RE-carbonizing chemicals — breaking the fossil dependence of products

Sustainable carbon management in Europe

Perstorp

A Subsidiary of PETRONAS Chemicals Group

European industry needs to strengthen its competitiveness in the global market. By taking early market shares in new markets – with a focus on sustainable materials and business models - the climate transition can become a growth engine for the EU. This would secure jobs and welfare, as well as EU's role as a leading industrial union. When European sustainable carbon sources replace imported fossil raw materials, our resilience is strengthened, and our vulnerability to external crises and geopolitical risks reduced. This white paper outlines the obstacles, as well as a policy pathway to get there.

Why RE-carbonise and not DE-carbonise?

Most products that are crucial for our society – from medicines and clothing to cars and mobile phones – cannot be manufactured without carbon atoms as the building blocks of the material. In today's industrial production almost all these carbon atoms come from "virgin fossil sources", primarily imported oil products and natural gas that is released into the atmosphere at the products' end-of-life. This cannot continue. The chemicals industry needs to RE-carbonise with sustainable carbon sources.

1. Executive summary

Most products that are crucial for our society – from medicines and clothing to appliances and mobile phones – cannot be manufactured without chemicals and carbon atoms as building blocks of the material. In today's industrial production almost all this carbon comes from virgin fossil sources, such as oil and gas, and is released into the atmosphere at the end of its life.

RE-carbonizing chemicals – replacing virgin fossil carbon atoms with carbon from sustainable sources such as biobased, recycled or CO_2 – poses a demanding challenge. Compared to demand, sustainable carbon is scarce, and regulation puts chemicals at a disadvantage compared to other sectors, such as fuels and energy. At the same time, to use our planet's resources in the most efficient manner, sustainable carbon should be used in sectors with no alternatives to carbon and where it creates the highest value.

A regulatory framework that enables the chemical industry to RE-carbonize will pave the way for a more sustainable, resilient and competitive society as a whole. Apart from the obvious climate emission reductions, it can create a much needed growth engine, strengthening European competitiveness in the global market, and reduce the dependency on fossil imports.

However, key to such a regulatory framework is the creation of a stronger demand and market for sustainable products, as this will drive the shift of raw materials all the way up the value chain, based on market signals.

Create market and demand	Sustainable carbon mandate on chemicals in end products sold on the EU market Public procurement for sustainable products - lead markets → Create demand and payment capability from the end of the value-chain
Technology neutral feedstock	All types of sustainable carbon (bio, waste & CO_2 (incl. fossil waste and CO_2)) → Allow for competition between feedstock → Let innovation, local condition, etc. find the best solutions
Broad transition of products	All types of chemical-based materials and end products (few exceptions) → Inclusion of all eligible chemical-based products, beyond plastics, to enable a broad transition
Global competitiveness	Applied on all goods sold in the EU, including imports Tradable certificates combined with traceable mass balance[1] to create flexibility, inclusion and larger scale transition

1. Mass balance with physical traceability on process level and chemical traceability with no overcompensation

Policy proposals:

- Introduce a holistic circular carbon regulatory framework, including a sustainable carbon mandate for chemicals and plastics in end products sold on the EU market, including imports.
- The ambition in the EU Sustainable Carbon Cycle communication from 2021 could be a relevant starting point for such a mandate regulation, gradually increasing the mandate towards 2050. With tradeable certificates among producers and a technology neutral feedstock approach, this creates a cost-effective transition to net zero 2050.
- Sustainable carbon is and will be scarce. Therefore, sustainable carbon should be defined as waste (biobased and fossil), biomass and CO_2 (biogenic and fossil). Sustainable carbon should be allocated to sectors with no alternatives and where it creates the highest value.
- The cascading principle in RED should be amended, going from wood-based products to sustainable carbon-based products. Storing renewable and/or recycled carbon in chemicals and products must be prioritised over burning it for energy purpose.
- The scope of LULUCF should be widened from today's "harvested wood products" to "harvested biobased products". More products should be added, such as biobased chemicals, as it can store biogenic carbon for a long time in materials and products that are recycled.

2. A resilient, competitive and sustainable European carbon cycle

Chemicals are the fundamental building blocks for human life. Approximately 96 percent of all manufactured products we use in our daily lives – such as clothes, furniture, medicine, computers, cars etc – are built on chemical products. With the right design, chemical products can give materials and products specific abilities and enable innovative breakthroughs. Thus, the chemical industry provides qualified solutions to meet current and future challenges, including climate change.

