and insight on what will need to be done, and when, in order to achieve this vision. The developments in the transition pathway envisaged are not autonomous developments; timely interventions will be required in order to ensure that the desired developments actually happen. In this process, efforts must be made to ensure that the phasing out of fossil processes does not occur more rapidly than the development of new chemistry, which will (partly) rely on them.

Present day – 2030

During this phase, the first developments of the raw materials transition will become visible, as companies initially decide to invest in ‘first-of-a-kind’ plants for **new chemistry** and **alternative routes**, the first pyrolysis plants (**direct substitution**) are established and there is experimentation involving Carbon Capture & Utilisation (CCU) for chemical production (**new chemistry**). The government will back these innovations. During this period, mechanical recycling techniques will be further developed and companies will invest in the scale up of biorefinery for biofuel production.

It will also become clear that the raw materials transition will not be smooth. Chemical companies and recyclers in Europe will find themselves in a challenging market position because of global overcapacity and competition with cheap fossil energy and raw material prices. This will result in delays to plant maintenance, closures and bankruptcies.^{19, 20} In this phase, in order to facilitate the transition towards a sustainable chemistry, ensure that any uncontrolled phasing out is kept to a minimum and to maintain strategic autonomy for critical sectors, policy focusing on improving the investment climate and creating market demand will be essential.

¹⁹ [The competitiveness of the European Chemical Industry - a Cefic & Advancy report - cefic.](#)

²⁰ [Change Inc.](#)

In this phase, sustainable carbon will mainly be used by other sectors. The gasification of biofuels for production will be upscaled in anticipation of the fuel-blending mandate for green gas in the built environment and biobased raw materials will be used for mobility. In this phase, there will only be limited changes to the chemistry itself: carbon chemistry will primarily be based on fossil naphtha from the refining sector. The first CCS projects will begin and the CO₂ infrastructure will be further developed for this purpose. For this, policy will be the most important driver.

2030 – 2035

In the period starting in 2030, the demand for recyclate will increase as a result of European product regulation. This will increase the capacity for both mechanical and chemical recycling into secondary raw materials. Biorefinery capacity in the Netherlands will increase, driven by the demand for biofuels. The CO₂ infrastructure will be further developed in the Netherlands and the same will apply to the hydrogen infrastructure. Demand-driven policy will result in the use of biobased raw materials in **direct substitution** and in **new chemistry**. In this period, biobased raw materials will mainly be used in the mobility sector, with their use increasing in aviation and in shipping. During this period, **alternative routes** will be further upscaled for the production of sustainable fuels, which will also find application in the production of sustainable feedstocks for the chemical industry (e.g. gasification). The production of synthetic fuels for aviation will also be upscaled in this period. The chemical industry will be able to benefit from the technological advances that result from this. The question of whether the production of synthetic fuels will happen in the Netherlands will depend on the availability and affordability of electricity and hydrogen. In this phase, crackers will continue to play an important role, although there will be declining demand for cracker capacity related to increased reuse and recycling²¹. Energy-intensive plants will make important progress towards climate neutrality, by means of electrification and some CCS projects. In the industrial clusters, there will be increasing competition for space as new technologies are being developed to an increasingly bigger scale and space is needed for processing and storage of raw materials.

2035 – 2040

In this phase of the transition, it will be important to maintain a balance between development, conversion of new and partial phasing out of fossil processes, since the sector will be less robust if these do not keep pace with each other. Demand for fossil products will decline in this phase of the transition because policy will be focusing on the use of sustainable carbon in the chemical industry. However, the capacity for gasification of waste and biobased raw materials as an **alternative route** will continue to grow and these will increasingly be used as feedstocks in the chemical industry alongside fuels. **New (bio)chemical** conversions and CCU for niche markets will be further upscaled for commercial use in this period. Market standardisation for secondary raw materials will increase as a result of increasing targets and product regulation and the market will develop into a commodity market. The phasing out of fossil processes will create space for new sustainable production.

2040 – 2050

This phase of the transition will be characterised by the further phasing out of the use of fossil carbon in the chemical industry and increasing use of sustainable carbon. In this period, the use of sustainable carbon will become more firmly established within the economy compared to fossil carbon. As a result, the use of sustainable carbon will become the ‘new normal’ for the bulk of products. Yet the transition will be more challenging for certain products: for example, the application of new raw materials in medicine will require a new market approval process. In order to prevent carbon losses and minimise the climate impact, the last plants will switch to electricity or hydrogen as a source of energy.

The scale up of the **new chemistry** of biobased raw materials will continue. CCU technologies will also be developed for niche markets. **Alternative routes** will be further expanded and optimised. This means that the shift in industrial clusters from fossil production to sustainable production will continue.

²¹ Physical and depolymerisation recycling techniques break down products into polymers or monomers, obviating the need for the cracker in the ensuing stages.

4 Policy strategy

At its heart, this vision aims to improve the sustainability of raw material use in the Dutch chemical industry, in view of the target set in the Climate Act to achieve climate neutrality by 2050. In order to achieve a climate-neutral and circular economy, phasing out the use of fossil raw materials as much as possible will be crucial. In the National Energy System Plan (NPE), the Dutch government expressed its aspiration to minimise the use of fossil raw materials as much as possible by 2050. In addition, the Netherlands also has the ambition of being circular and fossil free by 2050²².

It remains unclear exactly what a circular carbon chemistry would look like. This vision aims to provide an insight into the challenge involved in achieving the transition to a circular carbon chemistry. This chapter describes the government's policy strategy. This vision and accompanying strategy will also need to be integrated in related policy areas and at regional level.

4.1 Government approach

As set out in the vision, the chemical industry's position at the start of numerous value chains means that it plays a key role in the transition to circularity. The sector also supplies the building blocks for critical sectors such as the defence industry and makes an important contribution to economic activity in the Netherlands. In accordance with the expert advisory report, the government is therefore committed to *developing* new, sustainable chemistry, *converting* existing chemistry and *phasing out* the use of fossil raw materials in the chemical industry:

- The *development* of **new chemistry** and **alternative routes** for the production of sustainable chemicals and plastics. New chemistry can produce chemicals and plastics that have potential advantages in terms of carbon efficiency, functionality and the energy required for conversion. Gasification has potential for widespread use, both for raw materials and in the processing of existing intermediate products²³. As such, it represents a robust **alternative route** for the use of sustainable carbon in the chemical industry. The *Perspective for the Dutch chemical industry*, published together with this vision document, sets out in greater detail the growth potential for future green and advanced chemistry.
- The *conversion* of the existing petrochemical industry into a sustainable bulk chemical industry, enabling sustainable carbon (e.g. in the form of lignin oil or pyrolysis oil) to be **directly replaced** in existing infrastructure. This is important in view of the closely-linked nature of the chemical value chain. In this, it is important to ensure that companies are offered economical perspective in the short term, in order to prevent uncontrolled downscaling and loss of legacy assets.
- The controlled *phasing out* of the use of fossil raw materials in the chemical industry. The sustainable carbon transition will lead to the development of new processes, but also means that not all existing processes will have a future in the Netherlands. Moreover, in view of the international context of the industry, the Dutch basic chemical sector in its current form is likely to shrink without intervention.

²² The NPCE 2023 – 2030 describes a fully circular economy as one in which the environmental effects of the use of raw materials by all Dutch production and consumption remain within the planetary boundaries. The Dutch government's commitment to being fossil-free by 2050, which applies both to Dutch consumption and production, is at odds with the international objectives for the chemical industry, aviation and shipping. Currently, the use of fossil carbon carriers for these applications in 2050 has not been excluded.

²³ Plastic waste and biobased raw materials can both be converted into chemical building blocks by means of gasification. For plastic waste recycling, a hierarchy of processing preferences applies in the Netherlands. In this, the efficiency, energy consumption, quality and availability of the technology are the decisive factors. See also Parliamentary Papers 32 852 No. 230.

This is why it is important for policy in the Netherlands to support sustainable conversions and prevent a potential ‘milk-and-exit’ strategy²⁴. The challenge will be to prevent accelerated scale down of conventional processes before sustainable production routes have been developed. The government is currently working on a letter to Parliament on the responsible phasing out of fossil energy carriers.

Unless there is policy focusing on competitiveness and the right market conditions, it will not be possible to achieve the raw materials transition in the chemical industry. For the conversion of the existing chemical industry and development of new chemistry, major investments will be needed by the sector, and policy will have an important role to play in facilitating and encouraging those.²⁵ In order to encourage willingness to invest, a European internal market for sustainable raw materials and products will need to be created. The Netherlands is actively working to achieve a harmonised European legislative framework to enable a united EU market with a level internal playing field. However, additional measures will be necessary to ensure that imported products meet the same requirements. This harmonisation will also need to make trade in residual streams and raw materials easier within Europe whilst the quality and purity of material streams that enter the European market need to be protected. Transnational cooperation with Belgium and Germany can also be valuable in this. European rules for mass balance and carbon accounting will be essential in facilitating trade in and the use of non-fossil carbon. This will also help make access to funding easier. In addition, it is important for this access to be simplified and for more space to be provided for experimentation and scaling up of as yet unproven innovative technologies. Increased investment in (fundamental) scientific research, knowledge and innovation that comes about as a result of these incentives will make it possible to reap the rewards of these innovative (process) technologies at an earlier stage.

For the transition to sustainable carbon use in the chemical industry, it is important to improve supply of and access to sustainable carbon sources. The initial focus will be on domestic potential, but opportunities for import will also be considered. Some of the policies currently under development, such as the Action plan for the Supply of Sustainable Carbon Carriers (*Actieplan Aanbod Duurzame Koolstofdragende*, AADK) and the Biobased Raw Materials Strategy (*Biograndstoffenstrategie*) aim to increase supply of sustainable carbon for the chemical industry, as well as for other sectors. The NPE explores the relationship between demand from different sectors and the supply.

Finally, there are several important prerequisites that are essential for the success of the transition. However, these key conditions are under serious pressure. The focus will therefore need to be carefully targeted and structural limitations will need to be taken into account. A targeted focus on the availability of sufficient and affordable renewable energy will be essential, as the transition to sustainable carbon requires a lot of energy. For that purpose, (energy) infrastructure will need to be built and expanded. Moreover, physical and environmental space will be critical and systemic limiting factors in realising the sustainable chemical industry of the future. There are important overlaps here with policy in other domains, and efforts will be made to take account with these linkages in the implementation of this vision.

²⁴ Here, the term ‘milk-and-exit’ strategy refers to the situation where companies continue to produce based on fossil raw materials for as long as it is economically viable before exiting the Netherlands after that. These companies will not contribute to the transition and could actually slow down the process of decarbonisation by placing too much pressure on scarce (environmental) space.

²⁵ In the light of the recommendations in the Draghi report, the European Commission intends to forge stronger links between its announced Clean Industrial Deal climate policy and industrial policy in order to encourage private investments in circular and green products for the benefit of the transition.

4.2 Key principles

In developing this vision and further elaborating the policy strategy, five key principles were applied, which are of broadly equal importance. These will form the basis for policy decisions.

1. The public interests from the NPE will be carefully balanced.

The NPE identifies and explains the public interests that are relevant for establishing the energy system, i.e. sustainability, reliability, affordability, safety, quality of the human environment, participation, fairness and economic strength. For the use of raw materials in the chemical industry, as part of the carbon supply chain, these interests also need to be considered. Government will have a role to play in this raw materials transition and this will require choices in terms of balancing public interests. However, this does not mean that businesses do not have an important role to play in ensuring these public interests are met. [Table 2](#) and [Appendix 1](#) (Explanation of public interests set out in the NPE) provide further details and explanation of the public interests involved in the raw materials transition in the chemical industry.

Table 2: Explanation of public interests set out in the NPE

Sustainability	The aim of remaining within planetary boundaries and protecting the natural and economic capital for future generations by combating climate change and through the circular use of raw materials.
Reliability	The security of supply and robustness of access to raw materials for the chemical industry and products that it produces for wider society.
Affordability	Ensuring manageable social costs for society as a whole and manageable product costs for end-users.
Safety	Minimising safety risks for people and the environment.
Quality of human environment	Accommodating the spatial impact of the energy system and ensuring and safeguarding and where possible improving the quality of the environment and immediate surroundings.
Participation	The way in which stakeholders are involved in the decisions about the raw materials transition in the chemical industry.
Fairness	The distribution issues that emerge as a result of the raw materials transition, such as the fair sharing of global responsibility between countries and globally available resources as well as a fair distribution of benefits and burdens at European and national level.
Economic strength	The (future) earnings potential for the Netherlands, high-quality employment and good incomes for Dutch people in a sustainable and innovative economy, in which account is taken of the development of strategic sectors.

2. The value chain perspective, including application and waste processing, will be central in the raw materials transition.

The aim of this vision is to improve the sustainability of the raw materials in the future chemical industry. Since the chemical industry forms the start (and end) of the cycle of a diversity of value chains, the opportunities for improving the sustainability of raw-material use matters to the whole value chain. Mechanical recycling for example has an important role to play in improving the sustainability of the value chain and other solutions may not necessarily come from the basic chemicals industry. The value chain perspective needs to be central in the raw materials transition because this makes it possible to compare and evaluate different potential solutions at system level. By applying a value chain perspective, aspects can be taken into account that lie outside the domain of the chemical industry but may nevertheless be crucial in ensuring a successful transition, such as circular product design. This also applies to the role of the consumer, who can, for example, contribute by reusing products, leading to a decline in the need for production.

3. Er is een belangrijke rol voor het verminderen van de vraag door hoogwaardige en efficiënte inzet.

There are various important reasons for reducing demand, including limiting the pressure on the climate and the environment and minimising the costs of expensive and scarce sustainable carbon sources. Supply scarcity places upward pressure on prices and the extraction of scarce biobased raw materials can have negative environmental impacts. Reducing total demand and allocating for high-value application of scarce sustainable raw materials will therefore be important. By using strategies higher up the R-ladder (eg. refuse, reduce, reuse), the demand for sustainable carbon resources can be limited as much as possible. Everything that does not need to be produced or transported will ultimately reduce costs and lessen the environmental impact.

4. Predictable policy will be crucial for a successful transition.

Long-term certainty about the regulatory framework is important to realise the investments required for the conversion of existing chemical complexes and development of new plants. Major changes to chemical complexes and the construction of new product site takes a lot of time (5 – 10 years). Policies need to take into account the time required to upscale production.

5. The global character of the chemical industry means that international policy effort will be required; domestic policy will be used only where necessary and desirable.

The chemical industry operates in a volatile global market, which means that there is fierce competition. An assessment must be made whether domestic policy has the desired effects and does not undermine the competitiveness of the (future) Dutch chemical industry. European policy is the preferred approach, although domestic policy can be used if it benefits the raw materials transition and the other key principles.

