SYSTEMIQ

Fossil Free Plastics

EXECUTIVE SUMMARY

Driving Clean Industrial Leadership in Europe

MAY 2025

Preface

Plastics play a central role in our daily lives and our modern economy. They also bring three inter-linked challenges: 1) how to reduce plastic waste and pollution through circular economy strategies, 2) how to decouple plastics from fossil carbon and achieve the goal of a net-zero emissions economy by 2050, and 3) how to strengthen the competitiveness of the European plastics industry in a challenging global market.

In recent years, Systemiq has built system models of global and regional plastic flows containing environmental and socio-economic impacts, and published scenario analyses to inform strategic choices for the future of plastics. Our previous system modelling studies (notably ReShaping Plastics and Planet Positive Chemicals) have shown unequivocally that circular economy strategies have a critical role to play in a sustainable plastics system, but new "virgin" plastics will also be required to meet societal needs. Methanol-to-Olefins (MTO) technology was highlighted in these studies as a viable pathway to produce fossil-free virgin plastics at scale. MTO enables the production of standard-grade plastics using renewable carbon and green hydrogen, while offering full traceability compared to mass balance approaches, alongside compatibility with existing infrastructure and product standards. Pioneering this novel approach to plastics manufacturing in Europe could help to reinvigorate a beleaguered European plastics industry.

This report draws on data analysis and systems modelling to evaluate the role of fossil-free plastics via MTO in a future sustainable plastics system. While no solution is without limitations, our findings suggest that this approach could deliver significant emissions reductions, reduce reliance on fossil feedstocks, complement circularity strategies and support industrial competitiveness in a decarbonising global economy. Importantly, it underscores the unique potential for plastics system stakeholders to become proactive agents of carbon stewardship, managing scarce carbon resources more responsibly across the lifecycle, and potentially sequestering more carbon than they emit. The evidence indicates that this approach merits serious consideration as part of the policy and investment agenda for the sector's transition. As ever, we would welcome your feedback on our analysis and our recommendations.

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About this publication

About the study

This report has been prepared by Systemiq as an independent study, building on internal system modelling, previous publications, and new analysis to explore the potential role of the bio-methanol-to-olefins technology pathway in a sustainable plastics system. While funded by Vioneo, the report reflects Systemiq's own perspective and has been developed with editorial independence. The analysis and conclusions are data-driven and grounded in Systemiq's wider theory of change for the sector. Insights have also been shaped through engagement with a diverse expert panel, including voices from industry, academia and civil society, to ensure a broad and balanced perspective. The views presented here remain those of Systemiq.

About Systemiq

Systemiq is a systems change company that works with businesses, policymakers, investors and civil society organisations to reimagine and reshape the systems that sit at the heart of society - energy, nature and food, materials, built environment, and finance - to accelerate the shift to a more sustainable and inclusive economy. Founded in 2016, Systemiq is a certified B-Corp with offices in Brazil, France, Germany, Indonesia, the Netherlands, and the UK.

Find out more at www.systemiq.earth or via LinkedIn. To access the full report, 'Fossil Free Plastics', visit www.systemiq.earth/FFP

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Report design

Yesify

Endorsements

> In a truly circular economy, the use of plastic is decoupled from the consumption of finite resources. While this decoupling should happen in the first place through reducing the use of virgin plastic, it's also important that over time any remaining virgin inputs shift to renewable feedstocks where environmentally beneficial. This is not just my view but that of over 1,000 organisations around the world who have endorsed the common vision of a circular economy for plastics in the Global Commitment. This important new report reinforces this vision and the need for renewables to be part of the picture to achieve decoupling from finite resources. It shows how fossil-free plastics produced via MTO, using renewable feedstocks and clean energy, can be an important pathway to bring this vision one step closer.
>
> **Rob Opsomer**, Executive Lead, Plastics & Finance, Ellen MacArthur Foundation

> This report makes clear that all solutions are needed to work towards a low carbon and circular European plastics system, including plastics made from green methanol, and this must be recognised in EU policy. Clear definitions, robust sustainability criteria, and early policy signals—well before 2030—are essential to provide industry with the certainty and incentives needed to act decisively and secure Europe's leadership in this transition.
>
> **David Carroll**, Director of External Affairs, Plastics Europe