Sustainable chemicals is a cornerstone for reaching net-zero by 2050, reducing the chemicals sector's five percent share of total net climate emissions in the EU. A transition to sustainable carbon would in addition reduce EU's 98 percent dependency on imported fossil fuels and raw materials, which today represent a great geopolitical risk and high cost.

Furthermore, the European Commission identifies the chemicals industry as a key industry for European competitiveness. "*The European chemicals industry is a strategic sector for the European union. The sector brings state of the art innovation, growth, and – with 1.2 million direct jobs – high quality employment. The sector also plays an essential role to support decarbonisation and a competitive circular economy, two important EU objectives.*"[1]

For this potential to be realised, we need to change the fact that the majority of all raw materials for chemicals are derived from fossil sources like oil, gas and coal. The chemicals sector accounts for 14 percent of the global industrial greenhouse gas emissions. Within the European Union, chemical feedstocks account for about 10 percent of all fossil carbon used.[2] This equals roughly 100 million tons of fossil carbon, which emits 400 million tons CO_2 if incinerated.

However, the direct emissions from production and from energy use are only a small part of the total. The lion part of the emissions come from the raw materials used and the end of life treatment of the product, if it is recycled, incinerated or put on a landfill (Figure 1).

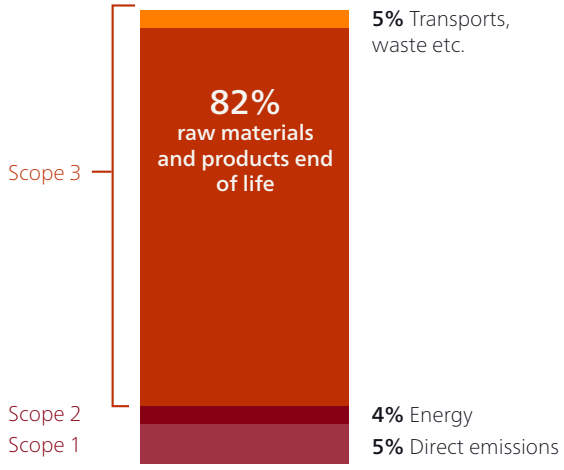

Figure 1

The main building block in most chemicals is, and will be, carbon. As the carbon atoms in chemicals used to build materials and products cannot be DE-carbonized through electrification like other sectors, it needs to be RE-carbonized with biogenic and recycled carbon.

However, today's market regulations pull sustainable carbon away from chemicals and materials, into the fuel and energy sectors. This is substantially slowing down the sustainable transition of carbon in chemicals. The chemicals sector needs a level playing field that can boost carbon recycling and bio-sources, preventing further use of virgin fossil carbon use in chemicals.

This paper outlines the chemicals industry's path to carbon neutrality, offering policy proposals and stressing the need for a regulatory framework that makes sustainable carbon available to the chemicals industry on competitive terms. This would strengthen European competitiveness, resilience and make it possible to reach our ambitious climate goals.

[1] Excerpt from the EU commission Concept Note regarding strategic dialogue on the future of the Chemicals industry

[2] https://renewable-carbon.eu/publications/download-confirmation-page/?somdn_rrpage=somdn_rrpage&somdn_rrdid=140782&somdn_rrdkey=MTQwNzgy&somdn_rrskey=MTY4NDE1MTAzMg=&somdn_rrpkey=MTI3NzE4&somdn_rrkey=MA=&somdn_rrtype=cmVkaXJlY3Q

3. The European carbon economy

The current overall carbon demand in Europe is roughly 1,200 million tons. By 2050, this demand is expected to be cut in half, as a result of the decarbonisation of the economy as a whole. This reduction, de-carbonization, is mainly the result of the on-going electrification, decreasing carbon demand by approximately 70-75 percent in the energy and transport sectors until 2050.

At the same time, carbon demand for chemicals is expected to grow by approximately 20 percent by 2050, from 100 to 120 million tons, as a result of a growing economy and increased demand for materials and products in Europe. This leads to an estimated total carbon demand of 650 million tons by 2050 (Figure 2).

About 25 percent of the carbon we use in the economy today is sustainable, i.e. it comes from biomass, waste or CO_2. Most of it goes into wood based products and paper, which is logical, while the rest is mainly allocated to energy and some to transport. Only two percent of the sustainable carbon is used by the chemicals industry (Figure 3).

