European Chemicals

The Circular Economy Nexus

Produce, consume, throw away: this is the linear economy our world has been built on. "Single-use" is most often heard in reference to plastics, but it's an accurate description of the vast majority of energy sources (e.g. oil and gas) and consumer/capital goods (e.g. mobile phones, laptops). A circular economy can stop or drastically reduce waste being produced. Circular production and consumption business models can be used to gain greater natural resource independence, reduce CO2 emissions, and design for optimal allocation of limited raw materials. A circular economy decouples economic activity from the consumption of finite resources.

Chemicals at the heart of circularity

From cosmetics and pharmaceuticals, flavour and fragrances, agrichemicals, electronics and sports equipment, to automotive, aerospace and construction, the chemical industry is of systemic macro importance. The industry is intertwined with nearly every aspect of the global economy, with chemicals present in c.95% of manufactured goods. By appraising the circular economy with respect to the chemical industry, we present investors and corporate actors with a toolkit for considering circularity strategies. We summarize the factors we expect to drive circular economy investments in the chemical sector, and introduce our GS Circular Alignment Monitor: our proprietary approach to analyzing the alignment of chemicals stocks.

Key considerations focus on costs, opportunities, and risks

(1) No Net Zero without circular: without circularity, chemical CO2 emissions could grow >120% by 2050, with Chemicals replacing Oil & Gas as the largest GHG emitting sector. (2) €1 trillion: the potential cost of Net Zero by 2050 for European Chemicals. (3) Feedstock switching away from fossil fuels poses the greatest technological and investment challenge. (4) Circularity could decouple chemical prices from the oil price. (5) Carbon is not the only element that needs a circular approach. (6) Curbing planned obsolescence would reduce demand for chemicals. (7) Without policy support, we are cautious on the ability of upstream chemicals in Europe to retain global competitiveness and attract the investment needed to drive sustainable innovation (see accompanying note on this topic).

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PM Summary

Produce, consume, throw away: this is the linear economy our world has been built on. "Single-use" is most often heard in reference to plastics, but it's an accurate description of the vast majority of energy sources (e.g. oil and gas) and consumer/capital goods (e.g. mobile phones, laptops). The circular economy can stop or drastically reduce waste being produced via sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products. Circular production and consumption business models can be used by companies, states, and regions to gain greater natural resource independence, reduce CO2 emissions, and design for optimal allocation of limited raw materials. A circular economy decouples economic activity from the consumption of finite resources.

A circular approach enables climate change and biodiversity ambitions to be met

We see potential for the circular economy to be understood by investors as an even larger thematic than climate change. It is often stated that climate change ambitions are not possible without the circular economy. While we agree with that statement, we find it limits the scope of circular thinking to greenhouse gas (GHG) emissions, or, even more reductively, to carbon. Carbon is the most abundant element on Earth and the basis of the vast majority of human energy, and material production/consumption and waste, but circular economy principles apply to all substances in all states of matter. The science most concerned with the properties and structures of substances, the transformations they undergo, and the energy that is absorbed or released in these processes, is Chemistry (as defined by the encyclopedia Britannica). The chemicals industry and the circular economy are therefore synonymous as the means to solving major global challenges such as climate change and biodiversity, in our view.

Chemicals at the heart of Circularity

From cosmetics and pharmaceuticals, flavour and fragrance ingredients, agricultural products, electronics and sports equipment, to automotive, aerospace and construction materials, the chemicals industry is of systemic macro importance. It is represented in almost every aspect of the global economy, with its products present in c.95% of manufactured goods. We believe global corporate Net Zero ambitions cannot be achieved unless the chemicals sector successfully transitions to more circular business models. It is our ambition, that by appraising the circular economy with respect to the chemical industry, we will present a wide range of investors and corporate actors with a toolkit for considering circularity strategies. With this work, we summarize the factors we expect to drive circular economy investments in the chemical sector, and introduce our GS Circular Alignment Monitor: our proprietary bottom-up approach to analyzing chemical stocks with respect to circular economy alignment.

Key considerations focus on costs, opportunities, and risks

(1) No Net Zero without circular: without circularity, chemical CO2 emissions could grow >120% by 2050, with Chemicals replacing Oil & Gas as the largest GHG emitting sector. (2) €1 trillion: the potential cost of Net Zero by 2050 for European Chemicals. (3) Feedstock switching from fossil fuels to renewable/recycled inputs poses the greatest hurdle from a technology and investment standpoint. (4) Circularity could see chemical prices decouple from the oil price. (5) Carbon is not the only element that needs a circular approach. (6) Curbing planned obsolescence could reduce the volume opportunity for chemicals. (7) Without regulatory and policy support, we are cautious on the ability of upstream chemicals in Europe to retain global competitiveness/growth opportunities and attract investment, and highlight the risk that Europe's ability to drive sustainable innovation would be materially hampered (see accompanying note on this topic).

GS Circular Alignment Monitor: a framework for investing in the circular economy

With this note, we introduce our GS Circular Alignment Monitor (Exhibit 3), aiming to identify the companies in our coverage most aligned to Circular Economy principles. The monitor compares companies on 5 different metrics: 1) circular energy as % of total energy consumption, 2) circular raw materials as % of total, 3) Circular Economy targets, 4) sustainable solutions and services as a % of sales, and 5) FY22-24E average CROCI. The average score across each of the 5 metrics is shown in the individual company profiles above. The logic for choosing these metrics for our screen is detailed below, and we show the average across all metrics (i.e. average of circular energy as % of total, circular raw mats as % of total, etc.) in Exhibit 16. We note that the GS CAM is intended to inform investment decisions with a longer-time horizon and our 12M price targets and stock recommendations are not based on this framework. A full CAM methodology section can be found towards the end of this note.

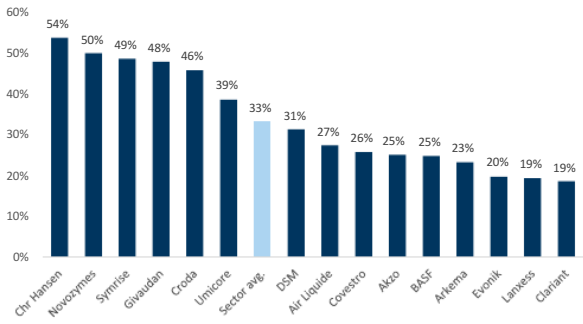
Consumer ingredients well-placed; Covestro and BASF stand out upstream

From today's perspective, we find the Consumer Ingredient names are currently better placed for the transition to a Circular Economy. We conclude Chr Hansen is the most aligned to a Circular business model, scoring above sector-average on all metrics thanks to its ambitious targets, strong cash generation, and high share of circular products in both its raw materials and energy consumption. Within the Consumer Ingredients sub-sector, DSM is relatively the lowest-scoring name, albeit we note this should improve significantly (particularly in terms of circular raw materials and sustainable solutions) upon divestment of its Engineering Materials business (expected to close 1H23). In the Diversifieds space, we see Covestro as best-positioned, largely thanks to it being the only upstream name targeting to be Fully Circular (albeit with no date attached to this ambition). We see BASF as having best-in-class disclosure of current Circular Economy solutions, with near-term targets and deliverables that are easy to track. Overall, we find Evonik and Lanxess are the lowest-scoring names on our methodology.

Policy support and higher selling prices needed to close the loop

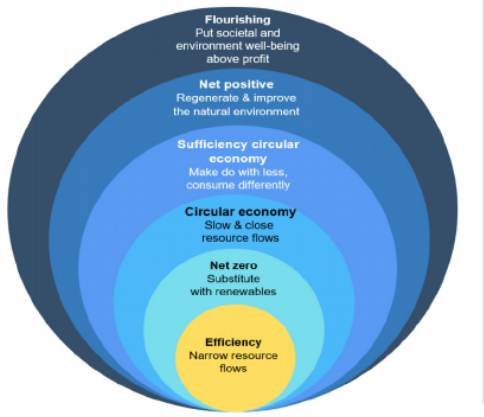
We find that chemical companies are generally optimistic about the upside opportunities a circular economy presents their businesses, but they also highlight the key requirements for the industry to make the changes required: better renewable energy availability, policy support including recognition of chemical recycling as a viable technology, funding support both from policymakers and commercial partnerships, and higher selling prices to customers. We find the Circular Economy is another inflationary thematic.