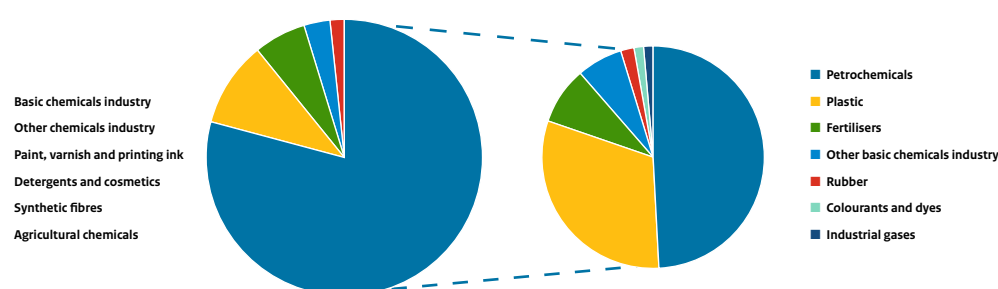
5 Context of carbon chemistry

5.1 Current situation

The chemical industry forms the basis for critical sectors such as defence, health and food and has a crucial role to play in the energy and raw materials transition. After further processing, products from the chemical industry are applied across virtually the whole of industry, from high-tech, plastics to composite materials, as well as solar panels, medical products, electronics, coatings and food. The key focus of this document is carbon chemistry: the chemical processes in which carbon is an essential building block. This vision encompasses both the production of basic chemicals and products produced based on these chemicals.

Carbon chemistry is of major importance for the Dutch economy. The Netherlands is the third largest chemicals producing country in the European Union.²⁶ In 2022, the basic chemicals industry was made up of 365 companies, accounting for €61 billion in revenue and providing 30,900 jobs.^{27, 28} The plastics industry totalled 1,395 companies, had a revenue of almost €12 billion and provided 41,300 jobs. Carbon is also used by the paint, varnish and printing-ink industry, the detergents and cosmetic industry and the rubber production industry. [Figure 3](#) shows the revenue distribution for each sector, including an enlarged section showing the breakdown within the basic chemicals industry, which provides an indication of what this industry produces. The chemical industry is international in its orientation and accounted for 16% of total Dutch exports in 2023. Around 80% of production is exported, most of which remains within Europe.²⁹ This illustrates the importance of chemical production for Europe's strategic autonomy.

Figure 3: Revenue distribution in the chemical industry (left) and revenue distribution in the basic chemicals industry as part of it (right)



Carbon chemistry has a role in all industrial clusters in the Netherlands. The Netherlands five existing crackers are located in Rotterdam-Moerdijk, Chemelot and Zeeland/West-Brabant, while later stages in the value chain are also present in the other three clusters, i.e. the Northern Netherlands, the North Sea Canal Area and the so-called 'Sixth Cluster'. Within and between the chemical industry clusters in the Netherlands and beyond, energy, raw materials, intermediate and final products are exchanged by means of pipelines and transport by road and water. There is particular cooperation with chemical industry

²⁶ [Een transitiepad met duidelijke afspraken en acties - VNCI](#).

²⁷ [StatLine - Bedrijven; bedrijfstak \(cbs.nl\)](#).

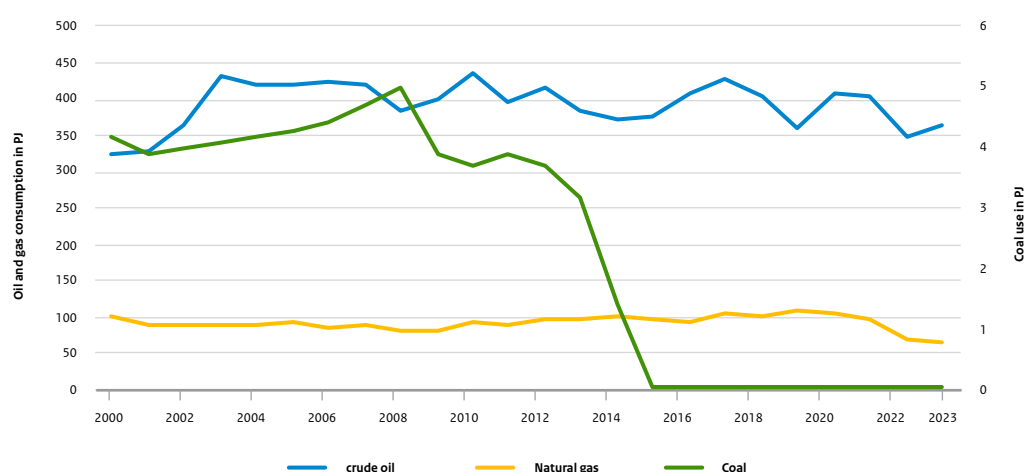
²⁸ [StatLine - Bedrijfsleven; arbeids- en financiële gegevens, per branche, SBI 2008 \(cbs.nl\)](#).

²⁹ [Nederland derde exporteur van EU | CBS](#).

centres in Belgium, Germany (*Antwerp-Rotterdam-Rhine-Ruhr-Area*, ARRR cluster) and Northern France. The Dutch chemical sector is part of an international value chain, both for the procurement of raw materials and the export of basic chemicals, polymers and later stages in the chain. Despite the high degree of operational efficiency and its strategic location, the competitiveness of the Dutch (and European) chemical industry has declined as a result of increasing raw material, energy, compliance, wage and capital costs, combined with a stronger competitive position for China and the United States (see [Chapter 5.2](#)).

The chemical industry is capital intensive and any changes involve major investments with long payback periods. The chemical sector is known for its innovation. This is mainly thanks to large companies with plenty of appetite to invest in R&D in order to develop and implement new materials, products, processes and sustainable technologies. Several international chemical companies have research and development centres in the Netherlands. There are also start-ups working on the development of sustainable technologies and products. Compared to surrounding countries, the investment climate for scale up is less favourable in the Netherlands, as a result of which the economy is less able to benefit from this innovation.³⁰

Figure 4: Non-energetic use of fossil raw materials in the chemical and petrochemical industry, source CBS/ Statistics Netherlands



Today's society depends on fossil carbon carriers for energy and products. The chemical industry plays an important role in producing some of these products. In the chemical and petrochemical industry, some 365.5 petajoules (PJ) of crude oil and 67 PJ of natural gas were consumed in 2023 for non-energetic use.³¹ This is around 30% of the total final fossil consumption in the Netherlands. [Figure 4](#) shows the trend in the non-energetic use of fossil raw materials in the chemical and petrochemical industry in the period from 2000 to 2023.

These fossil raw materials are used to obtain the carbon and hydrogen for production. Natural gas is mainly used to produce hydrogen or artificial fertiliser. This does not require the use of carbon, except for the production of ureum (approx. 0.3 megatonnes (Mt) of carbon³²). The non-energetic use of crude oil amounts to over 8.5 Mt of carbon.³³ This excludes the current use of sustainable carbon, which amounts to around 9%³⁴, primarily from mechanical recycling of plastic.

30 <https://www.consultancy.nl/nieuws/43937/mckinsey-nederland-loopt-voorop-in-startups-maar-blijft-achter-in-scale-ups>.

31 StatLine - Energiebalans; aanbod, omzetting en verbruik (cbs.nl).

32 Nationaal Plan Energiesysteem – Verdiepingsdocument B – Ontwikkelpaden ketens van het energiesysteem.

33 Nationaal Plan Energiesysteem Verdiepingsdocument B – Ontwikkelpaden ketens van het energiesysteem | Rapport | Rijksoverheid.nl.

34 CE Delft 200289 Een verplicht aandeel recycklaat of bio in plastic Def maart.pdf.

5.2 International and European context

The Dutch chemical industry operates in a global market and produces primarily for the European market. The Dutch chemical sector is highly competitive within Europe. It accounts for 9% of all European chemical industry revenue and as much as 14% of the revenue from organic basic chemicals.³⁵ As such, the Netherlands has a relatively high share in the European chemical industry. However, the European chemical sector is rapidly losing ground internationally. This is why a vision and transition pathway for sustainable carbon use must be part of the wider international context, both global and European.

Global context

The worldwide demand for chemical products is forecasted to grow by around 2.9% per year as the global population increases and standards of living improve.³⁶ However, worldwide production capacity has grown much faster in recent years than demand, especially in China, the United States and the Middle East.

Rapid growth in China has led to overcapacity for most basic chemicals. In 2022, Chinese production accounted for €2,390 billion, giving it a 44% global market share. Still an importer just a decade ago, China is now self-sufficient in many polymers and is set to become an exporter in numerous markets.³⁷ Products from Asia are sold in Europe at prices lower than that for which they were produced. Chinese climate policy focuses on reducing emissions by changing the energy mix, efficiency improvements and energy savings. There is no known policy to phase out fossil fuels and raw materials and coal continues to be used as energy fuel.³⁸ Despite this, there is large-scale production of biobased raw materials and green methanol, which can also be used in the chemical industry. Currently, a lot of recyclate is imported from Asia, of which the authenticity is difficult to verify.

In the United States, capacity has recently been increased based on shale gas, offering a significant cost advantage compared to conventional oil-based plants in Europe. The United States is now the third-largest producer of chemicals in the world, after China and Europe, with production amounting to €606 billion (11%). In recent years, the Inflation Reduction Act (IRA)³⁹ has boosted investments in green energy in particular, resulting in investments in energy efficient plants, including within the chemical industry. Biorefinery is incentivised to meet Sustainable Aviation Fuel (SAF) targets⁴⁰ and the BioPreferred Program sets out defined minimum standards for the use of biobased raw materials across a wide range of product categories.⁴¹

With production totalling €87 billion, Saudi Arabia has a small market share of 1.6%. However, many plants in the Middle East benefit from the low cost price of local materials and, together with those in the United States, are among the most efficient plants worldwide. For oil companies in the Middle East, many of them state owned, the diversification of oil for production of oil-related products, such as basic chemicals and plastics, is part of a targeted government strategy designed to spread risk and add value.⁴²

³⁵ Source: Cefic and VNCI data 2023.

³⁶ [Evaluation of Recent Reports on the Future of a Net-Zero Chemical Industry in 2050 \(PDF\) | Renewable Carbon Publications.](#)

³⁷ [EPCA 2024 seminar: Europe Petrochemicals – Transform to Thrive.](#)

³⁸ [The Carbon Brief Profile: China.](#)

³⁹ [Inflation Reduction Act Guidebook | Clean Energy | The White House.](#)

⁴⁰ [U.S. Department of Energy Announces \\$52 Million in Projects to Advance Production of Purpose-Grown Energy Crops | Department of Energy.](#)

⁴¹ [BioPreferred|Biobased Products.](#)

⁴² [Saudi Vision 2030.](#)

European context

With production amounting to €760 billion and a 14% market share, the chemical industry in the EU 27 countries was the second largest chemicals producer worldwide in 2022. Two decades ago, Europe was still the largest chemicals producer in the global market, with a 27% share.⁴³ As a result of demographic effects and high prosperity compared to other regions, demand here is expected to stabilise and potentially decline in the longer term, resulting in average annual growth of 0.4% by 2050.^{44, 45}

The Dutch chemical industry clusters in Rotterdam-Moerdijk, Zeeland and Chemelot are part of the larger ARRR cluster, where much of the chemical industry is concentrated. Some 40% of the European chemical industry is based in the trilateral region of North-Rhine Westphalia, Flanders and the Netherlands.⁴⁶ This makes the ARRR cluster Europe's largest petrochemical cluster and the second largest worldwide. This cluster developed organically based on the ports and the conversion of the coal sector in the 1950s and 1960s. The cluster benefits from a strategic maritime location, a logistic network of transport links and a strong local knowledge economy. The cluster is well interconnected thanks to a network of raw material and basic chemical pipelines. This ensures a high level of integration and efficiency. In general, European plants are less efficient than those in Asia and the United States. However, the Dutch plants are among the most efficient within Europe, partly thanks to the good logistical position and high level of cluster integration. Nevertheless, even in the case of a successful energy transition, research shows that energy prices in North West Europe will likely remain high in the medium term⁴⁷. This makes it uncertain whether the most energy-intensive processes in the chemical industry can remain competitive in the Netherlands. On the other hand, the expert vision document argues that the Netherlands has a strong starting position for improving the sustainability of the sector in view of its access to a significant potential for wind energy on the North Sea⁴⁸. One example is the Northern Netherlands cluster in Eemshaven and Delfzijl, which has a lot of potential for green and circular chemicals and where nitrogen emissions are less challenging compared to other clusters.

In Europe, several directives and regulations are in force or have been approved that (directly) affect the use of raw materials in the chemical industry.⁴⁹ For example, the Single-Use Plastics Directive⁵⁰ sets requirements for the use of recycled plastic in PET bottles and prohibits the sale of certain disposable plastic products. The recently adopted Packaging and Packaging Waste Regulation (PPWR)⁵¹ sets out measures for reducing the amount of packaging materials by up to 15% by 2040, encouraging reuse and refilling, increasing recyclability and improving collection and recycling systems. From 2030, packaging must be designed to be recycled and must contain a minimum percentage of recycled material, rising to 65% for certain packaging by 2040. Certain types of single-use plastic packaging are also prohibited. The Ecodesign for Sustainable Products Regulation (ESPR)⁵² aims to improve the circularity, energy intensity, recyclability and lifespan of products. This legislation makes it possible to set Ecodesign criteria, to cover such issues as lifespan, reparability and recyclability.

In its recently published European Chemical Industry Action Plan, the European Commission announced policy for strengthening and improving the sustainability of the industry. Supporting the transition to a clean and circular economy is a key part of this, along with market creation and the promotion of innovation. By means of the Industrial Decarbonisation Accelerator Act (IDAA), the Commission aims to introduce sustainability criteria to boost clean production and demand. This is expected to be published at the end of 2025. In addition, the Commission is also announcing an Advanced Materials Act (2026) with a view to

43 [2023 Facts and Figures of the European Chemical Industry - cefic.org](https://www.cefic.org/en/2023-facts-and-figures-of-the-european-chemical-industry).

44 [The-Carbon-Managers-iC2050.pdf](#).

45 [Evaluation of Recent Reports on the Future of a Net-Zero Chemical Industry in 2050 \(PDF\) | Renewable Carbon Publications](#).

46 [Trilateral Chemical Region](#).

47 'Preserving the NW-European industry is a balancing act for the government' - PwC.

48 Expertvisie 'De toekomst van duurzame koolstofchemie in Nederland'.

49 In addition to the regulations and directives mentioned, other European laws and regulations can have an effect on the raw materials transition in the chemical industry, such as the EU ETS. However, this effect is less direct, which is why this list is limited to laws and regulations that have a direct impact.

50 [Directive - 2019/904 - EN - SUP Directive - EUR-Lex](#).

51 https://www.europarl.europa.eu/doceo/document/TA-9-2024-0318_EN.html.

52 [Regulation - EU - 2024/1781 - EN - EUR-Lex](#).

boosting and rewarding technological development in the chemical sector. Specifically for the transition to sustainable raw materials, there are proposals for a Circular Economy Act (2026), as well as a vision and directions for scale up in the new EU Bioeconomy Strategy (end of 2025). The Commission has also announced the development of financial incentive measures for the use of sustainable carbon. A targeted revision of REACH (regulation of chemical substances) is also set to follow in 2025 in order to accelerate and simplify procedures for companies. Finally, the Chemical Omnibus Regulation and changes to the procedures within ECHA⁵³ are simplifying the regulatory framework for the chemical industry.