> All scientific studies on a future circular plastics system indicate that a significant share of virgin feedstock will still be needed. Preferably, this is not fossil based, and MTO can make a valuable contribution to meeting that demand.
>
> **Prof. Kim Ragaert**, Chair of Circular Plastics, Maastricht University

> Transitioning to sustainable plastic production—especially via scalable methods like methanol-to-olefins—is vital for Europe's climate goals. This commendable study powerfully illustrates how plastics, when paired with circular strategies and fossil-free feedstocks, can shift from being climate problems to climate solutions, delivering significant environmental, economic, and policy advantages.
>
> **Lars Börger,** CEO, Nova-Institute

> Using renewable and low-emission methanol for plastic production is one key technology to achieve net zero. The report is well aligned with other studies conducted for global associations and chemical companies.
>
> **Raoul Meys**, Managing Director and co-Founder, Carbon Minds

> This report reminds us of the urgency to act to make the plastics sector future proof. It makes clear how fossil free plastics based on sustainable renewable feedstock can complement circular strategies to defossilise the sector. Beyond convincing modelling and clear limits on sustainable biomass use, it also proposes policy interventions to secure investments and galvanize a fossil-free chemicals industry in Europe. These are goals that simplification and deregulation alone may not fulfil.
>
> **Stéphane Arditi**, independent expert on circular and bio economy, climate and industry.
> Former co-director of a major European civil society organisation

Executive summary

1 Most plastics today are produced from fossil feedstocks and used once before disposal, creating an emission-intensive system which will continue to escalate towards 2050.

Plastics play a vital role across modern economies, from keeping food fresh and supporting healthcare, to construction and transportation. However, the chemicals and plastics sector currently drives 4% of global greenhouse gas (GHG) emissions and is on track to grow this share significantly over the next years.

In Europe, nearly 80% of plastics are produced from virgin fossil feedstocks, and only 19% from recycled fossil materials and 1% from bio-based feedstocks, with most plastics incinerated after a single use. Recent studies have shown that producing fossil plastics and then burning them in waste incineration plants emit up to five tonnes of CO_2 equivalents (CO_2eq)[1] per tonne of plastic over their lifecycle. This is higher than previously estimated due to improved tracking of upstream methane emissions, a powerful greenhouse gas released in oil and gas extraction and production. With this current system, plastic production and disposal in Europe alone is on track to increase emissions by a further 40 million tonnes of CO_2eq per annum by 2050.

~80%
of plastics are currently produced from fossil feedstocks

40 Mt CO_2eq
projected annual emissions increase in Europe by 2050

2 Even in a highly circular European plastics system, half of all market demand (28 million tonnes per year) would likely still be required from virgin sources.

To make our use of plastics sustainable, it is crucial to use fewer resources and get more value out of the plastics we do use. System modelling and scenario analysis suggests that ambitious yet realistic measures for reduction, reuse, and substitution could lower plastic demand in 2050 by up to 20% (a reduction of approximately 15 million tonnes) compared to a business-as-usual scenario. However, even in the most optimistic circularity scenario, recycling would only produce half of the plastic required to meet this system demand annually, meaning **Europe will likely still require around 28 million tonnes of virgin plastic in 2050.**

28 Mt
of virgin plastic demand in Europe in 2050

Therefore, decoupling from fossil feedstocks and achieving "defossilisation" is the other essential part of creating a future plastics system that does not add to net GHG emissions.

1 CO_2 equivalents: standard unit of measurement used to measure the environmental impact of one tonne of greenhouses gases (carbon dioxide, methane, nitrous oxide, fluorinated gases) vis a vis one tonne of CO_2.

3 Fossil-free virgin plastics made from renewable carbon are a critical pillar of a circular, net-zero aligned plastics system. Established "reduce-reuse-recycle" circular economy strategies and efforts to reduce emissions from fossil-based plastics are essential, but not sufficient on their own to align the system with Europe's net-zero targets.

Fossil-free virgin plastics are manufactured from renewable sources of carbon (atmospheric carbon from biomass or direct air capture). System modelling carried out for this study focuses on the use of Methanol-to-Olefins (MTO) technology to produce polyethylene and polypropylene plastics from green methanol (based on renewable carbon and green hydrogen), creating identical, fully recyclable products compatible with today's systems. This MTO pathway is segregated, thus does not rely on mass balancing or mixing of fossil-free and fossil feedstocks, enabling greater transparency for customer assurance.