Exhibit 1: Chr Hansen and Novozymes are the highest scoring names on the metrics included in our Circular Alignment Monitor
Average of each of the 5 metrics in our monitor



Source: Goldman Sachs Global Investment Research

Exhibit 2: Croda, Symrise and Givaudan aim for Climate positivity, while Covestro targets fully circular
Hierarchy of sustainable business models and summary of company targets relating to circularity

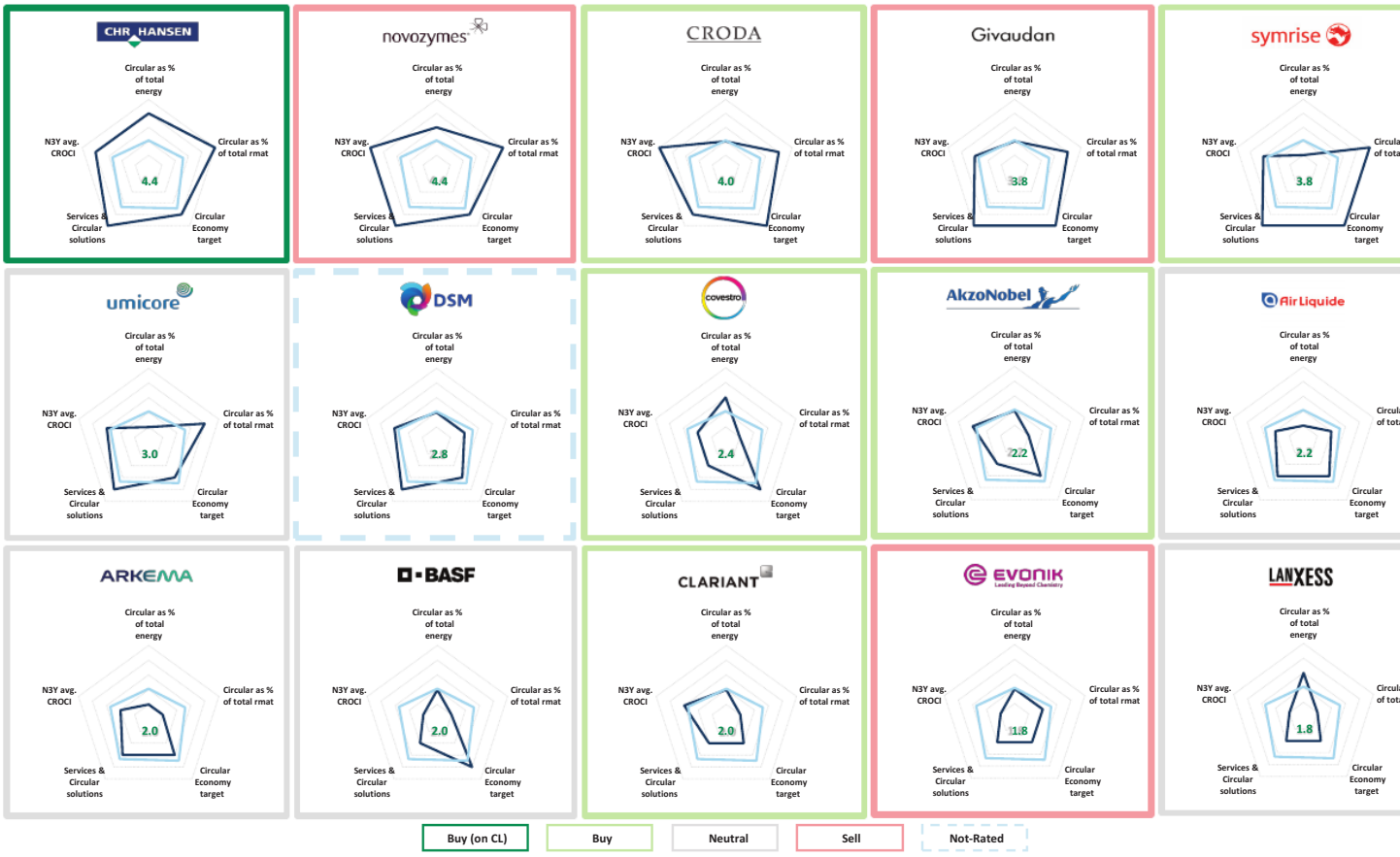


Sustainable Business Model	Company	Target year	Target
NET POSITIVE	Croda	2030	Climate-positive by 2030
	Symrise	2030	Climate-positive starting in 2030
	Givaudan	2050	Climate-positive before 2050
CIRCULAR ECONOMY	Covestro	N/A	Become fully circular
NET ZERO	DSM	2050	Net zero by 2050
	Novozymes	2050	Net zero by 2050
	BASF	2050	Net zero by 2050 (Scope 1+2)
	Clariant	2050	Climate-neutral by 2050
	Evonik	2050	Climate-neutral by 2050
	Air Liquide	2050	Climate-neutral by 2050
	Lanxess	2040	Climate-neutral by 2040
	Covestro	2040	Climate-neutral by 2035 (Scope 1+2)

Source: Company data, Goldman Sachs Global Investment Research

GS Circular Alignment Monitor (CAM) snapshot

Exhibit 3: GS Circular Alignment Monitor
Number indicates overall score (average of score across the 5 metrics)



Rmat = raw materials. Dark blue line = company metrics, light blue = sector average metrics.

Source: Goldman Sachs Global Investment Research

What to expect from our Circular Economy series

With this first report focusing on the circular economy for chemicals, we introduce an overview of the factors we expect to drive circular economy investments. We frame the climate change, regulatory, and consumer-led drivers we see for the chemical industry to adopt circular business models. We set out the key challenges we anticipate the industry will face in energy and feedstock switching. We examine the potential capex and trade implications for the chemicals industry to shift from a linear to a circular business model and question whether localisation becomes preferable to global supply chains if the industry sheds its linear approach. We consider the potential for chemical product pricing to decouple from the oil price as the feedstock slate evolves, and we explore new business models as the circular economy lends itself more towards leasing or service-based offerings compared to basic manufacturing.

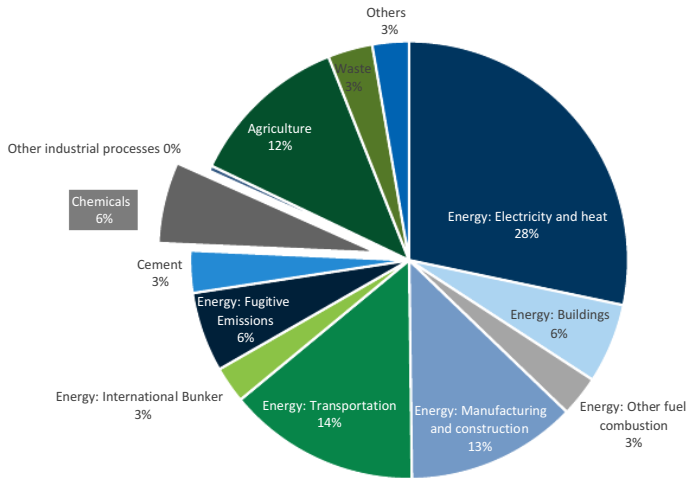
It is our ambition, via an ongoing series of reports, to provide more analysis and granularity on the evolving circular economy for the chemicals sector, as well as any new debates we encounter in our subsequent stakeholder engagement. We will highlight new circular economy growth opportunities along the way, as well as cautioning on the potential for structurally shrinking profit pools. Throughout, we will highlight stocks already favorably exposed to circular economy trends, those we anticipate to lead the transformation, and those that may be left behind.