Investment climate for raw materials and energy transition

The European chemical industry faces rising costs. Since the war in Ukraine and Russian gas boycott, European industry has faced high energy prices. Natural gas prices are expected to remain persistently twice as high as in the United States while electricity costs are 1.5 times higher.⁵⁴ In the Netherlands, electricity costs are even twice or three times higher than in surrounding countries, mainly as a result of differences in network costs and discount schemes.⁵⁵ European climate targets are also more ambitious than those in other regions. As a result of these factors, the cost price for the European chemical sector is already significantly higher than in the other chemical production regions worldwide. If the free allowances within the EU Emission Trading System (EU ETS)⁵⁶ are phased out further, the cost difference compared to other regions will be even worse. Additionally, the Netherlands applies a CO₂ levy to the industry.⁵⁷ Moreover, chemical products are not covered by the protection of the Carbon Border Adjustment Mechanism (CBAM)⁵⁸, which increases the risk of carbon leakage.⁵⁹

In a global market, with worldwide overcapacity in products that are easy to transport, buyers can easily import cheaper products. As a result, European basic chemical plants are forced to downscale production and operate at an average of 74% capacity.⁶⁰ In 2024, the closure of four crackers was announced, reducing production capacity by 10%. As a result of this, Europe has gone from being a net importer of chemical products to a net exporter in the course of the last five years.⁶¹

The companies in the chemical industry are made up of multinationals, many of them not headquartered in the Netherlands. Whether or not to invest in the Netherlands rather than other regions is decided based on a series of factors, including the breakeven period, the feasibility of investments and political stability. Improving sustainability will not only require significant investments in new facilities, but will also mean permanently higher energy and raw material costs in many cases. Investments in improving sustainability, and electrification in particular, do not always pay for themselves within the desired period. In addition, other regions often benefit from lower wages, lower financial and transport costs, and also have less stringent climate, environmental and labour market legislation and regulations compared to Europe. Increasing demand and easy access to financial support, especially in Asia, but also in the United States, makes it more attractive to invest there.

53 COM(2025) 526; COM(2025) 531 Fiche 2: Verordening Omnibus VI - vereenvoudiging eisen en procedures chemische producten; COM(2025) 386; BNC-Fiche 17 (ECHA basisverordening).

54 Competitiveness of European Energy-Intensive Industries.

55 Kamerbrief Onderzoek elektriciteits- en netwerkkosten industrie | kamerstuk | Rijksoverheid.nl.

56 EUR-Lex - 02003L0087-20240301 - EN - EUR-Lex.

57 CO₂-heffing voor industrie | Klimaatverandering | Rijksoverheid.nl.

58 Europees instrument om een eerlijke prijs te rekenen voor de productie-emissies van geïmporteerde producten, Carbon Border Adjustment Mechanism - European Commission.

59 The future of European competitiveness – In-depth analysis and recommendations.

60 2023 Facts and Figures of the European Chemical Industry - cefic.org.

61 EPCA 2024 seminar: Europe Petrochemicals – Transform to Thrive.

This not only threatens the process of decarbonisation, but also the future of the EU chemical industry and the strategic autonomy of the Netherlands and Europe with regard to almost every area of application of materials. In 2022, only 10% of foreign investments in energy-intensive industry were in Europe.⁶²

The European chemical industry is crucial for the manufacturing industry's resilience in general, preventing unwanted reliance on critical sectors such as defence, healthcare and green energy and maintaining the level of prosperity in Europe. In order to maintain competitiveness and sufficient prosperity in a rapidly changing international context, it will be important to focus on innovation, an integrated approach to improving sustainability and competitiveness and increasing economic security and reducing dependencies.⁶³

Efforts to achieve emission reduction targets place genuine pressure on the industry, especially the energy-intensive industry, such as the chemical industry. Current measures will likely be insufficient to achieve the transition while also maintaining the capacity to compete. There are also leakage risks as a result of the import of intermediate and final products, especially in the chemical industry. There could also be shifts in the energy-intensive industry in favour of areas where a sufficient, stable supply of affordable, renewable energy can be achieved. In this context, Draghi⁶⁴ has put forward recommendations for achieving a sustainable competitive industry in Europe. In this, he has identified two policy objectives: 1) support for industry-specific measures aimed at decarbonisation; and 2) the creation of a more level playing field with international competition. Based on three guiding principles, there are 11 recommendations. These guiding principles are 1) a competitive and predictable energy supply; 2) support for reductions in emissions by ensuring investments and markets; and 3) avoidance of production relocation driven by asymmetric subsidies or legislation. The recommendations that Draghi makes in his report apply equally to the transition to sustainable carbon in the chemical industry. The general recommendations for promoting investments, reducing the regulatory burden and decarbonisation are important examples of this. The recommendations for boosting demand for green products by increasing transparency, improving the circularity of raw materials and promoting the formation of regional green industry clusters are of specific importance for the transition to sustainable carbon.

5.3 Raw materials transition and other transitions

Both at national and European level, sustainability targets have been set and translated into relevant targets for the chemical sector⁶⁵; the aim is for the Netherlands and Europe to be climate-neutral, circular and healthy, clean and safe by 2050. In the chemical sector, that will be visible in terms of **which** raw materials are used in the chemical industry, **how** the chemical industry produces and **what** the chemical industry produces. Sustainable raw materials will be used as feedstocks (circular), the energy required will originate from renewable sources (climate neutral) and the substances produced will be safe and sustainable throughout their life cycle (healthy, clean and safe). In this way, the sector will have a beneficial impact on the human environment and surrounding residents and contribute to society's prosperity: it will provide earning potential, entrepreneurial possibilities, employment and innovation.

62 [ERT-Competitiveness-of-Europes-energy-intensive-industries_March-2024.pdf](#).

63 [The Future of European competitiveness – A competitiveness strategy for Europe](#).

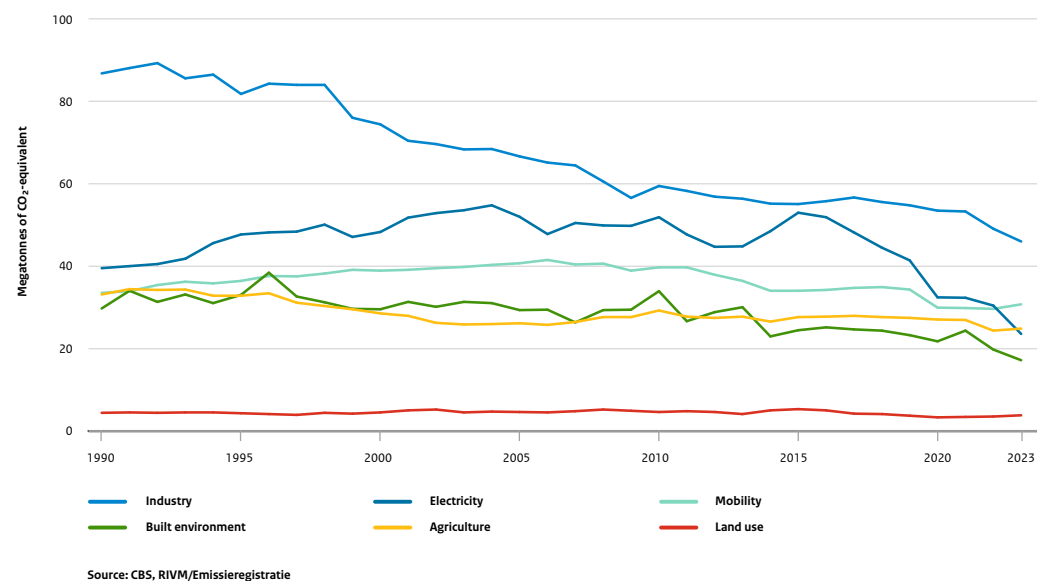
64 [The future of European competitiveness – In-depth analysis and recommendations](#).

65 [The European Green Deal - European Commission \(europa.eu\)](#).

The tasks required from the chemical industry

Humanity is rapidly exceeding the planetary boundaries. The European and Dutch chemical industry is a significant contributor to global warming, loss of biodiversity, ocean acidification and chemical pollution.⁶⁶ This is why the chemical sector must contribute to the overarching societal task of bringing the economy back within the planetary boundaries. The chemical industry has an enabling role for achieving this through the development of new circular and safe materials, based on sustainable raw materials and processes. The position of the chemical industry at the start of numerous value chains means that the advantages continue to have an effect further down the chain.

Figure 5: Greenhouse gas emissions by industrial sector



The chemical industry's greenhouse gas emissions account for 5% of the total net greenhouse gas emissions in the EU and as much as 10% in the Netherlands, due to its high concentration of energy-intensive factories. The chemical industry has seen emissions fall by a quarter (5.7 Mt) in terms of CO₂ since 1990, but they remain the highest of all industrial sectors, as shown in Figure 5.⁶⁷ This chart depicts the direct emissions from the chemical industry; indirect emissions are even more significant, with estimates suggesting that these account for more than 70% of total greenhouse emissions from the chemical industry⁶⁸.

The planetary boundary for chemical pollution, which describes the number of new chemicals ending up in the environment, is also being exceeded. Chemical pollution has major repercussions for the quality of air, water and soil. This threatens the environment and ecosystems and has a direct impact on health and therefore on people's quality of life. The amount of new chemicals and the volume released is increasing to such an extent that it is not possible to effectively assess the risks and monitor what the consequences of these (large volumes of) new chemicals are, or the associated risks to society.

Moreover, the chemical sector almost exclusively uses primary fossil raw materials (crude oil and natural gas). In order to limit/prevent global warming and the environmental impact of extracting and processing primary fossil raw materials, there needs to be a shift to other sources of carbon, such as secondary raw materials, sustainable biobased raw materials and CO₂. Switching from fossil raw materials to raw materials with less impact on the environment will contribute to the transition toward circularity and to the climate- and environmental challenge.

⁶⁶ Barnosell, I. & Pozo, C., 2024. The impacts of the European chemical industry on the planetary boundaries. 2024. Sustainable Production and Consumption 44, 188-207.

⁶⁷ Welke sectoren stoten broeikasgassen uit? | CBS.

⁶⁸ Measuring the emissions impact in the chemical sector: a guide on Product Carbon Footprint - cefic.org.

The three overarching societal tasks are inextricably linked. Manufacturing products and materials such as plastics from waste rather than primary fossil raw materials, not only limits the environmental impact caused by extraction and processing of primary fossil raw materials, but also reduces greenhouse gas emissions in the production stage and in the waste stage (incineration). Electrifying processes not only reduces greenhouse gas emissions, but also emissions of air pollutants, such as NO_x, currently released in the combustion of fossil raw materials. The application of biobased raw materials in production processes not only results in sustainable products, but also offers opportunities for achieving carbon removals. In this vision, the focus is on the transition to a circular carbon chemistry which is related to the transitions to a climate-neutral, healthy and safe and competitive chemical sector.⁶⁹

None of the three sources of sustainable carbon alone will be sufficient to meet future demand for carbon. In order to phase out fossil carbon in the long term, all three sources of raw materials will be needed. All three have advantages and disadvantages (see [Appendix 2](#)) and the production routes offer different opportunities with regard to functionality (e.g. biodegradability or recyclability). Based on the application and functionality required, it is therefore desirable to explore which production process based on which raw material is most suitable across the entire life cycle and makes a positive contribution to the above three transitions, something that can also shift during the transition itself.

This working method reflects the philosophy of Safe and Sustainable by Design (SSbD). SSbD means that a product or process is developed from the outset with a view to safety and sustainability and is based on **what** is produced, **how** it is produced and from **which** raw materials. Applying an SSbD approach makes it possible to identify any overlapping risks and opportunities between the three transitions in order to take advantage of-, or mitigate them. The Dutch government has commissioned a review of how the principles of climate neutrality – in addition to safety – can be made part of an SSbD approach.

However, there will also be competition between the three transitions and with other societal challenges. For example, the transition to sustainable carbon requires space, much of it in a high environmental impact category, which is and will remain in short supply in the Netherlands and needs to be distributed across different sectors. The establishment of projects will also require additional nitrogen emission allowance, which is unavailable. Currently, not enough is known about what the demand for (environmental) space will be for the raw materials transition in the chemical industry. In order to gain a better understanding of this, research is being conducted in the framework of the Spatial Planning Memorandum (*Nota Ruimte*) into the spatial impact of the energy and raw materials transition in the industry.

Finally, the raw materials transition in the chemical industry is closely interwoven with the energy transition itself. On the one hand, this offers opportunities for synergies, for example based on links with the (bio) refinery sector and the transition in that industry to renewable fuels such as methanol, which can also be used as platform molecules in the chemical industry. On the other hand, there will also potentially be competition for scarce sustainable carbon sources that could be used both in the energy transition and in the raw materials transition for the chemical industry. Examples include application of sustainable carbon as fuel, as fertiliser in the greenhouse horticulture industry or for carbon removal. This is why the non-energetic use of (sustainable) carbon for the chemical industry is seen as an integrated part of the energy system within the National Energy System Plan.

⁶⁹ In the case of the other primary raw materials used in the chemical industry, metals and salts, extraction and processing also leads (as in the case of fossil carbon) to loss of areas of nature, environmental pollution and greenhouse gas emissions. A switch to secondary raw materials and raw materials with a lower environmental impact is also needed here.

6 Sustainable carbon sources

In the Netherlands, around 430 petajoules (PJ) of carbon-containing fossil raw materials are used for non-energetic applications in the chemical industry per year⁷⁰, which is the equivalent of around 8.5 Mt of carbon content⁷¹, see [Chapter 5.1](#). Some 80% of Dutch production is exported, 20% of which outside of Europe. Based on geographic trends, demand for chemical products is expected to remain more or less stable in Europe until 2050, with estimated growth of +0.4% per year.⁷² However, this does not mean that European production will also remain more or less stable. Because of global overcapacity and the resulting challenging competitive position, (see also [Chapter 5.2](#)), export outside of Europe is also expected to face future pressure. Additionally, a larger proportion of European demand could be imported. Moreover, because of increasing circularity and reuse and recycling further down the value chain, demand for basic chemicals will decline compared to the current situation. In view of the Dutch chemical industry's strong position within Europe, the Dutch government is committed to continuing this important role within European production, although there may be shifts of locations within Europe for energy-intensive processes. The transition to sustainable raw materials will also result in new product chains for existing products (**alternative routes**) and for **new chemistry**. Intermediate products from these new routes, such as methanol, will partly be imported from countries where renewable energy is cheaper. However, significant demand for carbon will remain for the chemical industry in the Netherlands⁷³. This chapter looks at the sources and techniques that could be used to meet this demand.

6.1 Three raw material sources

There are three potential sources for replacing the use of fossil carbon as a raw material in the chemical industry: secondary raw materials (plastic waste), sustainable biobased raw materials and CO₂. This chapter outlines the current situation for each raw material source. It looks at which conversion technologies exist and identifies opportunities for scale up, including the necessary value chain formation and facilitating framework required. For each source, an assessment is provided of the potential for the use of this source.