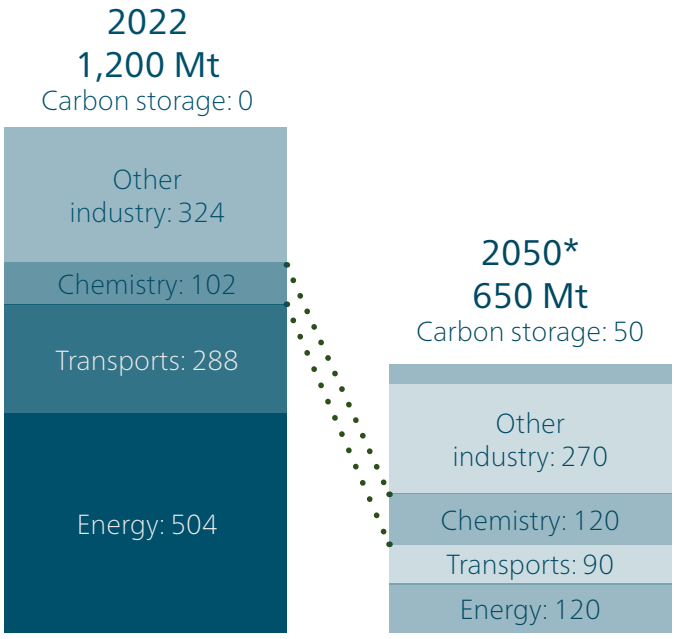

Figure 2

**A realistic, slightly conservative net zero scenario*

3.1 The sustainable carbon potential

An increased sustainable carbon supply is key to the green transition. More biomass use, increased recycling of waste and CO_2 capture and use (CCU), can increase the carbon supply with as much as 40 percent by 2050, from 320 to 450 million tons.

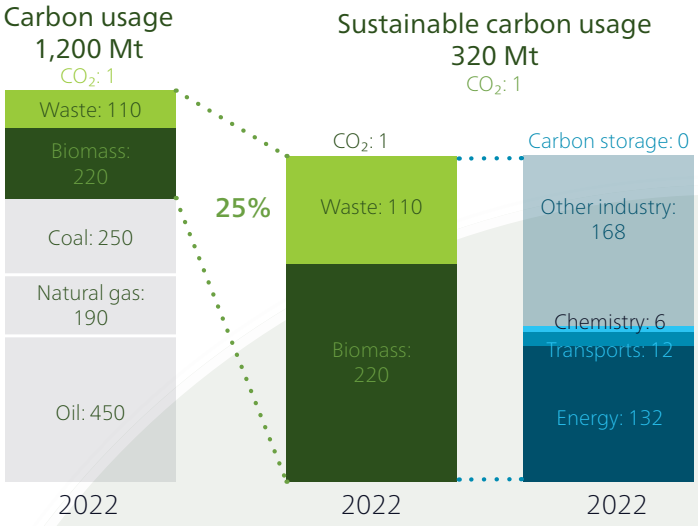

Figure 3

Biomass has the potential to increase by roughly 10 percent by 2050. This is a conservative number, as the extraction of biomass from forest and agriculture needs to be sustainable. Both first and second generation biomass will be needed to RE-carbonize chemicals and materials.

Waste offers a bigger potential, with a foreseen increase of 20 percent to 2050. The real potential with waste will be shifting it from landfill and incineration to the use as a raw material through recycling. Both bio and fossil waste should count as sustainable when used to RE-carbonize chemicals and materials.

CO_2 capture and utilization (CCU) has the biggest long-term potential, but it requires technological breakthroughs to be realised. With present technology, harvesting 90-100 million tons of carbon from CO_2 would require approximately 1,300 TWh of electricity, which is highly questionable whether this would be feasible or economic.

"The aim must be to circulate and reuse the carbon atoms as many times as possible, no matter its original source"

3.2 Mind the carbon gap

Assuming that the EU would utilize the full potential of all sustainable carbon until 2050, there would still be a projected gap of 100-300 million tons between demand and supply in the EU economy. The efficient allocation of sustainable carbon must therefore be dealt with urgently (Figure 4).

In addition, we cannot afford to limit the sustainable carbon sources by a too narrow sustainability criteria. When a carbon atom has entered the economy and is recycled or captured, it should count as sustainable. The aim must be to circulate and reuse the carbon atoms as many times as possible, no matter its original source, as the alternative is adding new virgin fossil carbon to the economy.