Circular investment considerations for chemicals

Decarbonisation provides impetus to adopt a circular approach

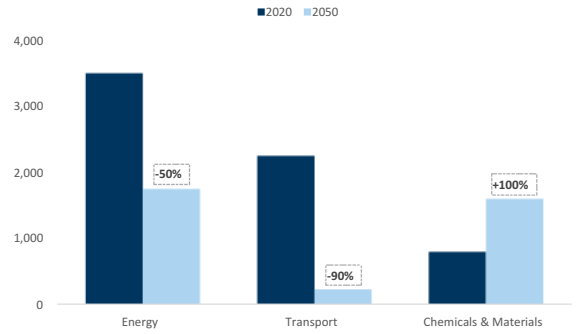
The circular economy is not just a major opportunity for the chemicals industry: it is essential to ensure it continues to attract investment given significant pressure to transform on the back of global Net Zero ambitions. Today, the chemicals sector accounts for 6% of global CO2 emissions. Unless the industry embraces circular economy principles (e.g. renewable, recycled, carbon capture inputs), its aggregate CO2 emissions are set to increase by 120% (2.7% CAGR) by 2050, according to the Nova institute. For context, the Energy and Transport sectors are expected to reduce emissions by 50% and 90%, respectively, over the same period. Energy consumption accounts for around two-thirds of all chemical industry carbon emissions today, which we expect to be solved in concert with the broader global energy transition, but the remaining third (related to production) must be addressed by circular economy initiatives. Without the circular economy, the chemicals industry could become the largest GHG emitting sector by 2050. We note that the EU Taxonomy currently includes a Circular Economy target only at the proposal stage, meaning details of sector implications and technical screening criteria are not yet finalised (as described by our GS SUSTAIN team).

Exhibit 4: The chemicals industry accounts for 6% of global GHG emissions
World GHG emissions by sector (2018)



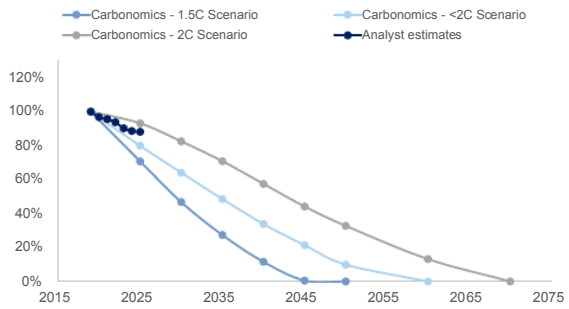
Source: WRI

Exhibit 5: The Chemicals sector is expected to see a significant step-up in embedded carbon demand, unless it embraces Circular principles
Embedded carbon demand for main sector today (2015-2020) and scenario for 2050 (mn tonnes of embedded carbon)



Source: Nova Institute

Exhibit 6: Scope 1+2 emissions intensities in the Chemicals sector are forecast to decline by 12% in 2025E vs. 2019
Emissions intensities profile for Chemicals, calculated as Scope 1+2 GHG emissions divided by the production index (referred to 2019 base). Indexed to 2019 base. Weighted average using market caps as weights.

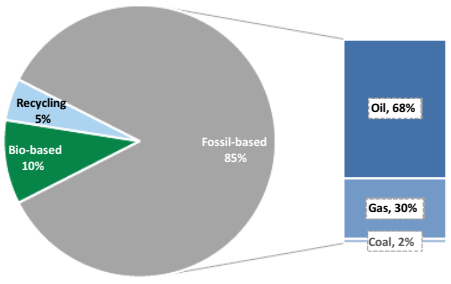


Source: Company data, Thomson Reuters, Bloomberg, Goldman Sachs Global Investment Research

Feedstock slate evolution more complex than renewable energy switch

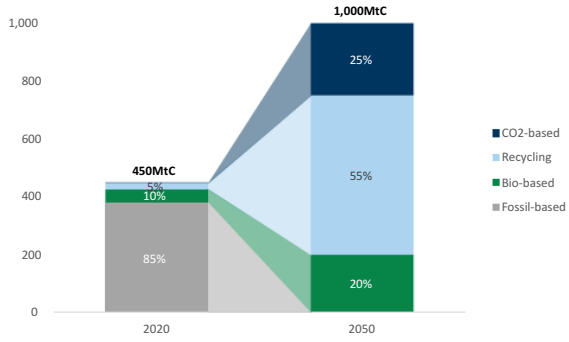
As the energy transition shrinks the role of oil and gas in the global economy, the easy access to raw materials in a global supply chain could become constrained and the economies of scale on which the chemicals industry was built could become challenging to maintain. A shift to alternate and more heterogeneous feedstocks is not as simple as it sounds: the assets operated by the chemicals industry today consume broadly two key globally traded commodities (oil and gas account for c.85% of total raw materials), from which it produces more than 45,000 different products. Will those same assets be able to receive hundreds or thousands of bio-based, recycled or carbon capture feedstocks? Will there be enough recycled/renewable feedstocks to fill those large assets? For comparison, the capacity of a typical ethylene cracker in the US is 1.5 mn tons per year and naphtha crackers in Europe range between c.0.5-1mn tons per year vs. most chemical recycling plants still at pilot-program scale (10-30kta).

Exhibit 7: Today, fossil-based feedstocks account for the majority of chemicals sector carbon demand...
Global carbon demand for organic chemicals and derived materials by type of feedstock, 2015-2020



Source: Nova Institute

Exhibit 8: ... but by 2050, this is expected to fall to zero
Global carbon demand for organic chemicals and derived materials by type of feedstock, 2050 vs. 2020

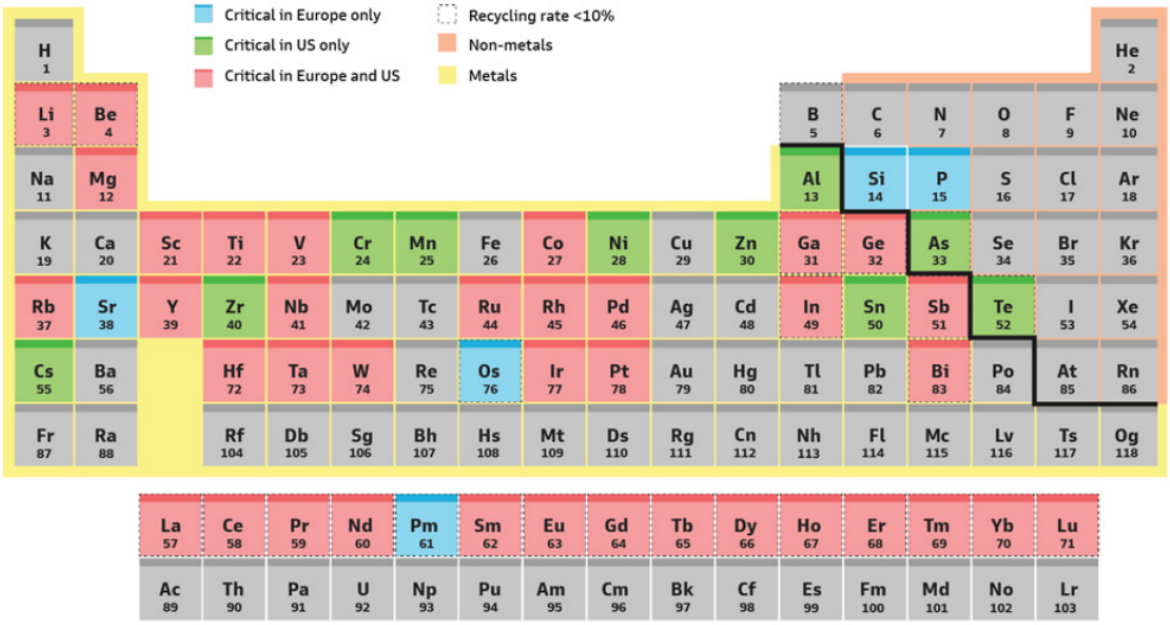


Source: Nova Institute

Carbon is not the only element a circular economy needs to plan for

Carbon is abundant and self-replenishing on Earth via photosynthesis. However, the vast majority of other elements are finite. Governments globally have developed individual critical material lists, broadly designating materials that are "critical" to their nation's economy. The periodic table below (Exhibit 9) shows the overlap between Europe and US CRM lists. Almost all metals are designated as critical in one country or more, but notable exceptions include iron, silver and gold (which have a long history of mining and recycling), and lead, cadmium and mercury (which are toxic, and hence no longer are commonly used). The metals industry is already one of the largest producers of waste and carbon dioxide emissions globally. Transitioning to a circular system will play a key role in reducing the environmental and social impact of the metals industry, given lower energy requirements, no new mining needed, and, by definition, zero metal waste ending up in landfill. The ongoing shift to "Green Energy" makes the transition to a circular system even more essential, to avoid the increasingly metal intensive sector permanently draining the Earth's reserves of certain metals.