Fossil-free plastic production via this MTO pathway can **reduce emissions by 5–7 tonnes of CO_2eq per tonne of plastic production**, based on a -1/+1 carbon accounting methodology. At a system level, this provides the opportunity for negative emissions from the plastics system, moving carbon from the atmosphere into durable plastics or long term sequestration.

5–7 tCO_2eq
reduction in emissions per tonne of plastic production via the MTO pathway

Without intervention, the **European plastics system's emissions could rise to 180 MtCO_2eq annually by 2050.** In a highly circular system, fossil-free plastics can make up to ~30% of production (~15 Mt), compensating for residual emissions from fossil plastics production and recycling and drive the European system to net zero emissions overall. In combination with circular economy strategies, the transition from fossil-based to fossil-free plastics would avoid 180 MtCO_2eq of emissions annually by 2050.

The success of this transition hinges on securing **high-integrity, sustainable biomass (e.g. agricultural residues) and captured biogenic CO_2 feedstocks,** as global demand for these resources is expected to outstrip supply by up to 10–20 times. Scaling circularity alongside fossil-free plastics is essential to achieve a resource efficient system, and justify the use of scarce available sustainable biomass for plastics production by almost halving feedstock requirements.

Furthermore, a strategy that combines fossil-free production with high levels of recycling and careful management of carbon all along the value chain is less dependent on any single new technology. This integrated approach reduces the overall risks involved in making the big shift to a net-zero emissions plastics system.

4 At scale, fossil-free plastics could be cost-competitive with fossil production, if carbon costs are factored in, and would deliver multiple socio-economic benefits to the system.

Currently, virgin fossil-based plastics are undeniably cheaper to produce at scale, in part because full lifecycle emissions and other externalities are excluded from their costs. However, the cost of green methanol is expected to decrease, and the technology in the MTO production pathway is advancing. Both factors will make fossil-free polyolefin plastics (polyethylene and polypropylene) increasingly affordable. At scale, the cost of producing fossil-free olefins could drop by 30–50%. This could result in cost parity with fossil-based olefins in the region of €2,000/t olefins when future carbon costs are included. Scaling the MTO value chain in Europe could also drive €30–40bn capex investment, provide new opportunities for suppliers to meet up to 40Mt of new green methanol demand per annum and contribute up to 50,000 direct and indirect jobs, which can protect the domestic workforce from deindustrialisation pressures in the chemicals and plastics sector.

–30–50%
potential reduction in the cost of producing fossil-free olefins by 2050

5 Scaling fossil-free plastics has broader strategic implications for European clean technology leadership, industrial resilience and competitiveness on a global stage.

For offtakers, fossil-free plastics match the performance of virgin fossil plastics, meeting strict specifications without constraints of mechanically recycled plastics. They can offer clear scope 3 emissions cuts that help companies meet their net-zero targets, in line with the Science Based Targets initiative (SBTi) Corporate Net-Zero Standard[2]. Fossil-free plastics offer segregated supply and full traceability, offering advantages over other bio-based or recycled plastics that rely on mass-balancing.

For the EU chemicals and cleantech sector, fossil-free plastics offer a scalable, proven abatement route, helping Europe's chemical sector transition competitively and with lower risk. Fossil-free plastic scale up can unlock synergies in other adjacent sector transitions such as aviation, shipping, fertiliser and agriculture via scale up of renewable energy, electrolyser capacity and high-integrity sustainable biomass supply chains. Early investment would allow Europe to leverage its technological lead, export clean technology capabilities and intellectual property, and reinforce its **industrial geo-political autonomy.**

6 Industry players are investing to scale fossil-free plastic production in Europe, but require early adopter customers, bold industrial strategy with definitive policy signals, clear market foundations and structural market support to develop a mature market.

Much of the technology and supply chain for fossil-free plastics is ready, with first-of-a-kind projects in Europe nearing final investment decisions. To demonstrate **first projects at commercial scale, early adopter customers must be mobilised** that recognise the strategic advantages of being a first mover. In parallel, **decisive industrial strategy is required to send clear demand signals** to the broader market, stating clearly that fossil-free plastics will be a central element of future plastics policy in Europe.