6.1.1 Secondary raw materials

Current situation

In the phasing out of fossil carbon in the chemical industry, a key role must be played by secondary raw materials (see [Textbox 2](#)). Of the 1.5 megatonnes (Mt) of plastic that ends up in Dutch waste every year, 44% is recycled.⁷⁴ This is mainly household waste; mixed commercial waste generally goes unsorted to the waste incineration plant. Secondary raw materials are so far used only to a limited extent in the Dutch chemical industry. For example, just 20% of the plastic is made from recyclate (13% of which is post-consumer recyclate and 7% post-industrial recyclate)⁷⁵, and the percentage of recycled plastic used

⁷⁰ CBS Energiebalans (2023).

⁷¹ Nationaal Plan Energiesysteem.

⁷² [Evaluation of Recent Reports on the Future of a Net-Zero Chemical Industry in 2050 \(PDF\) | Renewable Carbon Publications](#).

⁷³ In that context and as a follow-up to the NPE, the Ministry of Climate Policy and Green Growth (KGG) is working on an action plan for the supply of sustainable carbon carriers (*Actieplan Aanbod Duurzame Koolstofdragers*), and is expected to share this with the House of Representatives before the end of 2025. At the same time, through its Biobased Raw Materials Strategy, the Ministry of Agriculture, Fisheries Food Security and Nature (LNVN) is working to increase the domestic supply of sustainable biobased raw materials and on an overview of demand for these biobased raw materials (including animal feed and food) based on various key principles.

⁷⁴ Evaluatie aanwezigheid kunststoffen in brandbaar afval voor AVI's | [Rapport | Rijksoverheid.nl](#).

⁷⁵ https://www.internetconsultatie.nl/nationale_circulaire_plastic_norm/document/12507.

in the total chemical industry value chain is even lower. A key reason for these low percentages is the current plastic market situation, in which prices for virgin plastic are lower than those for recycle (see [Chapter 5.2](#)).

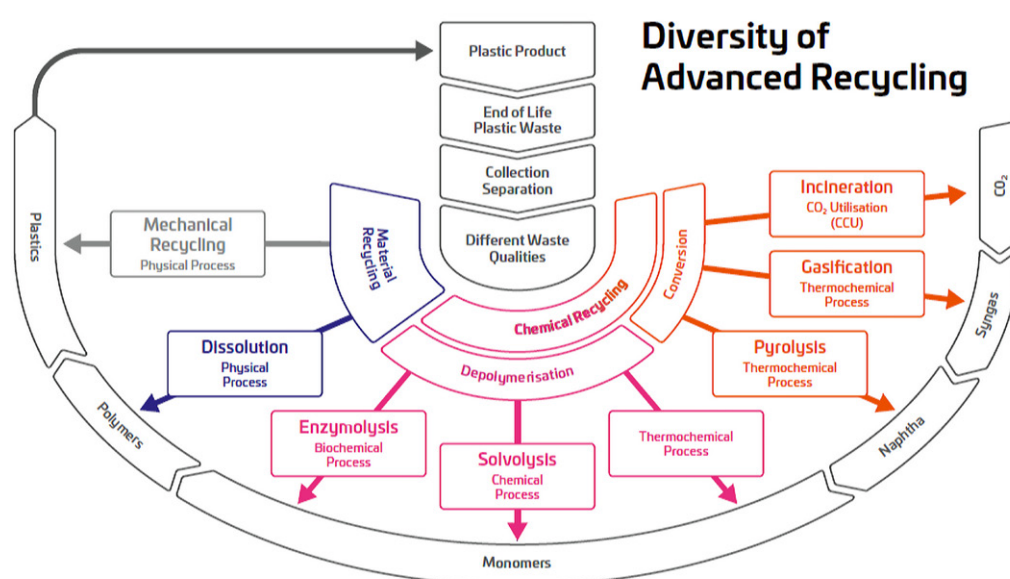
Textbox 2: Definition of secondary raw materials

Secondary raw materials are biotic or abiotic products or materials that have reached the end-of-waste phase and are reused as raw material after processing. The quantity and usability of secondary raw materials (aside from import) is heavily dependent on the Dutch collection, sorting and recycling quality and capacity. In the chemical industry, waste containing carbon can be used as a raw material because of the imbedded hydrocarbons. Inorganic residual streams, such as metal, must of course also be recycled, but are out of scope in this context. Because of its large proportion within the total waste, this chapter focuses on plastic waste (after processing of recycle) as a secondary raw material. Secondary biotic streams are included in [Chapter 6.1.2](#).

Opportunities for scaling up

In order to meet the demand of the future sustainable chemical industry, significant scale up will be needed in sorting and recycling capacity.⁷⁶ In its exploration of pathways towards climate neutrality (*Trajectverkenning Klimaatneutraal*), the Netherlands Environmental Assessment Agency (PBL) calculated that between 12 and 20 times more recycled plastic will be needed for a climate-neutral Netherlands.⁷⁷ In 2023, the Netherlands had operational chemical recycling capacity for 12 kilotonnes (kt) of plastic waste. The Dutch capacity envisaged for 2030 based on projects already announced is 4,237 kt, of which approximately 87% will be gasification.⁷⁸ However, in the current international context there is real doubt as to whether these planned investments will actually be operational by that time (see [Chapter 5.2](#)); a capacity of 50 – 100 kt by 2030 seems to be more likely. In order to ensure that the investments required in recycling capacity actually happen, it will be important that demand for these green products is created, obstacles resulting from end-of-waste status regulations are reduced as far as possible and the process of permitting and issues relating to end-of-waste status are made smoother and faster.

Figure 6: Schematic representation of recycling techniques⁷⁵



⁷⁶ KPMG onderzoek schetst route naar circulair plastic - Plastics Europe NL.

⁷⁷ Trajectverkenning klimaatneutraal 2050 | Planbureau voor de Leefomgeving.

⁷⁸ 'De Rapportage Monitoring Chemische Recycling Projecten 2023' (Rebel 2024).

There are several recycling techniques for converting plastic waste into secondary raw materials. Each one differs in terms of the specifications of the input (the waste), the quality (and therefore usability) of the output, the energy consumption, environmental impact, space needed and conversion costs. The range of recycling techniques in [Figure 6⁷⁹](#) shows a clockwise declining scale of the extent in which the waste can be mixed (left requires more homogenic waste), the extent to which energy is needed to reprocess the output into chemical products such as plastic (right requires more energy) and the diversity of applications for which the output may be used. In [Textbox 3](#) the different techniques are briefly explained.¹⁵

None of the techniques will be the sole solution to the problem of plastic recycling. For this reason, a combination of these recycling techniques will be needed to achieve a fully circular economy. However, not all of the routes are equally desirable: from an efficiency point of view, short-loop recycling (such as mechanical recycling) should be preferred over longer loop recycling, to minimise the extent of breakdown of molecules that will need to be reprocessed. The incineration of waste for heating purposes should also be avoided as much as possible.

Additionally, there is a great need for additional capacity of advanced recycling in order to ensure that there are also usable secondary raw materials for the more technologically challenging applications. This means that, despite the difficult current economic context for recyclers, more investment will be needed in chemical recycling (on top of the gasification capacity mentioned above). It still remains uncertain what the exact mix of recycling methods needed in the future will be. In an scenario in which still much use is made of existing petrochemical assets, there will be more demand for pyrolysis oil and gasification than in a situation where the industry focuses more on short-loop recycling.

Textbox 3: Overview of current recycling techniques

Various techniques can be used to recycle residual streams into raw materials:

- **Physical recycling**, in which molecular structures remain intact, comes in two forms:
 - **Mechanical recycling** (Technology Readiness Level (TRL) 9) - plastic is fragmented and/or melted down in order to make new products.
 - **Dissolution** (TRL 4-6) - a solvent is used for the targeted filtration of a polymer from plastic waste.
- **Chemical recycling** can be categorised under two types of technology:
 - Onder **depolymerisatie** (TRL 7-8), waarbij polymeren worden teruggebracht naar hun oorspronkelijke monomeren, vallen de volgende technieken:
 - ☒ • **Enzymolysis** - depolymerisation is carried out by means of biocatalysts (enzymes).
 - ☒ • **Solvolyis** (TRL 5-6) - a solvent is used to chemically break down polymers.
 - ☒ • **Thermochemical recycling** - a combination of heat and chemicals is used.
 - For the **conversion** of plastic waste, in which the polymers are converted into a wide range of different usable products, three techniques are commonly used:
 - ☒ • **Pyrolysis** (TRL 7-8) - waste is converted into pyrolysis oil (and gases).
 - ☒ • **Gasification** (TRL 8-9) - waste is gasified, resulting in syngas.
 - ☒ • **Incineration involving CCU** - where incineration is used to convert waste into energy and the carbon is captured and reused (see [Chapter 6.1.3](#)).

As well as varying in terms of desirability, the routes also differ in the extent to which they can be scaled up. Mechanical recycling is an advanced method that can be widely used and is relatively cheap, but quality is lost in the process. Additionally, mechanical recycling often leads to downcycling instead of usage in equivalent products. In dissolution, the loss of quality is less of an issue and contaminations and pollutants can be removed, but its application and scale up is limited because not all polymers can be dissolved. Besides, the

⁷⁹ [Diversity of Advanced Recycling \(2024\) | Renewable Carbon Publications.](#)

combination of plastics and fillers always differs in the various plastic waste streams, which means that new specific solvents are needed each time.

Depolymerisation is a more energy-intensive method by definition, because the products are further broken down, resulting in a longer loop in order to return to products. There is also the issue of loss of efficiency and a relatively high demand of space and the environment. The advantage of depolymerisation is that the resulting output can be used as a feedstock further down the value chain than is the case for conversion (a shorter loop). The output can also be used in high-grade applications, such as food and pharmaceutical packaging. When it comes to possibilities for scaling up, solvolysis is already at a more advanced stage of development, but the management and reuse of the solvents required remains challenging.⁸⁰

The disadvantage of conversion is that it is a long-loop recycling method requiring multiple stages and therefore relatively large amounts of energy in order to make new products from the resulting product (pyrolysis oil or syngas); these stages also place a significant burden on the environment and available space. However, both pyrolysis and gasification are relatively robust conversion methods that can process a wide range of input materials or heavily contaminated waste fractions. The gasification of plastic-contaminated waste streams can also contribute to the safe processing of micro-plastics. Moreover, the basic chemicals obtained from gasification can then be used widely for further applications and can, after necessary processing, be used in existing petrochemical plants.

Other factors

When the needed recycling capacity is realised, it will be important for there to be sufficient supply of feedstock (waste). The best opportunity for increasing the supply of secondary raw materials (besides import) will involve further **improvements to the Dutch waste collection system** (such as harmonization of collection and sorting methodologies or EPR schemes). This provides opportunities for increasing the purity of waste streams and reducing contamination in waste streams, enabling greater use to be made of mechanical recycling or delivering a more suitable raw material for other (chemical/physical) recycling techniques. Large quantities of commercial waste are currently still incinerated without prior sorting (this figure was still 55% in 2023). If this waste were to be sorted at the source or in after treatment, this would be a significant supply possibility.

There are also opportunities for simplifying and accelerating the policy and legal framework. This is why **(European) harmonisation and standardisation** relating to the rules on trade, transport and processing of waste into secondary resources is important. Regulations can also help in **improving the recyclability of products** by limiting the complexity resulting from the high number of different types of polymers, fillers and additives permitted for use in applications. The Packaging & Packaging Waste Regulation (PPWR)⁸¹ and the proposed Safe and Sustainable by Design Legislation will play a big role in this process.⁸²

Value chain formation

In a circular value chain, numerous different parties have to cooperate who are indirectly reliant on each other, but often far apart from each other. A circular economy is more complex and includes more processing stages than a linear economy, which often comes with higher costs. Products that have reached their end-of-life stage will be collected, sorted, recycled and reused as raw materials in order to be processed by producers in new equivalent applications. These **additional steps and actions between parties will need to be facilitated and encouraged**.

Facilitating framework

The required expansion of the existing Dutch collection and sorting infrastructure and pre-processing will place a burden on the available space in the Netherlands. It will also be necessary to take account of scaling up imports of secondary raw materials and the infrastructure required for that, since Dutch waste alone will be insufficient to meet feedstock demand.⁸³ The recycling facilities that need to be built, such

80 [De Nationale Technologiestrategie | Beleidsnota | Rijksoverheid.nl](#).

81 https://www.europarl.europa.eu/doceo/document/TA-9-2024-0318_EN.html.

82 [Safe and sustainable by design - European Commission](#).

83 [KPMG onderzoek schetst route naar circulair plastic - Plastics Europe NL](#).

as pyrolysis and gasification, will not only place a burden on space and the environment, but make significant demands on renewable energy.

6.1.2 Biobased raw materials

Current situation

Sustainable biobased raw materials can make an important contribution to replacing fossil raw materials (see [Textbox 3](#)). Biobased raw materials currently still play only a limited role in the chemical industry: just 5% of all chemicals and derived products in the EU are produced from biobased raw materials⁸⁴ and only 9% of chemical companies say that they are using biobased raw materials.⁸⁵ There are various scenarios for the share that biobased raw materials will have in the chemical industry of the future, which depend to a significant extent on the allocation of scarce biobased raw materials across sectors, on the extent to which the chemical industry puts efforts in becoming fossil free, and on the claim on biobased resources coming from negative emissions (biogenic carbon capture and storage). PBL⁸⁶ suggests a bandwidth of 225 – 290 PJ of demand for biogenic carbon raw materials for the chemical industry in 2050, or 35 – 55% of the total production in 2050 in the Netherlands. Other studies suggest a lower share for biobased raw materials. The Nova Institute, for example, predicts that the share of biobased raw materials in the global chemical industry will be 20% in 2050.⁸⁷ Despite of the differing estimations, all these studies make it clear that significant scale up will be needed both in terms of production of and demand for biobased raw chemicals and plastics.

Textbox 4: Definition of biobased raw materials⁸⁸

Biobased raw materials encompass all vegetable or animal material, or material of vegetable or animal origin. Biobased raw materials can originate from crops, trees and plants, algae and animal products and waste streams. These biobased raw materials can be used for different applications. Maize, for example, can be used for the production of animal feed, fuel (ethanol) and chemicals. The use of biobased raw materials is subject to the Sustainability Framework for Biobased Raw Materials (*Duurzaamheidskader biograndstoffen*). Put briefly, policy focuses (as far as possible) on the *high-value application* of sustainable biobased raw materials in order to achieve a climate-neutral and circular economy. The use of biobased raw materials in the chemical industry is a high-value application, for which the policy focus is to *scale up*.

Technological routes

Biobased chemicals and plastics can be divided into three different groups, with associated production routes, characteristics and market dynamics⁸⁹ (see [Figure 7](#) and [Textbox 5](#)).