Exhibit 9: There are many elements beyond carbon that the Circular Economy needs to address
Elements designated as critical by Europe and the US, and elements with recycling rate <10%



Source: European Commission, Federal Register, Goldman Sachs Global Investment Research

Today's capex decisions are critical given multi-decade asset life-spans

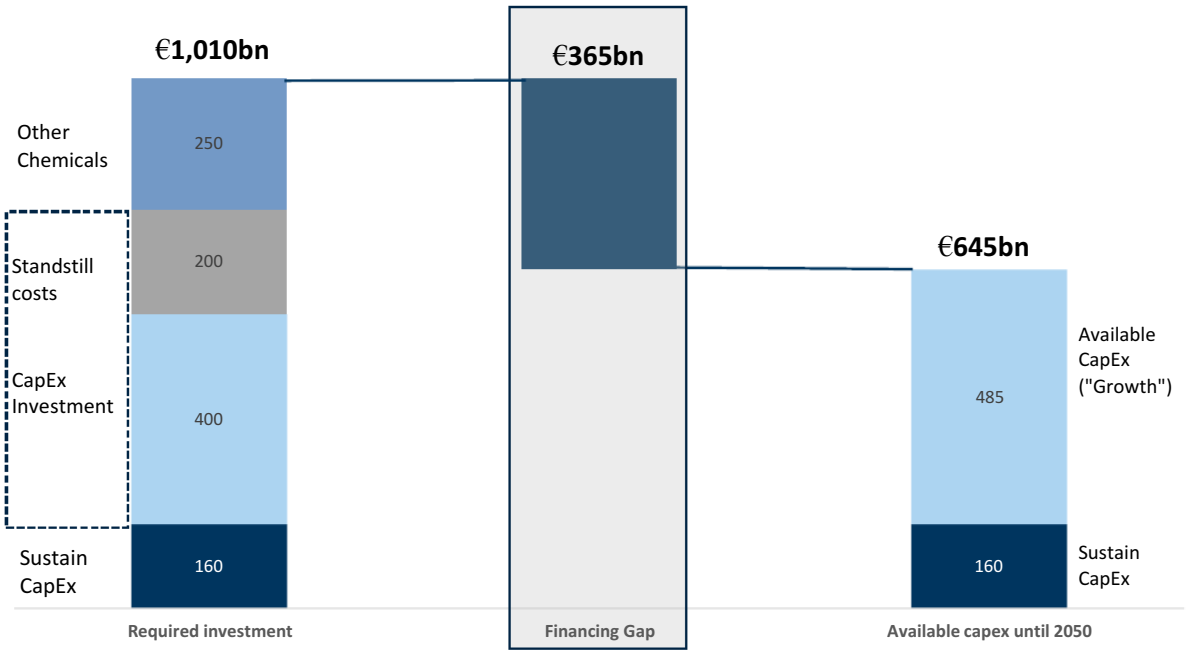
We find that chemicals/basic materials investment decisions are usually taken with multi-decade asset lifespans in mind: the average depreciable life span in upstream chemicals is c.15 years, while it takes five to eight years to build and commission new plants (assuming the technology is mature). This means that investment decisions being taken by management teams today are likely to determine whether the chemicals sector is able to deliver its Net Zero ambition by 2050 (some companies target earlier). It

is therefore critical that current management teams understand the opportunities and consequences of a circular vs. a linear approach.

The potential future rates of plastic recycling are reliant on continued investment, innovation and progress in new technologies. Transitioning from mechanical recycling to chemical recycling – changing the chemical structure of polymeric waste – would enable significantly higher recycling rates. However, with focus mainly limited to polyolefins, chemical recycling remains at R&D levels (1 kiloton or less) or pilot-program scale (10 to 30 kilotons). Most projects are still assessing the commercial viability and building experience to improve process stability and yield. Hence we still have a number of years to wait before first commercial plants come to the market (c.5 years).

We anticipate the chemicals industry will have to bear a high cost to deliver Net Zero given it will require new technologies and processes, involves the breaking and remaking of supply chains, and will incur operational disruptions to high fixed cost assets that depend on high utilisation rates to optimize profit margins. A study by industry consultants Accenture/NexantECA has estimated the cost of achieving Net Zero by 2050 for European chemical assets alone at more than €1 trillion. We note that EU policymakers recognise the need to implement regulation to encourage low carbon solutions, with the Green Deal providing financial support for renewable energy development and calling for sustainable financing to support other Net Zero initiatives.

Exhibit 10: The financing gap between available capex* and minimum required investment to reach net zero by 2050 currently stands at €365bn



* Available capex until 2050 is extrapolated from 2019 chemical company spend within EU27 countries.

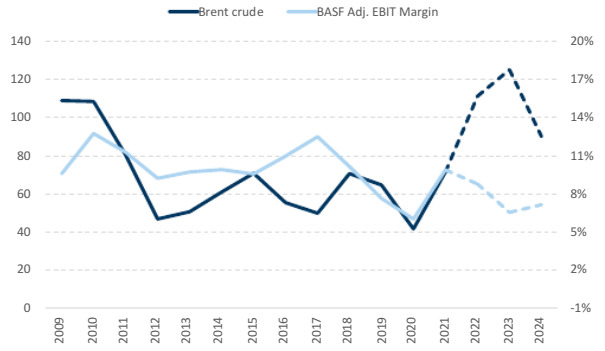
Source: NexantECA, Accenture, Goldman Sachs Global Investment Research

Breaking down the €1 trillion cost of Net Zero for the chemical sector: as shown in the chart above, the work by Accenture/NexantECA determined that meeting the 2050 goal for the production of the eight most energy intensive chemicals will require €400bn to €600bn in capital expenditures for core equipment and the design, construction and modification of facilities. According to those consultants, making the transition could entail another €200bn to €300bn in standstill costs (lost profits due to halted production as plants are retrofitted, improved or rebuilt). In addition, the research estimated that transitioning production of the other chemicals (i.e. European chemicals beyond the eight most energy intensive) would add another €250bn to €350bn to costs.

Chemical prices could decouple from oil prices in circular economy

The major driver of chemical prices today are raw material prices which are to a large extent derivatives of oil and gas. Historically, there has therefore been strong correlation between petrochemical prices and the oil price, with the overlay of the supply and demand dynamics in each specific value chain. Having a volatile global commodity as a key pricing input has its positives (strong supply visibility and easy to switch suppliers) and negatives (volatile costs, poor visibility on future product margins, difficulty in funding volatile hedge program mark-to-market, high customer visibility of costs reduces pricing power). In a world where the industry's feedstock slate becomes much more diversified, chemical product prices could decouple from the macro and geopolitically sensitive oil price and offer more value-based pricing models.

Exhibit 11: Historically, BASF's margins have shown a correlation to the oil price, albeit not perfect due to the overlay of S&D dynamics in each specific value chain
BASF EBIT margin (RHS) vs. Brent Crude price ($/boe, LHS)