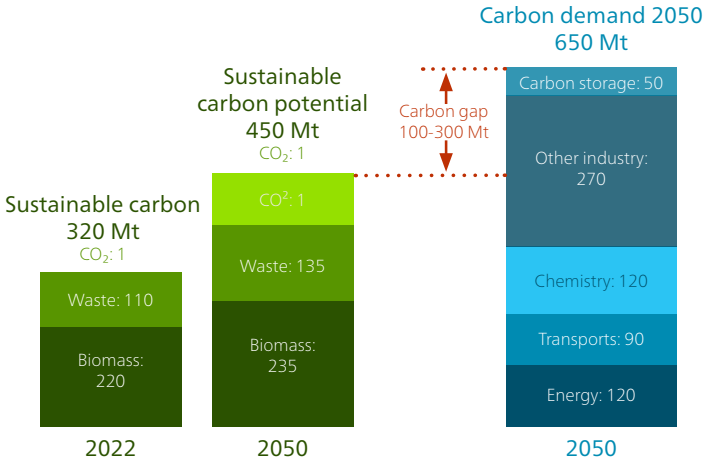

Figure 4

3.3 Sectors with no alternative to carbon must be prioritised

As sustainable carbon is scarce, it is also essential that it is allocated to the sectors that have no alternative. If not, the demand for virgin fossil carbon will remain, and the emissions from sectors that need carbon will never be eliminated.

The power, heating and transport sectors can cut or eliminate carbon use by switching to low or non-carbon power or electric vehicles. This is not possible for the chemicals industry, as carbon is the essential building block of most materials. Chemicals is the only sector dependent on sustainable carbon, as all other sectors have some long-term alternatives (Figure 5).

	MAIN USE OF CARBON	LONG-TERM DEPENDENCE ON CARBON FEEDSTOCK	COMMENT
Materials	Chemicals	●	Carbon is needed for chemicals and material products
Energy	Aviation	◑	Battery-electric aircraft, hydrogen fuel cells aircraft
	Shipping	◔	Battery-electric, electric, ammonia, green hydrogen, nuclear
	Road transport	○	Battery-electric vehicles, hydrogen fuel cell vehicles
	Power	○	Solar, wind, nuclear electricity; range of flexibility solutions
	Heating	○	Electric heat pumps, electric boilers
Processes	Industrial processes	◔	Electric heat pumps, electric boilers, hydrogen boilers, other electrification options