- **Biobased drop-ins** are chemically identical to existing fossil chemicals. Since they have direct fossil equivalents and can replace these, they can be used in established processes and products.
- **Smart drop-ins** are a specific group of drop-in chemicals. Although they are chemically identical to existing chemicals based on fossil hydrocarbons, their biobased production routes offer process advantages, such as energy efficiency, compared to conventional pathways.
- **Dedicated biobased chemicals and plastics** (new chemistry) are commercially produced via a dedicated production route and do not have identical fossil equivalents. One example is PEF: a biobased and recyclable polymer with improved barrier properties compared to PET and other

84 RCI's scientific background report: RCI carbon flows report – Compilation of supply and demand of fossil and renewable carbon on a global and European level (Oct. 2023) | [Renewable Carbon Publications](#).

85 3. Resultaten | CBS.

86 Trajecten naar een klimaatneutrale industrie en klimaatneutrale grondstoffen (pbl.nl).

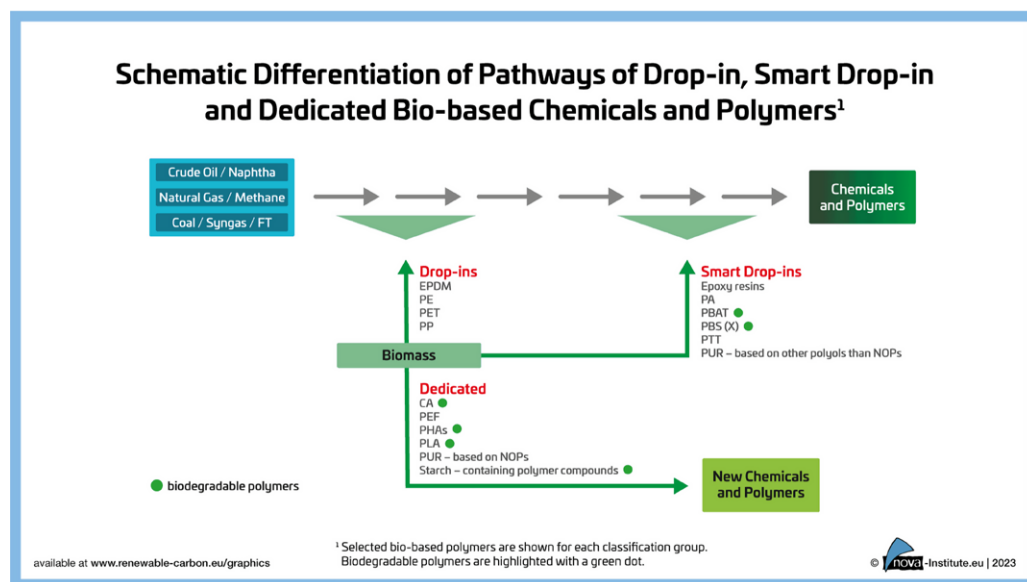
87 Explorative scenario for a global net-zero chemical industry in 2050, Update October 2023 - [Renewable Carbon News](#) (renewable-carbon.eu).

88 Kamerbrief over duurzaamheidskader biograndstoffen | Kamerstuk | Rijksoverheid.nl.

89 Zie voor definities: [Circular Biobased Europe Joint Undertaking - Annual Work Programme and Budget 2025](#).

conventional plastics. Other examples are PLA (annual production worldwide 500 kt) and PHA (100 kt extracted annually from sludge).

Figure 7: Groups of biobased chemicals and plastics



Because (smart) drop-ins are chemically identical to their fossil equivalents, they are easy to use in processes, as the market is familiar with the functionalities of these chemicals in products. Moreover, these routes can (partly) use existing production sites and infrastructure. This applies to the production of bionaphtha via biorefinery for example, which is suitable for use in existing naphtha crackers. These crackers are often part of an integrated chemical complex, in which producers and buyers are physically linked to each other. This offers advantages compared to dedicated biobased chemicals and plastics. However, the latter group of chemicals and plastics also have advantages compared to drop-ins. For example, they may have improved functionality and be better suited for recycling⁹⁰, which also means that fewer new raw materials will ultimately be needed. Their production also requires fewer biobased raw materials because of a higher carbon efficiency, production is often more energy efficient and dedicated biochemicals can be more biodegradable in the environment.

The Biobased Circular programme (KGG) has issued a Moonshot in which it calls for a transition towards biopolyesters⁹¹. Currently, production chains and applications are optimised for the use of existing fossil plastics (polyolefins, such as the frequently used PE and PP). On the route towards a fossil society, biobased raw materials will be needed; for biopolyesters, the need for land is 2.5x less than for drop-in biopolymers; biopolyesters also have better biodegradability than regular plastics. In view of increasing concern about the effects of micro-plastics, it is sensible to develop new chains based on biopolyesters.

In the transition, both (smart) drop-ins and dedicated biobased chemicals and plastics will be needed. Drop-ins can play an important role in improving sustainability and preserving existing plants, and have the potential for faster roll-out at scale. For example, it is already possible to blend bionaphtha from the refinery process in the cracker in order to produce biobased plastics and chemicals. For many dedicated routes, there are already sustainable alternatives available that present an opportunity for new industry, but most of these routes still need to be developed. The exact role that (smart) drop-ins and dedicated routes will play in the transition remains uncertain and will depend on a wide range of factors, including the price, impact on the energy system, CO₂ emissions, the speed at which scale up can be achieved and

⁹⁰ [A future vision for more sustainable plastics](#). Voor het daadwerkelijk recycleren van deze nieuwe polymeren is het wel van belang dat er voldoende sorteer- en recyclecapaciteit wordt opgesteld.

⁹¹ [Moonshot-BBC.pdf](#).

more. It is important to gain a greater understanding of the advantages that dedicated routes offer in terms of functionality, sustainability and impact on the energy system.

Textbox 5: Techniques for conversion of biobased raw materials

Biobased raw materials can be converted into chemicals and plastics by means of various conversion techniques:

- **Biochemical conversion** - biological processes involving microorganisms that take place at low temperature and under pressure. These include aerobic conversion, anaerobic digestion, enzymatic processes and fermentation. This technique is primarily suited to lower volumes of chemicals. In 2025, the Dutch government will submit its vision on biotechnology to the House of Representatives.
- **Chemical conversion** - processes that cause a change in a molecule's chemical structure by reacting with other substances. This includes transesterification and hydrogenation.
- **Thermochemical conversion** - processes that cause a change in a molecule's chemical structure at high temperature and under pressure. Thermochemical conversion processes include gasification, hydrothermal liquefaction, pyrolysis and supercritical conversion.
- **Mechanical conversion** - processes that change the morphology and composition of biobased raw materials, but do not change the structure, such as a size reduction, densification change or separation of raw material components. Mechanical processes play a role in ensuring that raw materials meet the quality requirements for biochemical and thermochemical processing. They include blending, extraction, fractioning and separation processes.

Opportunities for scaling up

There are significant opportunities for scaling up the use of biobased raw materials in the chemical sector towards 2050. Based on the expected role that the PBL and Nova Institute assume will be played by biobased raw materials in the chemical industry, the use of biobased raw materials will increase by around 4 to 11 times compared to the current situation.

This will require significant scale up of production capacity, with plenty of opportunities for the Netherlands. Existing biorefinery capacity in the Netherlands offers opportunities to apply larger volumes of biobased raw materials in the basic chemicals industry in the short-term. The strong integration of the existing chemical industry within industrial clusters is an added advantage. In addition to a focus on converting the existing chemical industry, there are also major opportunities for the development of production of smart drop-ins and dedicated biobased chemicals and plastics in the Netherlands. The Netherlands has a high level of knowledge in the field of chemistry, biotechnology, material science and process technology. Combined with the Netherlands' innovation driven culture, this has led to several promising start-ups and scale-ups that have originated at Dutch universities (e.g. BTG from the University of Twente and Avantium from the Vrije Universiteit Amsterdam) or are the result of alliances between the business sector and universities (e.g. BioBTX).

However, these developments will not be able to provide the volumes required and scale up is yet to properly take off. The main barriers to this scale up are economic in nature (see [Chapter 7.2](#)). Because the types of biobased raw materials primarily under consideration and their competition with biofuels and energy, the availability of biobased raw materials will also play an important role (see [Chapter 6.2](#)). In order to reduce the competition between use in the chemical industry and for fuels and energy, it will be important to further develop advanced production routes based on second- and third-generation biobased raw materials (wood, algae) in order to ensure that a **wide raw-materials base** can be used for production in the chemical industry and for fuels. In this aspect, it will be important to take an **integrated approach when considering the production of biofuels and biobased raw materials for the chemical industry**, as new technologies will produce products that can be used both as fuel and as raw materials in the chemical industry. The refinery sector is expected to focus in the future on producing (bio)fuels for aviation and shipping and raw materials for the chemical industry.

The scale up of the biobased chemical industry in the Netherlands, both by means of (smart) drop-ins and dedicated biobased chemicals and plastics, offers substantial opportunities for the Netherlands to unlock future earnings capacity. As already concluded in the National Technology Strategy (*Nationale Technologiestrategie*)⁹² and the Growth markets for the Netherlands (*Groeimarkten voor Nederland*) report⁹³ there are substantial economic advantages to be gained from scaling up the biochemical industry.

Value chain formation

Scaling up the use of biobased raw materials in the chemical industry will result in the formation of new value chains. Parties in the agricultural sector and those active in the collection and processing of biogenic residual streams will also gain a place in these chains. This chain formation will be essential for gaining access to funding (see [Chapter 7.2](#)). **Standardisation of biobased raw-material streams** will help to increase supply and create a market, ensuring that parties are not reliant on a limited number of suppliers for their raw materials. The agri-food industry already has a strong logistical value chain of standardised raw materials, which provides opportunities for the usage of and developing upon these stream.

It will be easier for (smart) drop-in solutions to form value chains, as they are often already part of integrated chemical industry complexes. This will be more difficult for dedicated routes since these processes and chains will still need to be developed in many cases. Investments will not only be needed for the production of dedicated biobased chemicals and plastics, but also for links further down the chain that use these new chemicals and plastics in their products. Besides that, chemical plants often produce a wide range of products which in chemical industry clusters, often already have an application. For dedicated routes who lack this integration however, it will take more time to find a way to valorise these byproducts.

Facilitating Framework

Scaling up the use of biobased raw materials in the chemical industry will require additional infrastructure, renewable energy and space. The production of biobased (smart) drop-ins can (partly) make use of existing infrastructure, for example if the production route runs via an existing integrated refinery-cracker route or uses the existing network of pipelines. However, these processes consume a lot of energy and raw materials. For the supply of biobased raw materials, the ports will have an important role to play because of the limited domestic availability of these materials. In addition to existing infrastructure, there will also be new demand for infrastructure, including for connections to the electricity grid and the production and transport of hydrogen.

The scale up of biobased production will also demand additional space. New production facilities, the infrastructure required and the cultivation of biobased raw materials all demand space. During the transition period, new facilities will need to be developed alongside existing plants. The extent of this demand for space still remains uncertain, as is its position within the overarching spatial challenge of the Netherlands. In this context, a study is currently being conducted into the space required for the future sustainable industry in the Dutch industrial clusters. Optimising the value gained from biobased raw materials will play a role in limiting this demand for space.

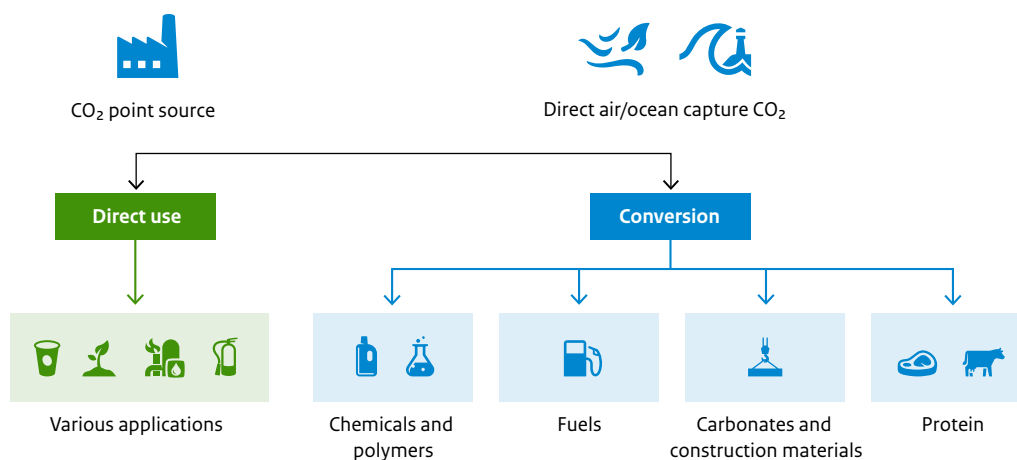
6.1.3 CO₂ as a raw material

CO₂ is also a possible sustainable raw material to replace fossil carbon. By means of Carbon Capture & Utilisation (CCU) technology, carbon capture and (re-)use, it is possible to use the carbon from CO₂ to make products. CO₂ can be used directly in applications such as carbonated drinks and in greenhouse horticulture, but, via conversion, can also be used in chemicals and polymers, fuels, carbonates and for the production of food, including proteins. For the purposes of this vision, this chapter focuses on its conversion into chemicals and polymers. Where there are links with the other uses, this will be mentioned. [Figure 8](#) provides a schematic representation of the applications and sources, with the scope of this chapter outlined in red.

⁹² [De Nationale Technologiestrategie | Bouwstenen voor strategisch technologiebeleid.](#)

⁹³ [Dialogic Groeimarkten voor Nederland.](#)

Figure 8: Schematic representation of potential applications



The origin of CO₂ can be both biogenic as well as fossil via point- sources⁹⁴. The CO₂ can also be atmospheric, via Direct Air/Ocean Capture. The origin of CO₂ is important because atmospheric CO₂ is pure, but this does not always apply to captured CO₂. Moreover, the origin of the CO₂ determines the level of sustainability of both production and final products, especially at the moment the CO₂ escapes to the atmosphere during or after use of the product. Fossil CO₂ that is emitted in this way will then contribute to human-induced warming of the climate. Nevertheless, additional CO₂ emissions will also be avoided. This is why, for the purposes of developing the technology, the origin is not taken into account at this time, but will play a role in the long run with regards to a climate-neutral economy. In general, the CO₂ captured from point sources, where CO₂ is released in industrial processes, have a relatively high concentration of CO₂ and therefore lower energy costs when used for processing into products. Because of the low CO₂ concentration in the atmosphere and ocean, Direct Air/Ocean Capture techniques demand more energy (costs); the carbon removal route map (*roetekaart koolstofverwijdering*) provides more context about these techniques. See [Chapter 6.2](#) for an explanation of the supply of CO₂.

Current situation

Of all the sequestered carbon in chemicals and derived materials (500 Mt), 0.03% is sequestered with the help of CCU technology.⁹⁵ In view of the relatively large basic industry based on crude oil in the Netherlands, this CCU percentage is likely to be lower domestically. Despite this, various companies and organisations are actively working on CCU innovations. Although there are various organisations working in the Netherlands on CCU technology at an individual level, a CCU sector has yet to take off. An evaluation of 20 studies looking at both the European and global chemical industry concluded that the average contribution of CCU in a climate-neutral industry is 33%, with a range from 0 to 90%.⁹⁶

Most CCU-based chemical products⁹⁷ are younger than recycled and biobased products, which means that a lot of further innovation is needed and the process of societal embedding is still very much in its infancy.⁹⁸ Current policy focuses on innovation by means of innovation grants and subsidies, see Chapter 7.1. Interest in the potential role that CCU could play is growing at European level. It features prominently in the Industrial Carbon Management Strategy⁹⁹ and falls within the scope of the Net-Zero Industry

⁹⁴ Point sources are fixed and canalised sources of CO₂ emissions, such as (bio)refineries, steel producers, (bio)energy plants.