Source: Bloomberg, Company data, Goldman Sachs Global Investment Research

Deglobalisation and circular economy themes are interlinked

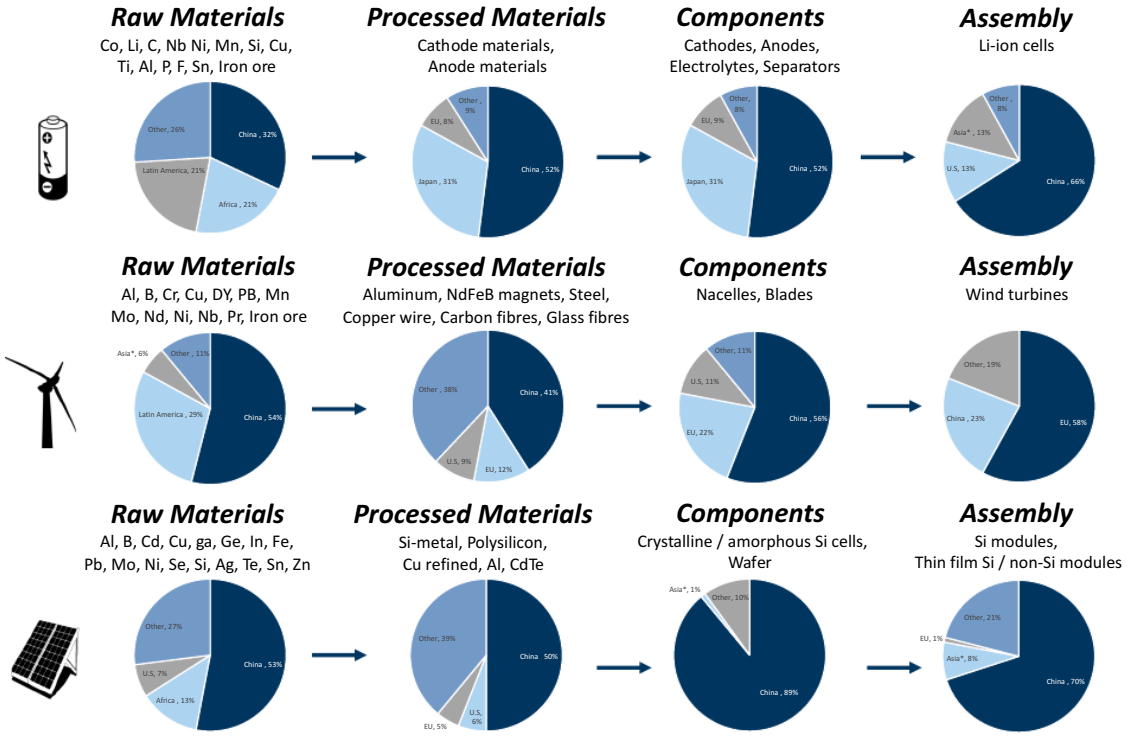
We believe deglobalisation and the circular economy are two sides of the same coin: both require the breaking and remaking of supply chains. As we have written about more extensively here, we believe both climate change and circular economy ambitions could drive fragmentation of global supply chains in favour of more localised business models. Alongside reducing CO2 footprints, regional business models also offer greater supply chain security and reduce dependence on other regions. We believe the chemicals sector's ability to innovate away from location-dependent oil and gas

feedstocks towards renewable and recycled inputs means circular economy implementation could generate strategically important local supply security.

That said, we see instances where local production for local consumption is harder, particularly for minerals/metals where global supply chains will continue to be important. The rising threat of climate change has provided a tailwind for the demand of non-carbon-emitting sources of electricity and energy storage technologies. As shown in Exhibit 12, clean energy technology components rely on a range of minerals with varying levels of criticality, largely dependent on price volatility and the stability of supplier country. Although available globally, these minerals are often highly concentrated in a few countries, with c.50% of global supply of cobalt coming from DR Congo and over 80% of the global supply of lithium coming from Australia, Chile and Argentina, and over 85% of the global supply of rare-earth elements coming from China.

Although traditionally known as a simple mineral producer or component assembler, due to developments in its midstream and downstream capacities, China has emerged as a high-value manufacturer that requires a growing volume of the minerals and metals which are essential for clean energy technology manufacturing. This has led to increased pressure on other major world economies, such as the US and EU, which are import-dependent to secure their critical mineral supply chains. Thus, these major economies are deploying strategies to secure their critical mineral supply chains, with the EU prioritising innovation to ensure the reduction, reuse and recycling of materials to enable at least some resource independence. Although currently still fairly import-dependent, the EU strategy, which aims to secure fair and sustainable supply of minerals while encouraging circular use of resources through recycling, is beginning to gain momentum.

Exhibit 12: Clean energy mineral supply chains and top global suppliers



*Asia excluding Japan and China

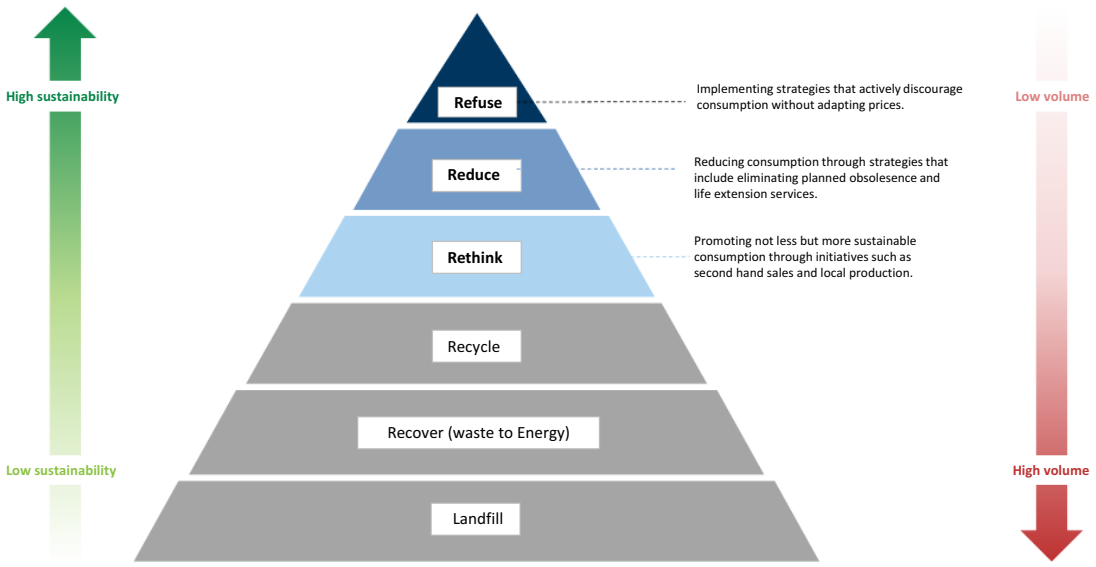
Source: CSIS, European Commission

Declining planned obsolescence could pressure volumes for chemicals

Planned obsolescence (e.g. iPhones, fast fashion, new car models) has been used to increase sales by stimulating desire or perceived need. A circular economy would mean the end of planned obsolescence as consumer goods improve product design to extend useful-life, reusability and reparability. We note the potentially significant downwards pressure on future volume expectations for chemicals. While we would not expect the sector to be able to fully offset demand declines, we could see chemicals collaborating more closely with customers in product design and recycling, thus creating new revenue opportunities to help soften the impact of weaker volumes.

While we could propose the extreme motion that the most environmentally friendly product is one that is not manufactured at all, there are basic shelter, food and water needs that can only be delivered at current population levels by making chemicals (and yes that includes plastics!). Additionally, the human desire to create and possess physical items will not disappear. In that case, the chemicals industry needs to work with customers to ensure product durability, reusability and recyclability are built in from the start in order to reduce consumption of virgin material and waste. We believe this product stewardship lends itself to more service-based business models.

Exhibit 13: Moving to a Circular Economy will drive a shift towards lower volumes for the chemicals industry

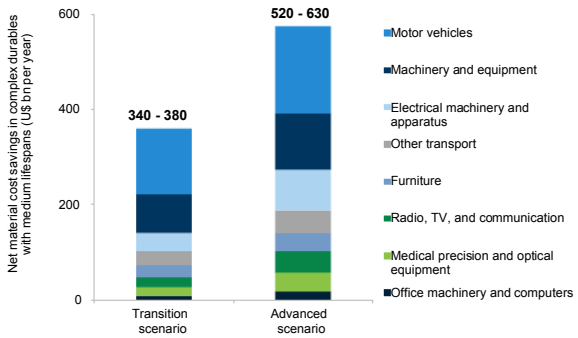


Source: Frontiersin, Goldman Sachs Global Investment Research

Customer circularity/climate change ambitions cannot be met without successful chemicals transition

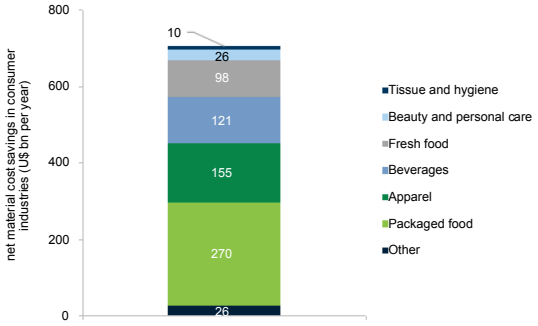
Chemical ingredients are used in almost all end markets. This means the sector is essential for enabling downstream customers to meet their own climate change or circularity targets. For example, per company targets, L'Oreal is aiming for 100% renewable packaging and 95% ingredients bio-based, circular or derived from abundant materials, and Unilever is aiming for 100% of plastic packaging to be reusable, recyclable or compostable by 2025. To enable this, their raw material suppliers will need to be in a position to supply these demands. The majority of chemicals companies we engage with on this topic anticipate a period, likely in the mid to late 2020s, where demand for low carbon/circular economy compliant products will far exceed available supply and generate a period of attractive pricing for these products. In this case, first movers on low carbon or circular economy-based products will be able to capture some good tailwinds and enjoy a period of competitive advantage, in our view (for an overview of early movers in EU chemicals, see following section, Exhibit 3).