Figure 5

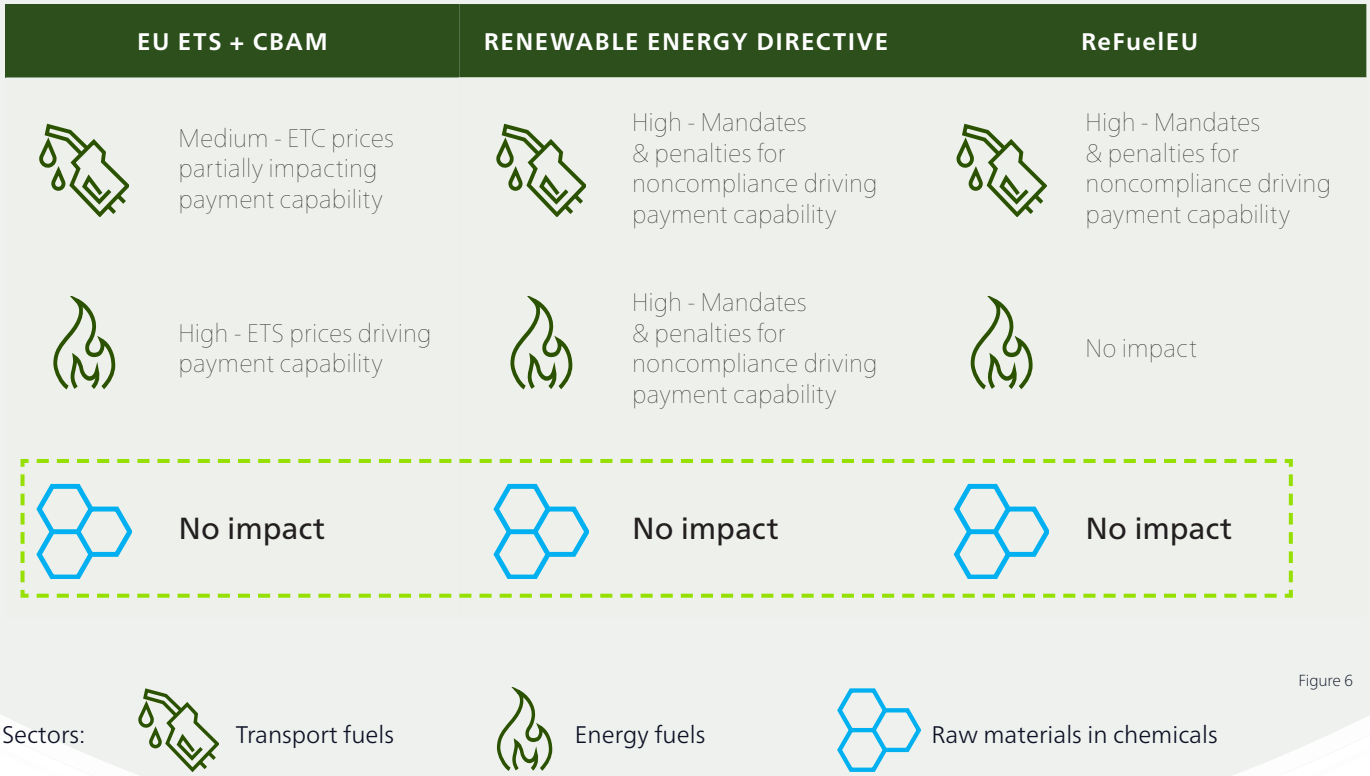

Figure 6

3.4 The need for better regulation

Today, EU regulations prioritise sustainable carbon to energy and transport, leaving chemicals at a disadvantage. In order to RE-carbonize the chemicals sector, there is a need for a total overhaul of the carbon policy, and to incentivise sustainable carbon use for the chemical sector instead of allocating it to sectors with alternatives (Figure 6).

For example, there are no incentives to use biomass to produce valuable chemicals. Instead, burning biomass for energy production has strong incentives under the EU ETS and the Renewable Energy Directive. Storing biogenic carbon underground, rather than using it as feedstock, is rewarded with carbon removal certificates and can be used in the ETS to compensate for fossil emissions. The LULUCF is on the right track with harvested wood products, but this should be expanded to all products that store biogenic carbon, like biobased chemicals.

"In order to RE-carbonize the chemicals sector, there is a need for a total overhaul of the carbon policy"

3.5 Correct market failures — make competition fair

EU regulations have a major influence on the allocation of carbon, as well as on where and how investments take place. Currently, the fragmented policies allow for the price of carbon to be set by the transport and energy sectors (Figure 7).

This has led to a classic market failure, that has put sustainable carbon out of reach as feedstock for the chemical industry. Well-designed and balanced regulation is needed at both the EU and national levels to achieve a competitive and sustainable economy in the broader sense. The chemical industry needs a level playing field to compete.