⁹⁵ Kähler, et al. (2023). RCI carbon flows report. *Renewable Carbon Initiative*. <https://doi.org/10.52548/KCTT1279>.

⁹⁶ Harrandt, J., Carus, M., vom Berg, C., 2024: Evaluation of Recent Reports on the Future of a Net-Zero Chemical Industry in 2050. <https://doi.org/10.52548/SXWV6083>.

⁹⁷ For the production of ureum, CCU is already common practice. This is not taken into consideration elsewhere in this document.

⁹⁸ MMIP_6.pdf (topsectorenergie.nl).

⁹⁹ Communication Towards an ambitious Industrial Carbon Management for the EU (COM(2024) 62 final). <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2024:62:FIN>.

Act.¹⁰⁰ In addition, the Renewable Energy Directive III includes a target calling for at least 1% of renewable fuels to be of non-biological origin by 2030. ReFuelEU Aviation also sets minimum targets for synthetic aviation fuels in the share of sustainable aviation fuels i.e. 0.7% from 2030, 5% from 2035, 10% from 2040, 15% from 2045 and 35% from 2050.¹⁰¹ This could help to mobilise technology that can contribute to the use of CCU technology in the chemical industry.

Textbox 6: CCU conversion techniques

CO₂ can be converted into chemicals and plastics by means of various conversion techniques:

- **Biotechnological conversion** (TRL 6-7) - bacteria enhanced by genetic modification are used as catalysts. Products are produced directly in the reactor medium.
- **Thermocatalytic conversion** (TRL 5-8) - CO₂ is reduced because the oxygen forms bonds with hydrogen or ammonia. A simple reaction produces CO. Via the Fischer-Tropsch process, this can then be converted with more H₂ into synthetic platform chemicals.
- **Electrochemical conversion** (TRL 5-7) - electricity is used to reduce CO₂ in an electrolyser. This process can be used to produce ethylene, methanol, methane, formic acid, oxalic acid and CO.
- **Plasma-based conversion** (TRL 1-3) - plasma is used to convert CO₂ directly into the desired products. CO₂ can be split in this way into CO and O₂, but can also react with other gases, such as CH₄, H₂ or H₂O, with a view to producing syngas and valuable oxygenates, such as methanol, formaldehyde and formic acid.
- **Photocatalytic conversion** (TRL 1-3) - CO₂ is converted with water/hydrogen to make the desired products using catalysts and/or photoelectrodes and sunlight as a source of energy. Various chemicals can be produced in this way.
- **Chemical conversion into polymers** (TRL 8-9) - CO₂ is used to introduce a carbonate group (-O-CO-O-) into the polymer. This process is also called copolymerisation of epoxides and results in a polymer that often contains polycarbonates, polyols and thermoplastic polymers.

Opportunities for scaling up

There are six different ways of converting CO₂ into polymers or platform chemicals (bulk production of chemicals that serve as a basis for products with a higher added value).¹⁰² In [Textbox 6](#) the different conversion technologies are explained.

The expert advisory report¹⁵ states that CO₂, that would otherwise be released, can be converted into hydrocarbons such as methanol in synthetic gas-based chemistry through the application of hydrogen (H₂). This is thermocatalytic conversion. On the one hand, the technological development of this technique is at an advanced stage and it requires few changes to the chemical industry and value chain. On the other hand, high pressure and temperature is needed for CO₂ to react with hydrogen (H₂), which means a lot of energy is required in addition to the energy consumption involved in the hydrogen production. Both low-carbon (non-fossil) hydrogen and (renewable) energy come with relatively high costs in the Netherlands. The report published by TAUW, Rebel and Drift states that the costs of CO₂-based fuels are four times those of oil.¹⁰³ The advantage of methanol production is the potential for economies of scale as a result of production for both the chemical industry and the fuel sector, thanks to the targets set in the Renewable Energy Directive III and ReFuelEU Aviation. But it is uncertain whether this development will happen in the Netherlands. Synergy benefits may also emerge in the case of biobased processes because the CO₂ (or CO) released in the process can be used within the same process through the addition of hydrogen. In TNO's decarbonisation scenarios, synthetic feedstocks have a

¹⁰⁰ Regulation on establishing a framework of measures for strengthening Europe's net-zero technology manufacturing ecosystem and amending Regulation (REG(2024) 1735). [Regulation - EU - 2024/1735 - EN - EUR-Lex \(europa.eu\)](#).

¹⁰¹ [Regulation - EU - 2023/2405 - EN - EUR-Lex](#).

¹⁰² [MMIP_6.pdf \(topsectorenergie.nl\)](#).

¹⁰³ Tauw, Rebel, Drift. (2025). *Transitiepaden naar een duurzame koolstofchemie*.

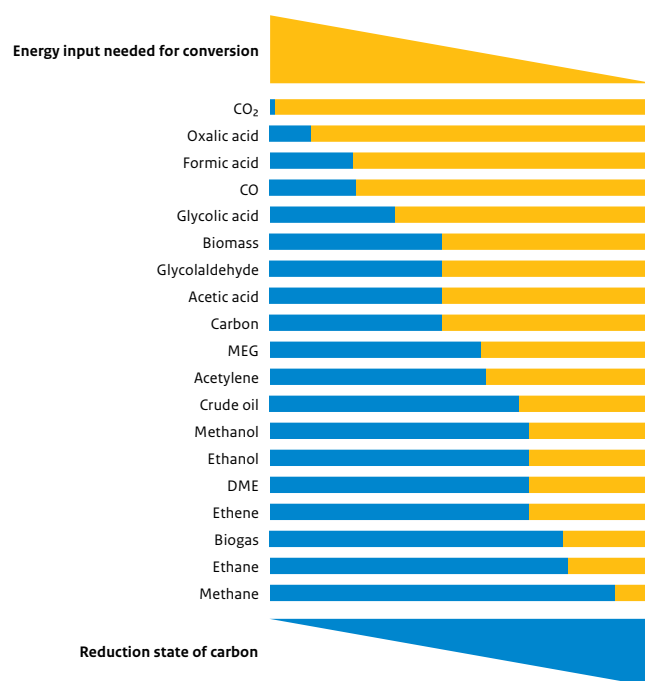
relatively minor role¹⁰⁴. In the specific case of naphtha cracking in a low-import scenario, synthetic feedstocks have a relatively significant role, but the quantity being cracked however, is expected to decline further still.

CCU can play a role in the ‘**new chemistry**’ route, especially in the production of oxygen-rich products, such as oxalic acid and formic acid, and polymers. Because these products contain more oxygen, less energy is required for conversion. See [Figure 9](#) for an overview of high to low oxygen-rich chemicals (left to right) and the energy required for conversion.¹⁰⁵

The conversion technique and energy required is not the decisive factor however, instead the demand for a product is what determines the most obvious technique to use. Because there is limited demand for oxygen-rich products and polymers, it’s unlikely for these products to be bulk produced. Therefore, the role of CCU’s in the Netherlands in 2050 is expected to be limited, besides some small-scale production of less energy-intensive forms of CCU. The role of imported CCU-based feedstocks (synthetic) may be more significant, but will be very dependent on the costs and availability.

Pilots will be needed to enable scale up. Developing pilots is not only subject to technological constraints; policy, society and funding are also factors to be taken into account. Pilot and demonstration plants also require certainty about the long-term profitability of CCU technologies. In this regard, **mandates** for CCU and CO₂ in products such as chemicals and materials and other forms of market creation (see [Chapter 7.2](#)) could prove helpful. Faster permitting and licensing of pilot and demonstration plants by means of experimentation spaces, regulatory sandboxes and Greenfields can help in the development of technologies in a pilot and demonstration phase. In view of the available expertise in catalysis and process technology, there are opportunities for the Netherlands in this area.

Figure 9: Overview of oxygen-rich (low reduction state) and low-oxygen (high reduction state) chemicals



¹⁰⁴ Fossil-free energy system and the chemical industry in the Netherlands - TNO 2025.

¹⁰⁵ [Home - FutureCarbonNL](#).

Other factors

The Netherlands has a relatively large number of point sources with a high CO₂ concentration, making the availability of CO₂ relatively high. Linked to that is the development of CCS in the Netherlands with the associated CO₂ infrastructure, which could also be used for CCU. The high level of cooperation within the Netherlands combined with the relatively short distances that need to be covered can also help boost CCU. Currently, there are relatively few incentives for the use of CO₂ as a feedstock in the chemical industry, compared to the permanent sequestration of CO₂. On the one hand, this is due to the technological developments needed in the field of CCU. On the other hand, the additional boost could benefit those developments. It is therefore a positive sign that the European Commission is exploring the option of including non-permanent CCU in the ETS system.¹⁰⁶

This is notwithstanding the lack of space combined with significant pressure on the environment in the Netherlands. The level of sustainability of CCU depends on numerous factors, such as renewable energy and low-carbon hydrogen use, the origin of CO₂, the extent to which fossil CO₂ emissions are avoided and the specifics of the final product. A complete life-cycle analysis and certification of sustainability will therefore be important. These impediments and uncertainties can be detrimental to the business case, which makes it difficult for the limited funding available to benefit CCU technologies (see [Chapter 7.2](#)).

Value chain formation

Scaling up CCU new technology to a commercial level will require the establishment of new value chains with new partnerships¹⁰⁷. CO₂-capture plants – at point sources and via Direct Air/Ocean Capture – will need to be built. In most cases, the CO₂ will then need to be transported to other parties. This means that parties using a conversion technique to convert CO₂ into chemicals and polymers will need to establish new partnerships with the suppliers. Depending on what is produced, existing players will need to use the new raw materials in their plants or the new polymer producers will have to establish new partnerships with buyers.

New chains can also develop as a result of emerging synergies as the various transitions that our country faces see the development of new activities that can be linked to CCU. This could result in opportunities becoming more attractive at local level. In the production of biogas for example, an electrolyser can be used to produce hydrogen and capture the CO₂ involved. Using a CCU technology, which can actually be feasible on a small scale, high-grade chemicals can be produced. Collaboration with greenhouse horticulture could also be another opportunity, where options under consideration include DAC (Direct Air Capture) for the use of CO₂ for crop growth in the summer months.

Facilitating framework

In order to scale up CCU technology to a commercial level for the purposes of the raw materials transition in the chemical industry, infrastructure, renewable energy and space will be needed. The CO₂ infrastructure for CCS can also be used for CCU, but pipelines will need to be made between other parties, both within and between the different industrial clusters. That, or liquefiers and road transport will be needed. All of the techniques require low-carbon hydrogen and energy, but the size of the demand depends on the technology and intended product. Integrating capture with the conversion stage could potentially save energy. Currently energy and hydrogen infrastructure are not the urgent problem because of the limited role envisaged for CCU, but uncertainty about the future availability of infrastructure will slow down investments.

Moreover, CCU technologies require a lot of space because the CO₂-capture plants are large (especially Direct Air Capture plants) and space is also needed for the conversion plants. Depending on the technology chosen and the product to be produced, other raw materials will be required alongside CO₂ and hydrogen. Critical raw materials, such as nickel, will be needed for catalysts, or alternatively, bacteria as biocatalysts.

¹⁰⁶ BNC Fiche 18: [Chemie Actieplan](#).

¹⁰⁷ Een belangrijk partnerschap op het gebied van CCU in Nederland is FutureCarbonNL ([Home - FutureCarbonNL](#)).

6.2 Supply of raw materials

In order to substitute the total carbon content of chemicals and products by sustainable carbon, a large quantity of secondary raw materials, sustainable biobased raw materials and CO₂ will be needed. However the supply of sustainable carbon sources is limited. Their use in the chemical and material industry competes with their usage in energy and, in the case of biogenic or atmospheric CO₂, with the purposes of carbon removal or usage in different sectors. For example, 2.7 Mt of biogenic CO₂ is expected to be needed for greenhouse horticulture in 2040¹⁰⁸.

Moreover, large (bio)chemical plants require stable and homogeneous input. The composition of both secondary raw materials and biobased raw materials is variable and the supply of biobased raw materials is often seasonal, which has an impact on the availability of sufficient suitable material. Additional processing stages are often required. The NPE makes the assumption that in the future there will still be a significant demand for sustainable carbon for aviation and shipping fuels in particular, additional to the demand for the chemical industry. For other energy-related sectors, the focus will be on meeting energy demand as far as possible with alternative, carbon-free energy carriers (electricity, hydrogen and heat) with the use of sustainable carbon being the last resort. As far as biobased raw materials are concerned, the chemical industry will compete with energy and applications in construction, but their use can also compete directly (in crops) and indirectly (through land use) with food, see [Textbox 6](#).¹⁰⁹ This chapter looks at the expected supply of sustainable carbon sources.

Secondary raw materials

Every year in the Netherlands, 1,497 Kt of plastic is available in waste, the equivalent of 52 PJ of energy content.¹¹⁰ Out of this plastic waste stream, 656 Kt is recycled (23 PJ) and 714 kt is incinerated in waste incineration plants.¹¹¹ TNO makes the assumption that by 2050 up to 50% of available plastic waste will be able to be chemically recycled and reused in the chemical industry.¹¹² Put in perspective, this is approximately equivalent to half of the feed capacity for an average cracker. In its exploration of pathways towards climate neutrality (Trajectverkenning Klimaatneutraal), PBL calculates that the Netherlands will need a minimum of 160 and maximum of 260 PJ of plastic waste by 2050.¹¹³ This will therefore require large-scale import. In 2021, 16.13 Mt of plastic waste was produced in Europe (565 PJ), 6.56 Mt (230 PJ) of which was recycled.¹¹⁴ By way of illustration, if the remaining 10 Mt of non-recycled European plastic waste were completely gasified, 50 gasification plants would be needed, which could produce 5 Mt of methanol, with almost 2 Mt of carbon content.

As described in Chapter 6.1.1, increasing the supply of secondary raw materials will require waste streams that are currently unseparated to be used more effectively and the recyclability of products to be improved. Even so, insufficient waste is expected to be available to meet the future demand for carbon. Therefore, this will need to be supplemented through import and other sources.¹¹⁵

Biobased raw materials

The current use of biobased raw materials for material production in the Netherlands is 106 PJ and mainly involves using secondary residual streams without nutritional value, to be used for energy.¹¹⁶ The application of biobased materials for material production must not be to the detriment of food security. The PBL estimates that future availability of biobased raw materials originating from the Netherlands for

¹⁰⁸ Actueel inzicht CO₂-behoefte Nederlandse glastuinbouw 2030 - Wageningen University & Research.

¹⁰⁹ Richtlijn - 2018/2001 - EN - EUR-Lex.