Exhibit 14: Our GS SUSTAIN team has shown circularity in manufacturing could yield significant net materials cost savings, in end-markets addressable by the chemicals industry
Net material cost savings in complex durables with medium lifespans, U$ bn per year, EU



Source: World Economic Forum, Eurostat, Ellen MacArthur Foundation

Exhibit 15: Circularity in relevant fast-moving consumer goods sectors could yield net materials cost savings of ~US$700bn p.a.
Net material cost savings in consumer industries, U$ bn per year, global



Source: World Economic Forum, Ellen MacArthur Foundation

Another inflationary thematic...

We find it clear from many of the previous topics discussed above (high capex requirements, deglobalisation, more value-based pricing models) that implementing a circular economy is likely to be inflationary, at least in the early phases.

GS CAM Methodology

With this note, we introduce our GS Circular Alignment Monitor (Exhibit 3), aiming to identify the companies in our coverage most aligned to Circular Economy principles. The monitor compares companies on 5 different metrics: 1) circular energy as % of total energy consumption, 2) circular raw materials as % of total, 3) Circular Economy targets, 4) sustainable solutions and services as a % of sales, and 5) FY22-24E average CROCI. The average score across each of the 5 metrics is shown in the individual company profiles above. The logic for choosing these metrics for our screen is detailed below, and we show the average across all metrics (i.e. average of circular energy as % of total, circular raw mats as % of total, etc.) in Exhibit 16.

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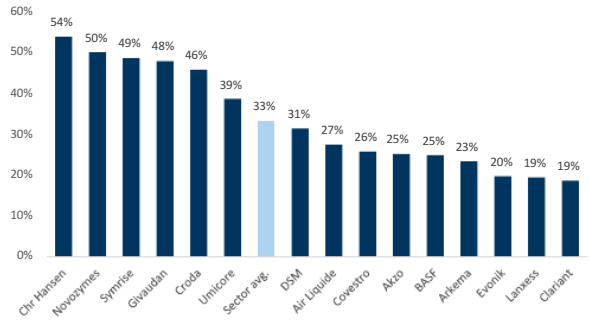
Average of each of the 5 metrics in our monitor



Source: Goldman Sachs Global Investment Research

Given the dynamic M&A backdrop within European Chemicals, particularly the ongoing trend of Diversified players looking to divest most upstream assets, we note this monitor will likely see significant changes over time. We aim to update the monitor as businesses evolve, both from an inorganic standpoint and a more fundamental standpoint, as companies announce new targets, and as technology makes progress towards achieving a fully Circular Economy. In the near future, we note DSM's metrics in our monitor should improve; DSM on May 31, 2022, announced its intention to divest its most cyclical business, Engineering Materials. We have also made assumptions for data where there were uncertainties or discrepancies in the data, which we expect to improve on over time.

We include AIRP in our CAM for completeness but highlight that the business model is quite different to the other product and ingredient manufacturers we cover. To some extent, Air Liquide's ability to deliver both Net Zero and circularity ambitions is in the hands of its customers that produces fuels, steel or chemicals and plastics also opting to take on these ambitions (hence Air Liquide's strategy to partner its customers towards climate friendly solutions). This is visible in the fact that Air Liquide's 2021 emissions report showed Scope 3 category 11 "use of sold products" corresponds to 9.2 MtCO2e, i.e. ~40% of Scope 3 emissions and ~15% of cumulative Scope 1+2+3

emissions. This sets the group apart from other companies where this emission item is linked to the main products and may represent more than 90% of the total carbon footprint. That said, the company actively pursues many circular economy strategies, including valorizing waste (including CO2 capture and recovery of organic waste into biomethane/bio-fertilizer) and co-products (nitrogen, rare gases, carbon monoxide, steam), increasing customer energy/emission efficiency, and has initiated an extensive review of its Scope 3 emissions.

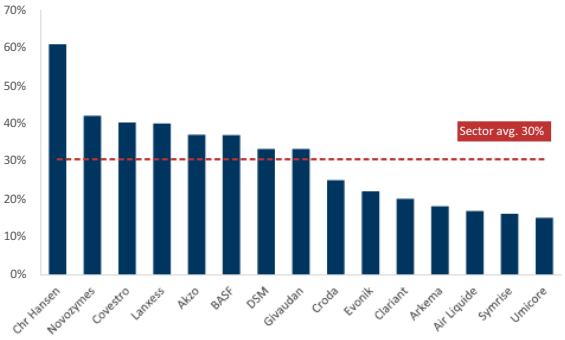
Consumer ingredients well-placed; Covestro and BASF stand out upstream

From today's perspective, we find the Consumer Ingredient names are currently better placed for the transition to a Circular Economy. We conclude Chr Hansen is the most aligned to a Circular business model, scoring above sector-average on all metrics thanks to its ambitious targets, strong cash generation, and high share of circular products in both its raw materials and energy consumption. Within the Consumer Ingredients sub-sector, DSM is relatively the lowest-scoring name, albeit we note this should improve significantly (particularly in terms of circular raw materials and sustainable solutions) upon divestment of its Engineering Materials business (expected to close 1H23). In the Diversifieds space, we see Covestro as best-positioned, largely thanks to it being one of the only names in the sector to disclose a target to be Fully Circular (albeit with no date attached to this ambition). We see BASF as having best-in-class disclosure of current Circular Economy solutions, with near-term targets and deliverables that are easy to track. Overall, we find Evonik and Lanxess are the lowest-scoring names on our methodology.

1. Circular Energy

We define circular energy as being renewable, waste-generated or bio-mass, among others. In our view, this is a key metric to track in determining Circular alignment, given energy is a significant source of both emissions and costs for the Chemicals industry. Additionally, we find this metric relatively easier to track than others given improving company disclosure of renewable energy share of total. We find Chr Hansen is the clear leader on this metric, with >60% of its energy consumption coming from circular sources.

Exhibit 17: Chr Hansen has the largest share of circular energy in its total energy consumption
Renewable energy as % of total energy consumption



Source: Company data, Goldman Sachs Global Investment Research

Exhibit 18: Sector ranking and ranking criteria summary

	Circular as % of energy	Rank
Arkema	18%	1
BASF	37%	2
Covestro	40%	3
Clariant	20%	2
Evonik	22%	2
Lanxess	40%	3
Chr Hansen	61%	4
Croda	25%	2
DSM	33%	2
Givaudan	33%	2
Novozymes	42%	3
Symrise	16%	1
Akzo	37%	2
Air Liquide	17%	1
Umicore	15%	1
Sector avg.	30%	2.1

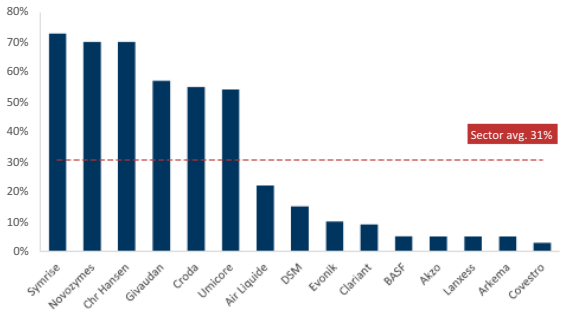
Rank	Criteria
1	20%
2	40%
3	60%
4	80%
5	100%

Source: Goldman Sachs Global Investment Research

2. Circular Raw Materials

The second metric we track in our alignment monitor is circular raw materials as a share of total. We view changing feedstocks as a major consideration in the shift towards circularity, and expect it to represent one of the most obvious demonstrations of company implementation. Below we show where we see the % of circular economy adhering feedstocks for our European chemical coverage, including natural/biobased, recycled or carbon capture feedstocks. We find that among the consumer ingredients, Symrise, Novozymes and Chr Hansen are leading the way, while DSM is currently lagging (albeit should improve significantly upon divestment of its Materials business). Among the more cyclical names, the picture is broadly similar, but we highlight Evonik and Clariant as slightly ahead of the remaining peers.