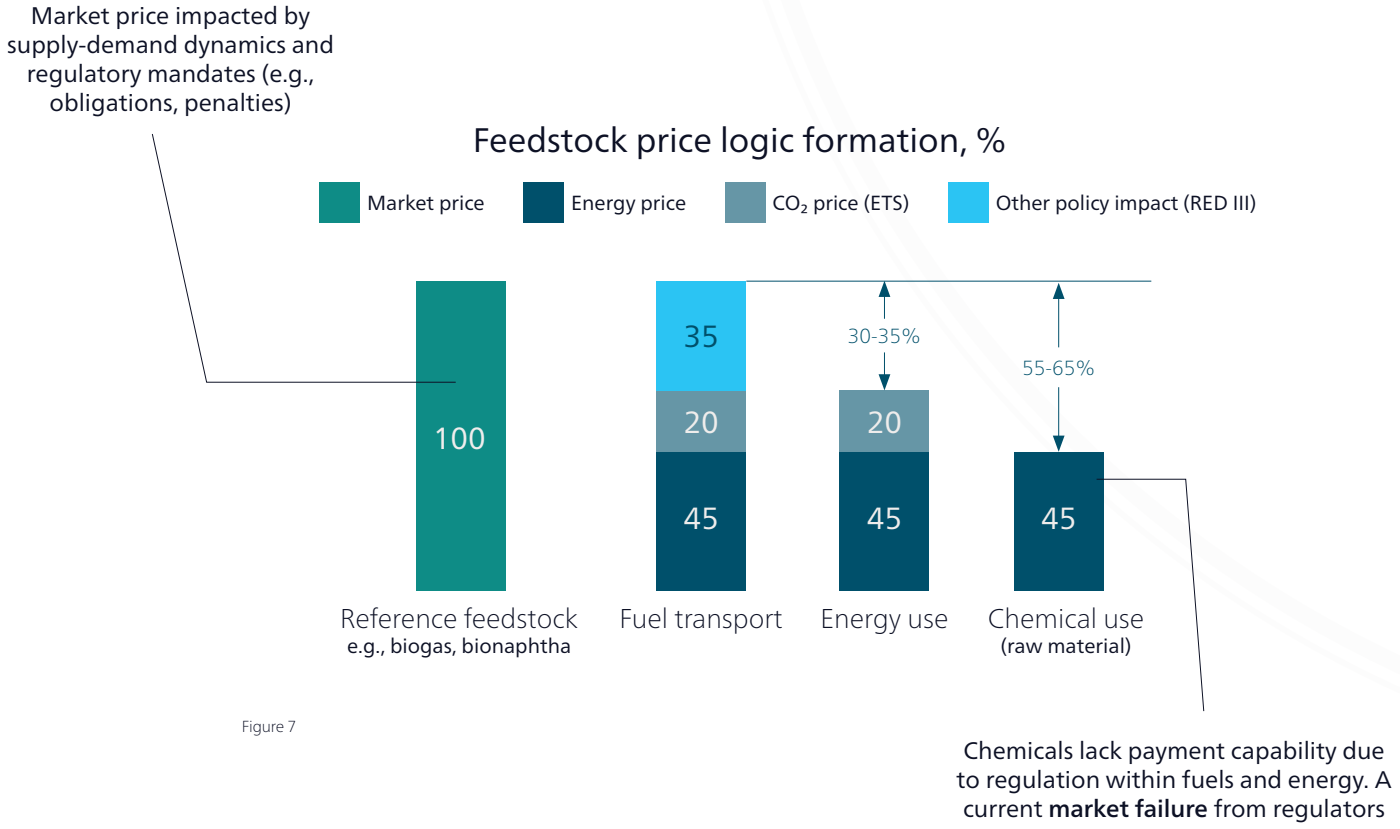

Figure 7

3.5 System-level actions for sustainable carbon utilisation

Constructing long term efficient regulations is complex. Legislations like PPWR and ELVD, that mandate recycled feedstock at product level, is a good start for creating a demand for sustainable chemicals. However, regulating each raw material stream and product category separately creates a fragmented regulatory environment and focuses on details rather than systemic effects. The risk is that this will create administrative burdens and low predictability, i.e. red tape, instead of aiding the industry's transition.

Furthermore, for political and practical reasons, regulation has focused primarily on plastics, leaving a regulatory gap for a broad group of categories, e.g. coatings, plastic additives, nutritional additives etc.

Instead, the regulatory framework needs a holistic approach, a red carpet, covering the vast majority of product groups and sustainable feedstock. We need a framework that sets goals, while leaving it to the market, regional opportunities and innovation to find the most effective solutions to reach those goals.

"...a classic market failure, that has put sustainable carbon out of reach as feedstock for the chemical industry"

4. Policy proposals

4.1 Policy proposal I: A coherent framework for sustainable carbon

Based on the principles below, we believe that it is possible to create a framework that would generate a strong and cost-efficient policy for all sustainable products, instantly also incentivizing the long-term transition to a more competitive chemicals industry in the EU, while driving new investment and reducing CO_2 emissions rapidly – all at a manageable cost for consumers (Figure 8).

Create market and demand	Sustainable carbon mandate on chemicals in end products sold on the EU market Public procurement for sustainable products - lead markets → Create demand and payment capability from the end of the value-chain
Technology neutral feedstock	All types of sustainable carbon (bio, waste & CO_2 (incl. fossil waste and CO_2)) → Allow for competition between feedstock → Let innovation, local condition, etc. find the best solutions
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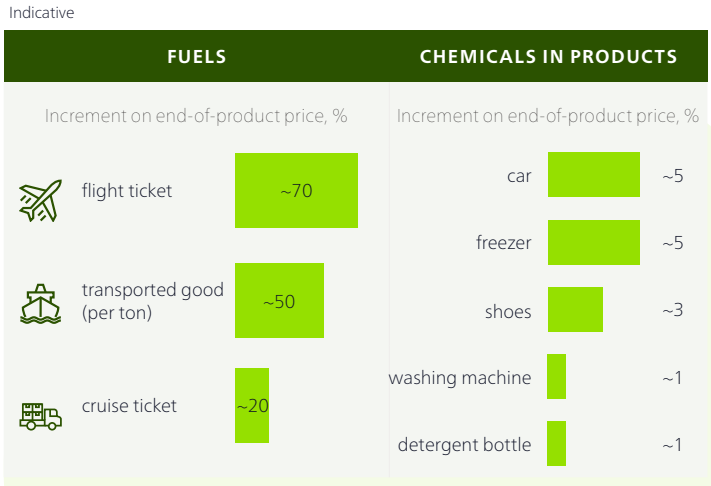
1. Mass balance with physical traceability on process level and chemical traceability with no overcompensation