¹¹⁰ De energie-inhoud van kunststofafval wordt aangenomen op 35 GJ/ton, bron: [Stegmann, P., Daioglou, V., Londo, M. et al. Plastic futures and their CO₂ emissions. Nature 612, 272–276 \(2022\).](#)

¹¹¹ [Evaluatie aanwezigheid kunststoffen in brandbaar afval voor AVI's | Rapport | Rijksoverheid.nl](#), op basis van data over 2021.

¹¹² [Towards a sustainable energy system for the Netherlands in 2050](#), de aanname van 50% komt overeen met het TRANSFORM scenario.

¹¹³ [PBL trajectverkenning klimaatneutraal](#).

¹¹⁴ [Plastic waste and recycling in the EU : facts and figures](#).

¹¹⁵ [Plastic feedstock for recycling in the Netherlands](#), KPMG, 2023.

¹¹⁶ [Beschikbaarheid biogronstoffen in Nederland en de Europese Unie](#), PBL, 2024.

use in energy and as feedstocks for the chemical industry to be 125 to 231 PJ in 2050 and 18 to 26 PJ for materials. Of this, 30 to 105 PJ will originate from agriculture, 40 to 48 PJ from forestry and 56 to 79 PJ from organic residual and waste streams, such as paper pulp, sludge and GFT waste. In Europe, 14.6 to 23.7 exajoules (EJ) is expected to be available for energy and materials in 2050. Scale up will require land use changes, cultivated crops and the use of residual- and waste streams. The Dutch Biobased Raw Materials Strategy, which is expected for 2026, will be looking closer at the issue of increasing the supply of sustainable biobased raw materials.

As stated in Chapter 6.1.2, the availability of biobased raw materials is closely related to the breadth of the raw-materials base. Many of the materials used are crops that contain oil and sugar, which have limited availability. There is greater availability potential from the use of woody crops containing lignocellulose, but the advanced production methods handling these woody crops must first be demonstrated at large scale in order to become commercially viable.¹¹⁷ If the supply of biobased raw materials is ultimately achieved based on a wide raw-materials base, this can also help to reduce the risks of undesirable dependencies.

Textbox 7: The role of sugar-containing crops

The role of sugar-containing crops

Sugar and starch are widely traded raw materials and sugar crops are being refined across the world by using traditional methods and by the established industry. Starch can easily be broken down into sugar. The good solubility of sugar in water makes it highly suited for use on a large scale. Both starch and sugar form the starting point of much of the chemical and biochemical production of platform chemicals, equal to fermentation of sugar in bread, wine and yoghurt.

This is why the most efficient and developed technologies for producing dedicated materials based on biobased raw materials have their basis in sugar. The use of woody biobased raw materials, based on lignocellulose, requires additional pre-processing stages and changes to the production process. This slows down industrialisation, increasing the costs per product.

The availability of biobased raw materials for energy and the chemical industry will therefore very much depend on choices made in the use of agricultural land and the availability of land and water. The Dutch Sustainability Framework for Biobased Raw Materials sets out sustainability criteria based on those in the Renewable Energy Directive, which apply to the application of biobased raw materials in the chemical industry.

Sustainable biobased raw materials are scarce. Their use in the chemical industry competes strongly with their use for biofuels, energy and also negative emissions in the future. This competition is currently driven by policy incentives that encourage the use of biobased raw materials for biofuels and energy, while incentives for their use in the chemical industry are still lacking. However, there is potential for synergy in the production of biofuels and biobased raw materials for the chemical industry. Similar to how oil refinery produces petrol, diesel, naphtha and asphalt, the refining of woody materials can produce a portfolio of pulp, feedstocks for the chemical industry and biofuels. Cascading principles will be essential in order to ensure the highest possible value can be gained from the biobased raw materials. Coproduction of biobased raw materials and basic chemicals can also lead to improvements in efficiency and economic benefits.¹¹⁸

¹¹⁷ Microsoft Word - Veelgestelde vragen over biobrandstoffen.doc (wur.nl).

¹¹⁸ IEA 2020, Biobased Chemicals, a 2020 update.

CO₂

Currently, around 230 Mt of CO₂ is used worldwide, mainly for the production of ureum (130 Mt) and the extraction of fossil raw materials (80 Mt). In addition, CO₂ is also applied in greenhouse horticulture, the beverage industry and for slaughtering and culling.¹¹⁹

The NPE sets out the long-term aim of using as much non-fossil CO₂ as possible. The availability of biogenic CO₂ in the Netherlands is closely related to the amount of use of biobased raw materials in the production of fuels and in the chemical industry, as well as the extent to which the conversion of these takes place in the Netherlands. The degree to which atmospheric CO₂ can be used for conversion will largely depend on the availability of (large volumes of) renewable energy.

The global potential for biogenic CO₂ from industrial point sources is estimated at 370 Mt per year, sufficient to produce a total of 5.4 EJ in sustainable carbon carriers, providing that sufficient renewable energy is available. Most of this point source potential is located in Europe and America.¹²⁰ However, there are still very few industrial CCU plants. Based on the current project pipeline, around 15 Mt of CCU capacity can be expected worldwide, of which 8 Mt will be for the production of e-fuels.¹²¹ There are no known large-scale projects in the Netherlands, although there are start-ups active, such as Zero Emission Fuels.

By 2050, not all fossil raw materials are expected to have been replaced by renewable sources, while negative emissions are expected to be needed in order to be climate neutral by 2050 and climate negative after that.¹²² If availability of captured biogenic or atmospheric CO₂ from industrial sources, air, or water is limited, competition may emerge between application as a carbon source for the chemical industry and application for the purposes of negative emissions. These interests will need to be carefully balanced and, where possible, opportunities for cross-sector collaboration will need to be capitalized.

In conclusion, the supply of all sustainable carbon sources and the conversion capacity to convert these sources into usable sustainable carbon carriers will be need to be scaled up to meet the anticipated demand. Domestic supply by itself will not be sufficient to meet the demand for sustainable carbon carriers, which means import will also play a key role. Even though the volumes and form of this import remains uncertain, it is likely that because of transport reasons preliminary processing stages (e.g. torrefaction and pyrolysis and possibly also methanol production) will happen close to the source. As a follow-up to the aspiration expressed in the NPE of maximising the supply of sustainable carbon carriers, the Dutch government is working on an action plan for the supply of sustainable carbon carriers (*Actieplan Aanbod Duurzame Koolstofdragers*, AADK). This plan aims to increase the availability and security of supply of sustainable carbon carriers for all sectors where there is still expected to be a need for sustainable carbon carriers in the future.

¹¹⁹ [CO₂ Capture and Utilisation - Energy System - IEA.](#)

¹²⁰ [Global Availability of Biogenic CO₂ and Implications for Maritime Decarbonization](#), Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping.

¹²¹ [CO₂ Capture and Utilisation - Energy System - IEA.](#)

¹²² [Trajectverkenning Klimaatneutraal, PBL.](#)

7 Funding

The challenges in the transition to a climate-neutral and circular carbon chemistry are significant, both in terms of the knowledge and technology as well as for the funding required for new plants and processes. In the ideal scenario, a transition will only cost money during the process of the transition itself, but the operational costs will be systematically lower when the transition has been completed. However, in the case of the raw materials transition, the systematic operational costs for the sector are expected to be higher in many cases.¹²³ In order to ensure a successful transition for the sector, sustainable and economically viable business models will be essential, which is why this area demands specific focus.

7.1 Public funding

An assessment of the opportunities within public funding primarily shows that there are piggybacking opportunities within the use of existing grants and subsidies. This is thanks to the Netherlands (and Europe) having a wide-ranging subsidy landscape with funding opportunities for innovation and process technologies in different phases of the Technology Readiness Level (TRL), see **Table 3**. Additionally, there are also other opportunities for financial support that increase the access to private funding, such as the Business Loan Guarantee Scheme (*Garantie Ondernemingsfinanciering*, GO).¹²⁴ The GO makes it possible for banks to obtain a 50% state guarantee on loans and bank guarantee facilities from €1.5 million to €150 million. This enables companies to secure funding that would otherwise not have been possible. Credit facilities are a third possibility, such as the Innovation Credit (*Innovatiekrediet*).¹²⁵ This is intended to boost innovative development projects that involve technological risks that have market potential.

Table 3: Selection of the grants and subsidies available in the Netherlands and Europe for the different raw material sources for the transition to sustainable carbon in the chemical industry

Subsidy	Secondary raw materials	Biobased raw materials	CO ₂ as a raw material	TRL
Topsector Energy – Industry Studies Scheme (<i>Regeling Topsector Energiestudies Industrie</i>)	✓	✗	✓	2-6
Energy and Climate Research and Development subsidies (<i>Energie en Klimaat Onderzoek en Ontwikkeling</i>)	✗	✓	✓	3-6
Mission-driven Research, Development and Innovation Scheme (MOOI/ <i>Missiegedreven Onderzoek, Ontwikkeling en Innovatie-regeling</i>)	✓	✓	✓	4-6
SME Innovation Stimulus for Regional and Top Sectors (<i>nMkb-innovatiestimulering Regio en Topsectore</i>)	✓	✓	✗	4-6
MOOI: Biobased Circular	✗	✓	✗	4-7
Public-Private Partnership Allowance for R&D (<i>Publiek-private samenwerking programmatoeslag</i>)	✗	✓	✓	4-8
DEI+ (Energy and Climate Innovation Demonstration Scheme (<i>Demonstratie Energie- en Klimaatinnovatie</i>))	✓	✓	✓	6-8
Green Projects Scheme - Category 3.2 (<i>Regeling Groenprojecten - Categorie 3.2 Grondstofbesparing</i>)	✓	✓	✗	6-9
Accelerated Climate Investments in Industry Scheme (<i>Versnelde Klimaatinvesteringen Industrie, VEKI</i>)	✓	✓	✓	7-9
Horizon Europe programme	✓	✓	✓	3-9
Innovation Fund	✗	✓	✓	8-9

¹²³ Zibunas, et al. (2022). Cost-optimal pathways towards net-zero chemicals and plastics based on a circular carbon economy. *Computers & Chemical Engineering*, 162. <https://doi.org/10.1016/j.compchemeng.2022.107798>.

¹²⁴ *Garantie Ondernemingsfinanciering (GO)* | RVO.nl.

¹²⁵ *Innovatiekrediet* | RVO.nl.

There are also existing tax allowances, such as the Energy Investment Allowance (*Energie-investeringsaftrek*, EIA) and the Environmental Investment Allowance (*Milieu-investeringsaftrek*, MIA) and the Arbitrary Depreciation of Environmental Investments (*Willekeurige afschrijving milieu-investeringen*) (Vamil) scheme.^{126, 127}

Lastly, through its central government procurement policy, the government can serve as launching customer. In the material transition, there will need to be a combination of public and private funding. Public funding alone will not be sufficient and also has its shortcomings, relevant examples of which are mentioned in [Chapter 7.2](#).

7.2 Private funding

Securing private sector funding is complex because private providers of funding demand a level of certainty that is difficult to guarantee at the start of a transition. Funding is also mainly targeted at investment costs (CAPEX), but the funding opportunities that focus on covering the operational costs (OPEX) arising from sustainable production are highly limited at this moment. For private funding of sustainable carbon in the chemical industry, various factors are important, including access to funding, market opportunities and the legislative framework.

7.2.1 Access to funding

In the transition to a sustainable carbon chemical industry, there are various financial challenges involved in converting existing chemistry and the development of the new chemistry. Research shows that the Netherlands excels when it comes to start-ups, but has a less impressive record for scale-ups.¹²⁸ In other words, the Netherlands is very good at product development, but companies struggle with market introduction and scaling up. This is blamed on reticence among investors caused by complex regulations and poor insight in the risks involved. In order to successfully commercially develop start-up and scale-up innovations, suitable funding would ideally be available in every TRL phase.¹²⁹ Currently, access to and the provision of funding varies in each TRL phase. Funding for late-phase scale up (TRL 7 to 9) remains a challenge. Combined with a lack of market demand (see [Chapter 7.2.2](#)), start-ups and scale-ups see this as an obstacle, exposing them to the risk of going bankrupt or be acquired by foreign companies. Especially when looking at the large ticket sizes of the funding required, it is desirable to provide an additional boost to venture capital for start-ups and scale-ups. This will give new companies the opportunity to develop in the Netherlands, which will secure its future earnings potential. As part of the Ministry of Economic Affairs' new sectors policy, an investment agenda has been developed for the chemical sector for pilot and demonstration projects wanting to make a final investment decision between now and in three years' time¹³⁰. This agenda is also intended to provide input for conversations in Brussels, including with the European Investment Bank.

The existing chemical industry owns very capital-intensive, mainly fossil-related assets. If competitiveness worsens and costs continue to increase (see [Chapter 5.2](#)), many of these assets risk becoming 'stranded assets' and losing their value. This uncertain future makes investments difficult. This means that, even in the existing industry, market demand creation also plays an essential role in stimulating investment certainty.

Access to funding can additionally be increased for both existing and new companies by providing greater certainty with regard to the supply of affordable sustainable raw materials. Providers of funding often demand (multi-year) feedstock contracts as a condition for investing in new plants. Standardisation of raw material streams reduces dependency on few raw material suppliers, increasing access to funding. It is equally important that the economic benefits resulting from sustainable production, come back to the link in the value chain where the investment for the sustainable production has been made. This will help to stimulate sustainable investments, while keeping the additional costs for the end-consumer

¹²⁶ [Energie Investeringsaftrek \(EIA\)](#).

¹²⁷ [Mia en Vamil | RVO.nl](#).

¹²⁸ [Building a world-class Dutch start-up ecosystem | McKinsey](#).

¹²⁹ [Technology Readiness Levels \(TRL\) | RVO.nl](#).

¹³⁰ [Investeringsagenda-Innovatieve-Chemie-oktober-2025.pdf](#).

limited to the additional costs of (processing) on the basis of sustainable raw materials. For the purpose of pilots and new plants, the prerequisites will also need to be in place to provide the certainty investors need. Examples of these are certainty in regard to affordable energy (infrastructure) such as electricity and hydrogen, and availability of both physical and environmental space.

7.2.2 Market opportunities and demand creation

Currently, the costs of producing products based on sustainable carbon are higher than the costs of producing fossil-based products. This is mainly because sustainable raw materials require more stages of processing to prepare them to be used in existing processes. In addition, new techniques and technologies have not yet been able to benefit from the advantages of scale and technical optimisation that fossil production processes have seen in the last decades. These higher costs have an impact on price competitiveness and therefore, on demand for these products.