Exhibit 19: The Consumer Ingredient names generally have higher shares of circular compliant raw materials, while the Diversifieds are weaker on this metric
Secondary/bio-based materials as % of total raw materials



Source: Company data, Goldman Sachs Global Investment Research

Exhibit 20: Sector ranking and ranking criteria summary

	Secondary /Bio as % of total rmat	Rank
Arkema	5%	1
BASF	5%	1
Covestro	3%	1
Clariant	9%	1
Evonik	10%	2
Lanxess	5%	1
Chr Hansen	70%	5
Croda	55%	4
DSM	15%	2
Givaudan	57%	4
Novozymes	70%	5
Symrise	73%	5
Akzo	5%	1
Air Liquide	22%	2
Umicore	54%	4
Sector avg.	31%	2.6

Rank	Criteria
1	10%
2	30%
3	50%
4	70%
5	100%

Source: Goldman Sachs Global Investment Research

3. Circular Economy Targets

This metric is the only qualitative one within our framework; we compare Circular Economy targets, where there are any, across our coverage, and assign a rank based on the scope and timeframe of the target. Through incorporating targets, we aim to capture company momentum towards a Circular Economy, which we believe makes the alignment monitor more comparable across Diversifieds and Consumer names, as although the Diversified names generally have exhibited less progress towards a Circular Economy to date, some have ambitious future targets (e.g. Covestro is targeting to become fully circular). We summarise targets across the sector in the table below.

Exhibit 21: European Chemicals Circular Economy target specifications

	Target year	Base Year	Circular Economy Target specification
Arkema	2024		50% of sales volume covered by a life-cycle assessment by 2024
BASF	2030	2020	Double sales of circular solutions (vs. 2020)
Covestro	n/a		Become fully circular
Clariant	2025		1% annual growth by developing bio-based products, enabling defossilization, and promoting circularity
Evonik	2030		Circular Plastics Program >€350mn sales potential by 2030
Lanxess	2040		100% reuse, recycling and/or recovery of plastics packaging in EU
Chr Hansen	2024		100% key packaging materials recyclable (67% in FY19/20)
Croda	2030		>75% organic raw materials will be bio-based
DSM			Maintain the % of recycled waste in range of 80-90%
Givaudan	2030		100% plastic circularity
Novozymes	2030		100% key raw materials managed in circular systems
Symrise	2025		Recycle more than 95% of recyclable plastics
Akzo	2025		50% recycled content in its plastic packaging (Deco Europe)
Air Liquide			>€6bn hydrogen sales and 3GW elctrolysis capacity by 2035. Partnering with industry to become circular via H2, oxy-combustion, biogas and carbon capture technologies
Umicore	2030		50% of metal supply requirements from in-house recycling

Source: Company data, Goldman Sachs Global Investment Research

Exhibit 22: Sector ranking and ranking criteria summary

	Circular Economy Target	Rank
Arkema	35%	3
BASF	45%	4
Covestro	45%	4
Clariant	25%	2
Evonik	25%	2
Lanxess	25%	2
Chr Hansen	45%	4
Croda	55%	5
DSM	35%	3
Givaudan	55%	5
Novozymes	45%	4
Symrise	55%	5
Akzo	35%	3
Air Liquide	35%	3
Umicore	35%	3
Sector avg.	40%	3.5

Rank	Criteria
1	No ambition
2	Some targets
3	Moderately ambitious
4	Significantly ambitious
5	Full circularity

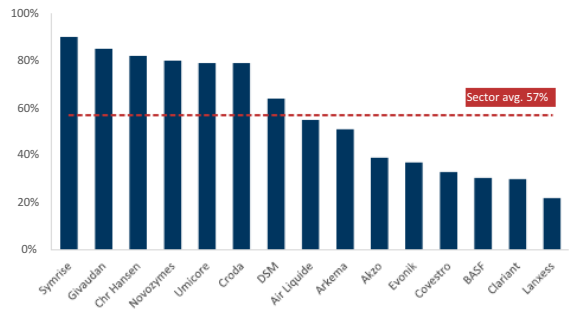
Source: Goldman Sachs Global Investment Research

4. Services & Circular Solutions

This metric addresses the share of total company sales that address Circularity, or

provide services to help customers address Circularity such as recycling and engineering support, which are emission-free revenue generating activities, and as Circular as possible. We believe this is an important factor to analyse given many of the companies in our coverage are actively helping customers to decarbonise and become more sustainable (e.g. Novozymes is supplying products that can replace traditional surfactants, Air Liquide is providing services to help customers become more Circular), which in some cases offsets lower scores on metrics such as current circular targets. The Consumer Ingredient companies lead on this metric, and are all broadly similar, and we highlight Arkema as not being far behind.

Exhibit 23: Symrise and Givaudan lead the sector on the basis of sustainable solutions as % of sales



Source: Company data, Goldman Sachs Global Investment Research

Exhibit 24: Sector ranking and ranking criteria summary

	Services & Circular solutions as % of sales	Rank
Arkema	51%	3
BASF	31%	2
Covestro	33%	2
Clariant	30%	2
Evonik	37%	2
Lanxess	22%	2
Chr Hansen	82%	5
Croda	79%	4
DSM	64%	4
Givaudan	85%	5
Novozymes	80%	5
Symrise	90%	5
Akzo	39%	2
Air Liquide	55%	3
Umicore	79%	4
Sector avg.	57%	3.3

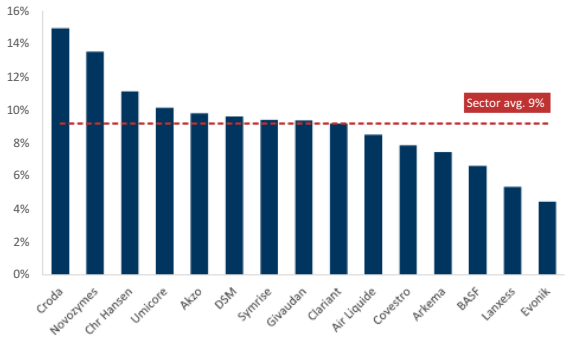
Rank	Criteria
1	20%
2	40%
3	60%
4	80%
5	100%

Source: Goldman Sachs Global Investment Research

5. CROCI

We believe transitioning to a circular business model will involve significant investment for companies across our coverage given new technologies will be required, involving the breaking and remaking of supply chains. Additionally we see the transition causing significant operational disruptions to high fixed cost assets that depend on high utilisation rates to optimise margins. Therefore, we screen our coverage on a CROCI basis, to determine which names are most likely to be able to generate the cash to support this investment, and therefore which names are better placed for the transition to a Circular Economy. We highlight Croda in particular for its sector-leading CROCI over the next 3 years; we forecast average 15% over FY22-24E, vs. sector 9%.

Exhibit 25: Croda screens as best-in-class on a CROCI basis, followed by Novozymes and Chr Hansen, while BASF, Lanxess and Evonik clearly lag peers
FY22-24E average CROCI



Source: Goldman Sachs Global Investment Research

Exhibit 26: Sector ranking and ranking criteria summary

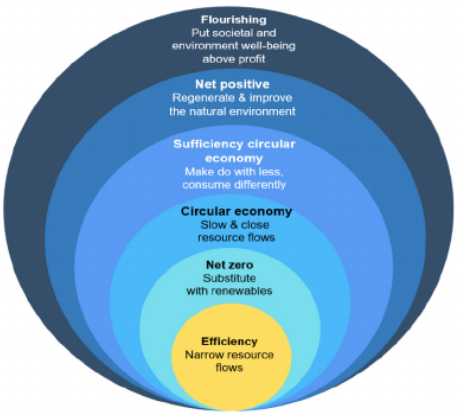
	N3Y avg. CROCI	Rank
Arkema	7%	2
BASF	7%	1
Covestro	8%	2
Clariant	9%	3
Evonik	4%	1
Lanxess	5%	1
Chr Hansen	11%	4
Croda	15%	5
DSM	10%	3
Givaudan	9%	3
Novozymes	14%	5
Symrise	9%	3
Akzo	10%	3
Air Liquide	9%	2
Umicore	10%	3
Sector avg.	9%	2.7

Rank	Criteria
1	7%
2	9%
3	11%
4	13%
5	15%

Source: Goldman Sachs Global Investment Research

We provide an overview of European Chemicals' current stance on the circular economy. We find that only Covestro, BASF, Givaudan and Novozymes have targets expressly linked to the circular economy, but all have climate change ambitions that we believe can only be achieved with circular economy implementation. We also rank the stocks according to the greatest number of mentions in most recent annual report in Exhibit 28.