4.1.1 Create market and demand

Without a demand for sustainable products, there will be no transition of raw materials nor chemicals. The most efficient policy is therefore to mandate that all end products sold on the EU market, including imports, should contain a certain amount of sustainable carbon in the chemicals and plastics content of that product.

This would create demand for sustainable products as well as for sustainable raw materials in chemicals. Hurdles within the value chain would be dealt with by market mechanisms. As the mandate is downstream on the end-product, the additional cost would be transferred to the customers. However, the additional cost of sustainable carbon in the chemical or plastic part of an end product is foreseen to be rather small and therefore manageable (Figure 9).



4.1.2 Set a sustainable carbon mandate for products sold in EU

The EU Communication on Sustainable Carbon Cycles sets a mandate of at least 20 percent sustainable carbon in chemical and plastic in end products by 2030. A corresponding legal mandate of sustainable carbon in products sold on the EU market could have notable outcomes for the chemicals sector already by 2030 (Figure 10).

Creating a long-term plan until 2050 with increasing mandates for sustainable carbon over time would create predictability, decrease political risk and regulatory insecurity for cleantech investments for a struggling industry hesitant to invest in Europe.

Potential evolution of sustainable carbon targets for transformation of products

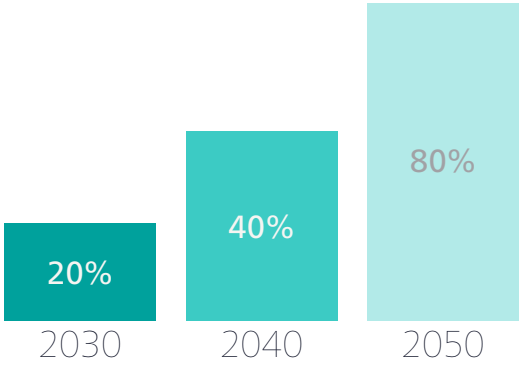


Figure 10

4.1.3 Allow for tradeable certificates

One size does not fit all. Some actors will be faster and others slower in the transition, and some materials are more challenging to transition than others. Tradable certificates for sustainable carbon on a market should therefore be introduced to create flexibility and cost-effectiveness. Those who cannot, or choose not to, meet the mandate by actual transition can buy sustainable carbon certificates from those who have a surplus, via the market, creating an additional driver for sustainable chemicals.

Providing flexibility and cost-effectiveness at the product end, it is important to ensure that the mandate for sustainable carbon really leads to an actual shift of raw materials. The crucial point for receiving a sustainable carbon credit is that there is a real physical connection between the raw materials and the end products at a system level, i.e. that it covers the entire value chain. Therefore, a mass balance allocation model using both chemical and physical traceability on process level is required.[4]

4.1.4 Technology neutral feedstock

All types of sustainable carbon should be included in the mandate, i.e. bio, waste and CO_2. As it would create sound competition between sustainable raw materials, it would assure that the cheapest raw material closest to the market would be used first, pushing the cost of the transition down, and making the cost impact on customers as low as possible. As sustainable carbon is scarce, it is important to maximise the amount of sustainable carbon. Therefore, fossil waste and CO_2 should also count as sustainable, as well as first generation crops when binding its carbon into chemicals and products, as the alternative is virgin fossil carbon. Imported products and sourcing of its raw materials must mirror EU sustainability criteria.

4.1.5 Ensure broad transition of products

As many carbon-based materials and end products as possible should be included. This ensures a broad transition of products, creates a level playing field between product categories, ensures a proper market for sustainable chemicals and enables all companies to be part of driving the transition.