As indicated, private investors require certainty. Sufficient market demand, is a very important factor in this context. The purchase of sustainable carbon products is currently a voluntary choice. This means that the potential market is limited to those buyers willing to pay a 'green premium'. As a result of this, higher costs cannot sufficiently be passed on to the customer, making investments non-viable and deterring investors from investing. This means that creating market demand will play a key role in achieving investments and the scale up of green production.¹³¹ By using policy to create market demand, the price of sustainable chemicals and plastics can be decoupled from the price of fossil chemicals and plastics, which are currently still cheaper. This could result in a viable business model for facilities using sustainable carbon in the chemical industry and provide investment security to investors. When new sustainable technologies achieve sufficient scale, they can bring the market to a tipping point, after which the sustainable technology becomes the most favourable route. In using policy to stimulate market demand in this way, it will be important to achieve a level playing field as far as possible by implementing incentive measures at European level, rather than a national level. However, as long as there is no market demand or willingness to pay for sustainable products, sustainable business models will be unlikely to take off and the necessary investment will fail to materialise.

Recent research by CE Delft showed that it is important to create demand at European level by means of green blending mandates. The recommendation is to implement these measures in ongoing European policy initiatives in order to further develop standardisation at product level, with step-wise increasing blending targets. It is also argued that sustainable public procurement by (central) government could be of significant value¹³².

7.2.3 Regulatory framework

Predictable regulation is essential in order to provide certainty for investors. Frequent changes to the legislative framework are seen as obstacles to funding because they make it difficult to assess risks. Frequently cited examples include the high number of obligations for businesses, complexity of the legislative framework, strict requirements and standards, and the length of permitting procedures. The latter is particularly relevant for scale-ups. Risks are difficult to assess for investors if there are multiple regulatory frameworks. The chemical industry has to apply by environmental policy (including those relating to nitrogen emissions, waste and REACH), climate and energy policy (including the Renewable Energy Directive III, Emission Trading System and the CO₂ levy), competition laws and regulations and associated administrative burdens. With this many regulations applying to the chemical industry, the predictability of the legislative framework is even more important when looking for funding. This is compounded by the fact that the chemical industry works on projects with long throughput times and even longer breakeven periods.

The development of a sustainable carbon value chain will involve significant financial challenges for the sector. There is a need for security with regard to access to funding. This can be improved by creating market demand and providing a clearer and more predictable legislative framework.

¹³¹ EU biorefinery outlook to 2030 - Publications Office of the EU ([europa.eu](https://europea.eu)).

¹³² Groene bijmengverplichting Europese basisindustrie – CE Delft 2025.

8 Implementation

In order to ensure that this vision provides well-founded guidance for the raw materials transition in the chemical industry, careful management, a consultative structure with clear governance, involvement of public and private stakeholders and monitoring, will all be essential. This chapter takes an initial proposal for these aspects.

8.1 Policy and implementation agenda

[Chapter 4.2](#) set out the key principles that the Dutch government is applying when shaping policy in order to bring about the raw materials transition in the chemical industry. The government's approach that has been formulated based on these, will be further developed in a policy and implementation agenda outlining actions that the government and private players will take in order to scale up the use of sustainable carbon in the chemical industry over the next five years. This agenda will link with the future vision for the chemical sector (KGG). The Dutch government expects to publish its policy and implementation agenda next year.

8.2 Annual stakeholder progress dialogue

This vision has been developed with the involvement of large numbers of stakeholders who represent different parts of the sector and value chain: existing industry and new industry, the agricultural industry and waste sector, multinationals, start-ups, knowledge institutions and NGOs. The involvement of this large group of stakeholders has helped to ensure that the raw materials transition in the chemical industry has been assessed from multiple perspectives. In moving forward, it will be essential to involve the entire sector and value chain in future discussions. For this reason, an annual progress dialogue will be organised in order to evaluate whether sufficient progress has been made, the right actions have been taken and to discuss where parties have faced setbacks or have specific needs. Based on this progress dialogue, an assessment can be made as to whether further adjustments are necessary. The annual progress dialogue will also consider the knowledge development necessary to achieve this transition.

8.3 Periodic updating

This vision and the policy and implementation agenda will be monitored, evaluated and updated as part of the NPE policy cycle. By adhering with this cycle, any developments in the carbon value chain and the energy system that are discussed as part of the NPE can be taken into account in updating this vision. This will also strengthen government coordination in terms of achieving the set targets and will link in with existing monitoring and accountability processes. This will involve the following:

- **Annual monitoring and evaluation:** the House of Representatives will be updated annually by the Dutch government on progress in realising the NPE and on adjustments required (when possible) in the Energy System Monitor and the Energy Memorandum. In addition, the National Programme for Sustainable Industry (NPVI) offers a clear overview of the milestones and timelines for decarbonising Dutch industry and will also include actions from the policy and implementation agenda. In order to keep track of progress in the raw materials transition in the chemical industry, there will be links with these monitoring documents and those focusing on waste and reuse.
- **Quinquennial evaluation and update:** the NPE will be updated at least every five years in order to enable interim adjustments to be made. Just like the NPE cycle, this vision and associated policy and implementation agenda will be updated at least every five years in order to take account of new developments and insights. Where required, the policy and implementation agenda can also be updated in the meantime.

Appendices

Appendix 1: Explanation of public interests set out in the NPE

Sustainability is about the attempt to remain within the planetary boundaries and protect the natural and economic capital for future generations. The Dutch government is committed to *combating climate change* with a stringent pathway for phasing out greenhouse gas emissions. This is not only necessary based on natural capital, now and here, later and elsewhere, but also based on economic capital and health. Alongside combating climate change, the *circular use of raw materials* can also contribute to countering the loss of biodiversity, preventing pollution of the human environment and contributing to improving security of supply. These different aspects of sustainability can reinforce each other, but can also work against each other. For further details, see [Chapter 5.3](#).

Reliability is about security of supply and robustness of access to raw materials for the chemical industry and the products that it produces for wider society. Although the market itself has an important role to play in this, the government can also make efforts to improve reliability. It is important to have sufficient *security of supply* with regard to raw materials and products, especially those that we cannot provide ourselves. In determining the strategic dependencies, importance for society and the level of vulnerability of access to raw materials and products are key factors. For *robustness* it is important to focus on diversification of sources and raw material streams as well as flexibility and exchangeability in value chains and chemical complexes.

Affordability is about ensuring tolerable *social costs for society* as a whole and tolerable *product costs for end-users*. The raw materials transition will require effort from society (companies and government) to upscale (new) processes and build infrastructure with the associated major investments needed, as described by TNO¹³³. Ultimately, these costs will most likely end up with the end-user or citizen. This is why it is important also to take into consideration the economic costs of different alternative routes in the raw materials transition. In this, higher products costs for producers need not necessarily lead to significant price increases for consumers¹³⁴. Affordability also relates to a significant extent to fairness, see the next page.

First and foremost, **safety** is about minimising *safety risks* for people and the environment. The production and use of chemicals involves risks, which will of course not disappear when fossil raw materials are replaced by sustainable ones. Moreover, new product routes and materials can also introduce new safety risks. In the raw materials transition, it will also be important to focus on producing both sustainable and safe products and materials, see also [Chapter 5.3](#).

The public interest **quality of the human environment** is about the spatial impact of the energy system, the *quality of the environment and immediate surroundings*. A sustainable chemical industry will place demands on space and two systems will run concurrently during the transition, placing additional pressure on space. This must be carefully balanced against other (growing) claims on space. Research is currently being conducted in the framework of the Spatial Planning Memorandum into the spatial impact of the energy and raw materials transition in the industry. The Dutch government aims to protect the quality of the (human) environment and where necessary bring about improvements. The transition to sustainable carbon can also result in an improvement to the quality of the human environment, but can also introduce risks. This is explained in more detail in [Chapter 5.3](#). It is important to emphasise that the impact on the quality of the human environment may be felt close to home, but also further away (e.g. because of plastic in oceans).

Participation refers to the way in which stakeholders *are involved in decisions* about the raw materials transition in the chemical industry. The raw materials transition is a transition in society that affects

¹³³ Fossil-free energy system and the chemical industry in the Netherlands - TNO 2025.

¹³⁴ [How the plastics industry can function without fossil fuels – and at what cost | articles | ING Think](#).

everyone: from separating waste streams at home to changes in the infrastructure. It is therefore important to have input from different stakeholders. During the transition itself, this input must also be able to lead to adjustments. [Chapter 8](#) describes in concrete terms how this will be shaped in this vision.

Fairness is about the issues of distribution that emerge from the raw materials transition in the chemical industry and as part of the future chemical supply chain. When considering the principle of *fair global distribution* the Dutch government is looking to achieve a ‘reasonable’ allocation of responsibilities between countries for resolving global issues and a ‘reasonable’ allocation of globally available resources. This means that there are limits to the claim that the Netherlands wishes to make on the globally available supplies. At European and domestic level, the government is committed to a *fair distribution of benefits and burdens*. For this purpose, various principles can be applied, such as the ‘polluter pays’ principle, the cost-by-cause principle and the solidarity principle. The aim is to ensure that the burdens are reduced when negative societal impacts are caused in order to ensure that everyone can participate, even those who struggle.

Economic strength is about (future) *earnings potential* for the Netherlands, *high-quality employment* and *good incomes* for Dutch people. In order to keep public amenities and purchasing power up to standard, economic growth will remain important for the Netherlands. Through green growth, we aim to achieve a *sustainable and innovative economy* that is continually reducing its reliance on fossil fuels and raw materials. The raw materials transition offers opportunities for economic growth and future competitiveness. Moreover, the *development of strategic sectors* is increasingly important in terms of contributing to a strategically positioned, competitive European economy. This will involve a focus both on sectors that reduce our vulnerability to geopolitical shocks and sectors where we can gain innovative advantage. The chemical industry can play an important role in both of these.

Appendix 2: Opportunities and risks in the transition to sustainable carbon

With its strong knowledge position in process technology, material science, biotechnology and catalysis, there are significant opportunities for the Dutch chemical sector in the three transitions required.¹³⁵ In view of the long lifespan of chemical plants and the major investments needed for conversion and development, it makes sense to address these transitions simultaneously. In addition to (synergy) opportunities, there are also risks in the transition to the use of more circular raw materials for the other transitions.

The use of secondary raw materials can significantly contribute to reducing CO₂ emissions. First of all, less CO₂ is released during the production process, because recycling can be more energy efficient than the production of new (virgin) plastic.¹³⁶ Secondly, recycling prevents the need for incineration at the end of the lifespan, which is associated with CO₂ emissions. Mechanical recycling of plastic recycle rather than producing plastic from primary fossil carbon sources brings about a 3 kg CO₂-equivalent reduction for every kg of plastic on average.¹³⁷ An industry fully committed to recycling also helps to minimise plastic leaking into the environment through litter. After all, the producers have a strong need for plastic waste. Despite this, there are inherent limitations to recycling: more raw materials are consumed than released through recycling because of efficiency losses, losses in the environment or because recycling is technically impossible in some cases (e.g. paint or detergent). This means that strategies higher up the R-ladder will be needed, such as reuse and reducing demand, but also other sustainable raw materials, such as sustainable biobased raw materials and CO₂, to replace fossil carbon.

The recycling of carbon avoids certain environmental risks from processing primary fossil raw materials, but some environmental risks remain to an equal extent and other specific new risks also occur. Just as in processing primary fossil raw materials, recycling also involves environmental risks. Similarly to the production of new plastic, the recycling of plastics leads to the spreading of micro-plastics and other substances of high concern in the air and water. This is because plastics can contain substances of (very) high concern that are damaging to humans and the environment. Through recycling, these substances of concern can remain 'in the loop' and end up in the environment and human body. If a plastic cannot be safely recycled or reused, it must be destroyed. Until now, this has meant incineration. When recycling techniques such as solvolysis, pyrolysis and gasification become available, it will be possible to recycle (seriously) contaminated plastic waste streams. Despite this, it is (with the exception of gasification) technically unavoidable that residues will be produced that are not suitable for recycling or gasification and therefore need to be incinerated or disposed of in landfill.

There are increasing numbers of alternative chemicals and plastics being developed based on biobased raw materials, that have a positive effect on the climate and the environment.¹³⁸ In addition to the emissions avoided, some processes for producing biobased plastics require less energy than those for virgin fossil plastics. Moreover, biobased raw materials can be used to obtain safer alternatives for chemicals made from crude oil.¹³⁹ For example, not all biobased plastics are biodegradable, but when biodegradable products are used in applications where there is a real risk of emission to the environment, this reduces micro-plastic leakage, as in the case of paint.¹⁴⁰

The use of biobased raw materials also involves some risks. The production of biobased raw materials can require additional land use and therefore exacerbate loss of biodiversity, soil degradation and greenhouse gas emissions. The cultivation of biobased raw materials can also contribute to acidification

¹³⁵ [De Nationale Technologiestrategie | Titel uitgave \(overheid.nl\)](#).

¹³⁶ Not every recycling process is more energy efficient than the production of virgin plastics (e.g. pyrolysis). Where possible, it is therefore important to use recycling processes that are more energy efficient, such as mechanical recycling and for renewable energy sources to be used.

¹³⁷ [CEDelft_220327_CO2-winst_met_kunststofrecycalaat_DEF.pdf \(cedelft.eu\)](#).

¹³⁸ https://ce.nl/wp-content/uploads/2023/04/CE_Delft_22021_Sustainability_of_Biobased_Plastics_Def.pdf.

¹³⁹ [Biobased alternatieven voor prioritaire stoffen \(rivm.nl\)](#).

¹⁴⁰ <https://www.rivm.nl/bibliotheek/rapporten/2016-0026.pdf>.

and eutrophication. It will therefore be important to focus the production of biobased raw materials as much as possible on hybrid applications and only to use sustainably cultivated biobased raw materials whilst also providing incentives for the reuse and recycling of biogenic waste and residual streams. The sustainable cultivation of biobased raw materials also offers opportunities for decarbonising agriculture. The use of biobased raw materials is subject to the Sustainability framework for Biobased Raw Materials.¹⁴¹

One area of concern for every new type of plastic, including biobased plastics, is the fact that sorting systems for plastic waste will need to be adapted for them. Until this happens, there will be a risk that streams of mixed plastic waste become unsuitable for recycling and must be incinerated. This can also create challenges in the transition to a circular plastic supply chain.

In the long-term, using CO₂ via Carbon Capture and Utilisation can contribute to CO₂ reduction, if sufficient renewable energy is available. Gasification in combination with CCU can be an interesting solution for maintaining carbon in the supply chain, where there are no opportunities for recycling and this would otherwise lead to emissions. Compared to the processes mentioned above, many CCU processes place greater demands on the energy system through their high energy consumption. The import of synthetic carbon carriers (e.g. synthetic methanol) from countries with larger surpluses in sustainable energy may also be a potential alternative.

Replacing fossil raw materials by secondary raw materials, sustainable biobased raw materials and CO₂ involves various advantages and disadvantages. It is important to prevent or mitigate detrimental impacts as far as possible. In addition to the use of sustainable carbon as a raw material, the chemical sector will also need to switch to non-fossil energy sources for its energy consumption for the three transitions and for the purposes of the overarching environmental challenge, companies will need to limit their emissions into the air, water and environment.

¹⁴¹ [Kamerbrief over duurzaamheidskader biogronstoffen | Kamerstuk | Rijksoverheid.nl](#).

Colophon

The **‘Vision on sustainable carbon in the Dutch chemical industry’** is a publication of the Ministry of Infrastructure and Water Management and the Ministry of Climate Policy and Green Growth.

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