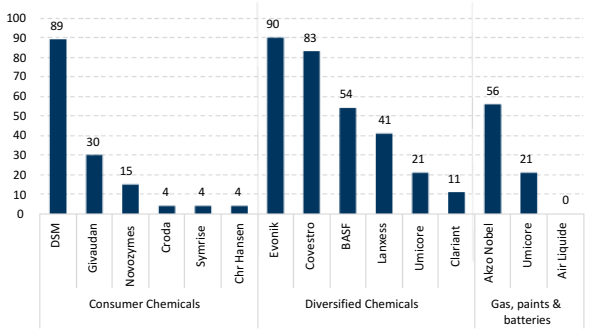
Exhibit 27: Covestro targets fully circular while Croda, Symrise and Givaudan aim for Climate positivity
Hierarchy of sustainable business models and summary of company targets relating to circularity



Sustainable Business Model	Company	Target year	Target
NET POSITIVE	Croda	2030	Climate-positive by 2030
	Symrise	2030	Climate-positive starting in 2030
	Givaudan	2050	Climate-positive before 2050
CIRCULAR ECONOMY	Covestro	N/A	Become fully circular
NET ZERO	DSM	2050	Net zero by 2050
	Novozymes	2050	Net zero by 2050
	BASF	2050	Net zero by 2050 (Scope 1+2)
	Clariant	2050	Climate-neutral by 2050
	Evonik	2050	Climate-neutral by 2050
	Air Liquide	2050	Climate-neutral by 2050
	Lanxess	2040	Climate-neutral by 2040
	Covestro	2040	Climate-neutral by 2035 (Scope 1+2)

Source: Company data, Goldman Sachs Global Investment Research

Exhibit 28: DSM, Evonik and Covestro lead the sector in terms of number of mentions of Circular Economy in their latest annual report
Number of mentions of Circular Economy key words* in most recent annual report (FY21)



*Key words are "Circular Economy", "Circularity", "Product cycles"

Source: Company data, Goldman Sachs Global Investment Research

We note few companies in our coverage currently disclose "green capex" targets, indicating the expected level of investment into sustainable products and solutions in future. Two we would highlight are Covestro and BASF. Covestro is the only name to have committed to a circular economy investment target; the company expects to spend up to €1bn of its capex budget over the next 10 years to projects promoting a circular economy. BASF has committed to spending up to €4bn on transforming its operations to become more sustainable from 2021-30, with the majority of the investment coming over 2026-2030. Additionally, we note Air Liquide and Umicore, while not explicitly providing green capex targets, have an implied high share of sustainable investments. At Umicore's recent CMD, management noted it plans to run the Catalysis business (the less sustainable business that supplies traditional ICEs) for cash, with limited investment over the next 10 years. Therefore, with investment targeted in the Recycling and E&ST divisions, we expect green investments to make up a high share of total capex. Air Liquide reports next 12-month investment opportunities, and the % of this which are projects relating to energy transition (i.e. are green). At its 2Q results, Air Liquide noted this metric currently stands at 40%, in line with the last few quarters.

Policy support and higher selling prices needed to close the loop

We find that chemical companies are generally optimistic about the upside opportunities a circular economy presents their businesses, but they also highlight the key requirements for the industry to make the changes required:

- Better renewable energy availability
- Policy support - recognition of chemical recycling as a viable technology
- Funding support - both from policymakers and commercial partnerships
- Higher selling prices

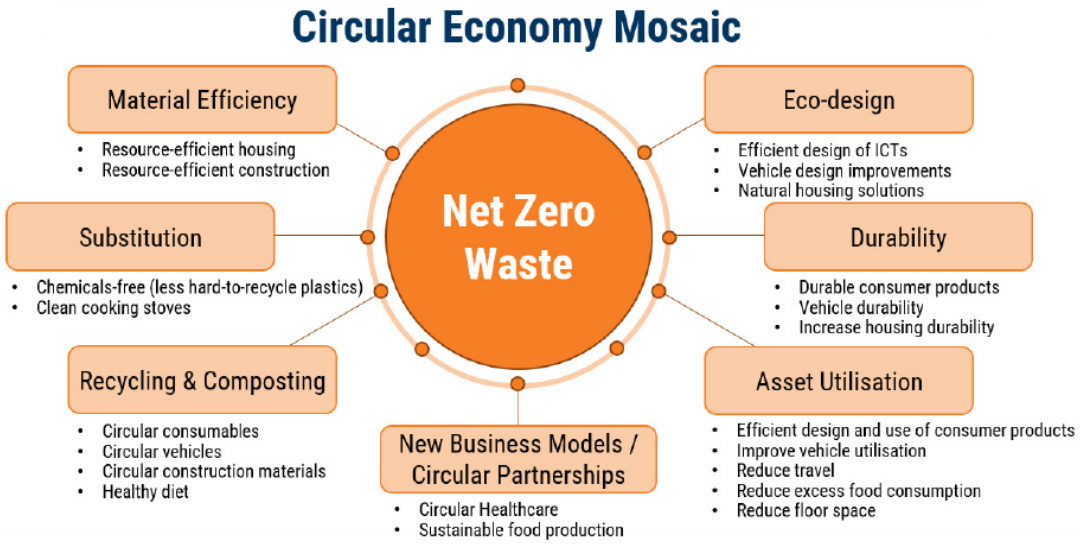
BASF believes that low emission products from its climate change and circular economy initiatives will deliver above-average volume growth and higher margins vs. traditional/higher emission products. To deliver on these expectations, BASF states the following requirements:

- Increased capex partially mitigated through public funding for pioneering, new technologies
- A supportive regulatory framework for alternative feedstocks (encourage renewable/recycled feedstocks and encourage innovation), sustainable products (rate sustainability using a holistic approach) and waste management (harmonize and simplify)
  - A level playing field must be created for mechanical, chemical and organic recycling; this includes incentives for both segregated as well as mass balance allocated recycled content.
  - Policy framework on the use of biodegradable or compostable plastics should consider the benefits of such materials for certain applications, particularly when these are collected with food residues and help separate collection of bio-waste.
- Customer willingness to pay higher prices for low-emission products
- High initial variable costs for renewable energy have to decline with increased availability and favorable regulatory changes

Without regulatory and policy support, we are cautious on the ability of upstream chemicals in Europe to retain global competitiveness/growth opportunities and attract investment and highlight the risk that Europe's ability to drive sustainable innovation would be materially hampered (see accompanying note on this topic).

Appendix

Exhibit 29: Utilising the Oxford Institute for Energy Studies, our GS SUSTAIN team sees seven critical components for unlocking the opportunity in wasted resources and reduced waste



Source: Oxford Institute for Energy Studies, Circle Economy, Goldman Sachs Global Investment Research

Disclosure Appendix

Reg AC

We, Georgina Fraser, Ph.D., Ji woo Song and Isabel Appen, hereby certify that all of the views expressed in this report accurately reflect our personal views about the subject company or companies and its or their securities. We also certify that no part of our compensation was, is or will be, directly or indirectly, related to the specific recommendations or views expressed in this report.

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Growth is based on a stock's forward-looking sales growth, EBITDA growth and EPS growth (for financial stocks, only EPS and sales growth), with a higher percentile indicating a higher growth company. **Financial Returns** is based on a stock's forward-looking ROE, ROCE and CROCI (for financial stocks, only ROE), with a higher percentile indicating a company with higher financial returns. **Multiple** is based on a stock's forward-looking P/E, P/B, price/dividend (P/D), EV/EBITDA, EV/FCF and EV/Debt Adjusted Cash Flow (DACF) (for financial stocks, only P/E, P/B and P/D), with a higher percentile indicating a stock trading at a higher multiple. The **Integrated** percentile is calculated as the average of the Growth percentile, Financial Returns percentile and (100% - Multiple percentile).

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Akzo Nobel (€63.94), Arkema (€85.98), BASF SE (€42.19), Chr Hansen (Dkr428.70), Clariant (SFr17.96), Covestro (€30.22), Croda (6,834p), DSM (€129.60), Evonik (€18.85), Givaudan (SFr3,166.00), Lanxess AG (€33.00), Novozymes (Dkr427.80), Symrise (€105.50) and Umicore (€32.20). Prices as of close August 30, 2022.

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