In the near term, clear market foundations are required to build market confidence and demand, including a legal definition of green methanol based plastics in key policies, as well as harmonisation of accounting methodologies to recognise and fairly value the benefits of fossil-free plastics. In turn, value chain players need to align internally and collectively advocate externally for an enabling policy environment for fossil-free plastics, as well as potentially explore innovative value chain partnership models to redistribute commercial risk and cost.

The technology is ready, mobilising pioneer customers is now essential to unlock the first wave of commercial-scale production

In the medium term, structural support is required to overcome market failures and reshape the European value chain for scale. This includes creating **stronger demand** by setting clear targets and requirements in upcoming plastics policies. These should encourage or mandate the use of fossil-free alternatives. Europe should also **create a level playing field** between fossil-free plastics and more emissions-intensive products, both domestic and international. In parallel, **new market structures for public funding** are needed to overcome high initial costs of production and mitigate uncertainty on value chain revenue, price fluctuation and counterparty risk. If governments show strong leadership with these policies, Europe can protect the future of its chemical industry, reduce its dependence on fossil fuels, and become a world leader in producing green materials.

2 The SBTi draft Corporate Net-Zero Standard v2.0 emphasises the importance of actions that can be fully traced through the corporate value chain using credible chain of custody models including identity preservation, segregation, and controlled blending.

Fossil-free plastics in a circular, net-zero emissions European plastics system

SYSTEMIQ

European plastics system the state of play today

54Mt
of plastic demand in the European system today

80%
of plastic produced from virgin fossil feedstocks and only **1%** from bio-based feedstocks, with the remainder from **recycling**

+5tCO2eq
GHG emissions per tonne of plastic produced, (if incinerated)

140 MtCO2eq
GHG emissions per year, rising by 30% by 2050 in a Business-as-usual scenario

A 2050 Integrated Scenario combines fossil-free plastic production with circularity and carbon management along the value chain

-50%
In an integrated scenario, demand for **scarce sustainable biomass resources** is halved due to circular efficiencies

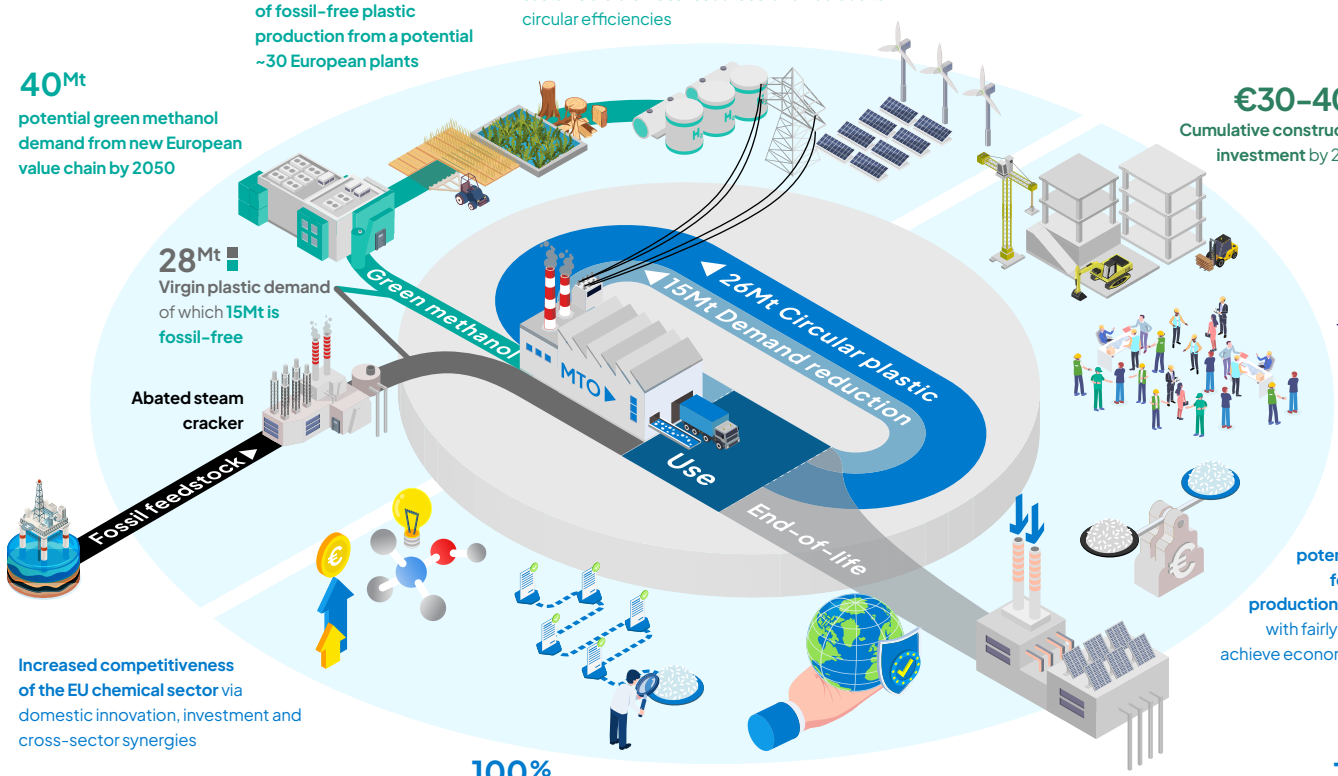
15Mt
of fossil-free plastic production from a potential ~30 European plants