4.1.6 Global compatibility and competitiveness

The EU market is not an island and it is important that the policy is consistent with trade and imports. The mandate should not cover exports as Europe must be able to compete globally. Consequently, production in Europe exported and sold outside Europe would not be covered by the target. However, the sustainable carbon target of 20 percent would give effects also on production outside of Europe as companies in third countries exporting to the EU would have to follow the EU regulation. Long term, this will hopefully inspire other countries, outside the EU, to follow suit with similar legislation.

[3] https://climate.ec.europa.eu/system/files/2021-12/com_2021_800_en_0.pdf
[4] The mass balance allocation model should have a physical traceability on process level and chemical traceability with no overcompensation.

4.1.7 The impact of a 20 percent mandate for sustainable carbon

A mandate of 20 percent sustainable carbon in chemicals and plastics in products would have a significant impact. According to the scenario, it would shift 22 million tons from fossil to sustainable carbon and reduce roughly 60 million tons of CO_2. Equally important, it would drive much needed investments amounting to approximately €40 billion, of which a significant part would be invested in waste management and recycling (Figure 11).

Figure 11

20% scenario

FEEDSTOCK	PRODUCTION COSTS (EUR/t HVC)	FEEDSTOCK DEMAND (Mt)	INVESTMENT (EUR bn)
Biomethane & methanol	2,500 - 3,100	1	1
Vegetable oils	2,400 - 3,100	3	5
1G ethanol	1,500 - 2,000	3	4
Plastic	1,400 - 1,500	6	11
Municipal solid waste	1,600 - 1,800	6	16
Forestry residues & energy crops (gasification & pyrolysis)	2,200 - 2,600	3	4
	2,800 - 3,400		
2G ethanol	3,200 - 3,600		
CO_2 and H_2	3,600 - 4,000		
		22 Mt	40 EUR bn

4.2 Policy proposal II: Incentivize carbon stored in products

Today, there are positive signs in both the current renewable energy directive (RED) and in the Land Use and Land Use Change Forestry directive (LULUCF) regarding carbon stored in products. However, current applications are insufficient and should be broadened.

4.2.1 Broaden the scope of LULUCF

In the LULUCF, biogenic carbon can be accounted for as stored, if it is present in a harvested wood product (HWP: sawn wood, panels and paper). However, there are several more product groups that could and should be included as HWP. For example, products made of chemicals based on biogenic carbon can store wood-derived carbon for a long time.

Since this is not recognised in LULUCF today, the interest from national politicians is low to see a growth in these products as a way to reach the LULUCF-target. However, if "harvested wood products" were changed to "harvested biobased products" and thus, these products were included, it would gain more traction and support from politicians and hence speed up the chemicals sector climate transition.

4.2.2 Strengthen the cascading rule in RED

With the same thinking, the cascading rule in RED should be revised and strengthened. The cascading rule says that biomass should be used in the most efficient way – first by making wood-based products, then by extending their life. After that, companies should re-use the products, then recycle them, burn them and lastly dispose of them. However, the rule has several derogations, making it too easy to burn valuable biomass directly.

We suggest that the cascading rule should be more holistic and have a broader approach. Instead of burning biomass, a lot of industries, including the chemicals industry, can transform biomass to valuable products that store carbon for a long time, which then can be reused several times before they are disposed of. In this way, we create longer carbon loops maximizing the use of the valuable carbon atoms and reduce emissions. This would in effect create a societal carbon sink.

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Do good with chemistry

Perstorp is a leading specialty chemicals innovator, operating as an interconnected part of PCG Specialty Chemicals.

Perstorp believes in improving everyday life – making it safer, more convenient and more environmentally sound for billions of people all over the world. As a world leading specialty chemicals provider, Perstorp's innovations provide essential properties for products used every day and everywhere – from cars and mobile phones to towering wind turbines and the local dairy farm. Simply put, Perstorp works to do good with chemistry.

Operating under the PCG Specialty Chemicals umbrella, Perstorp adds value with its unique brand identity in a functional structure designed for growth. As an interconnected part of this growth structure, Perstorp oversees the global procurement, production and sales for business areas Polyols, Oxo, Formates and Animal Nutrition. With seven production sites in Europe, Asia and North America, and approximately 1500 employees globally, Perstorp is well positioned for future growth in its business areas.

PCG Specialty Chemicals is the strategic growth division of PETRONAS Chemicals Group Berhad, with a clear growth agenda that reflects the strong ambition for the future and the commitment to sustainability, innovation, and customer-centric solutions. Perstorp operates as an interconnected part of PCG Specialty Chemicals who reports to PETRONAS Chemicals Group Berhad.

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