40Mt
potential green methanol demand from new European value chain by 2050

€30-40bn
Cumulative construction investment by 2050

28Mt
Virgin plastic demand
of which **15Mt is fossil-free**

~50k
Total jobs via fossil-free value chains by 2050



30%-50%
potential cost reduction for fossil-free olefin production at scale, combined with fairly pricing carbon, can achieve economic parity with fossil

Increased competitiveness of the EU chemical sector via domestic innovation, investment and cross-sector synergies

100%
Segregated production, making emissions reduction certification simple, with identical quality as virgin fossil plastics

European cleantech leadership can reinforce **geopolitical autonomy**

-85%
Reduction in end of use/life emissions by scaling circularity and CCS on incinerators, combined with fossil-free production, unlocks negative emissions

Infographic is non exhaustive, and for illustrative use only. The assumptions and citation of numbers in this infographic can be found in the main body of the report to substantiate these values.

In an Integrated Scenario in 2050, the European plastics system can achieve net zero with the greatest resource efficiency and lowest transition risk

69Mt
of plastic utility is required by 2050. Circularity measures of elimination, reuse, and substitution reduce demand by 15Mt, leaving 54Mt of plastic needed to deliver the same utility

~50%
of virgin plastics produced from fossil-free feedstocks, equating to ~55%

Up to **-2** tCO2eq
sequestration per tonne of fossil-free plastic cradle to grave, driving 5-7 tonnes of emissions reduction vs fossil plastic today

Net zero
emissions, with residual positive system emissions compensated for by fossil-free negative emissions

To make fossil-free plastics a reality in Europe, four stages to unlock scale are required:

Build first projects by mobilising pioneer customers

Announce bold industrial strategy to establish the relevance of fossil-free plastics in Europe's future

Establish clear market foundations to define and clearly account for the value of fossil-free plastic

Provide structural market support to stimulate demand, level the playing field with fossil and provide public support for early market development

Fossil Free Plastics

Driving Clean Industrial Leadership in Europe

Fossil-Free Plastics: Driving Clean Industrial Leadership in Europe is an independent study by Systemiq examining the potential role of fossil-free plastics – particularly via the methanol-to-olefins (MTO) technology pathway – in building a competitive, circular and climate-aligned European plastics system. Commissioned by Vioneo, the report reflects Systemiq's independent perspective and builds on its previous modelling of plastics and chemicals transitions, where MTO has consistently emerged as a high-potential solution. It draws on new system modelling, data analysis, and input from an expert panel spanning academia and civil society, to assess the emissions impact, scalability, and industrial value of fossil-free production. The report highlights that even in a highly circular European plastics system with widely deployed state-of-the-art recycling infrastructure in 2050, half of all market demand would likely still be required from virgin sources. Fossil-free MTO technology offers a scalable route to meet this demand while cutting emissions, strengthening clean tech competitiveness, and reducing fossil dependence.

Find out more at www.systemiq.earth/FFP
or contact plastic@systemiq.earth

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