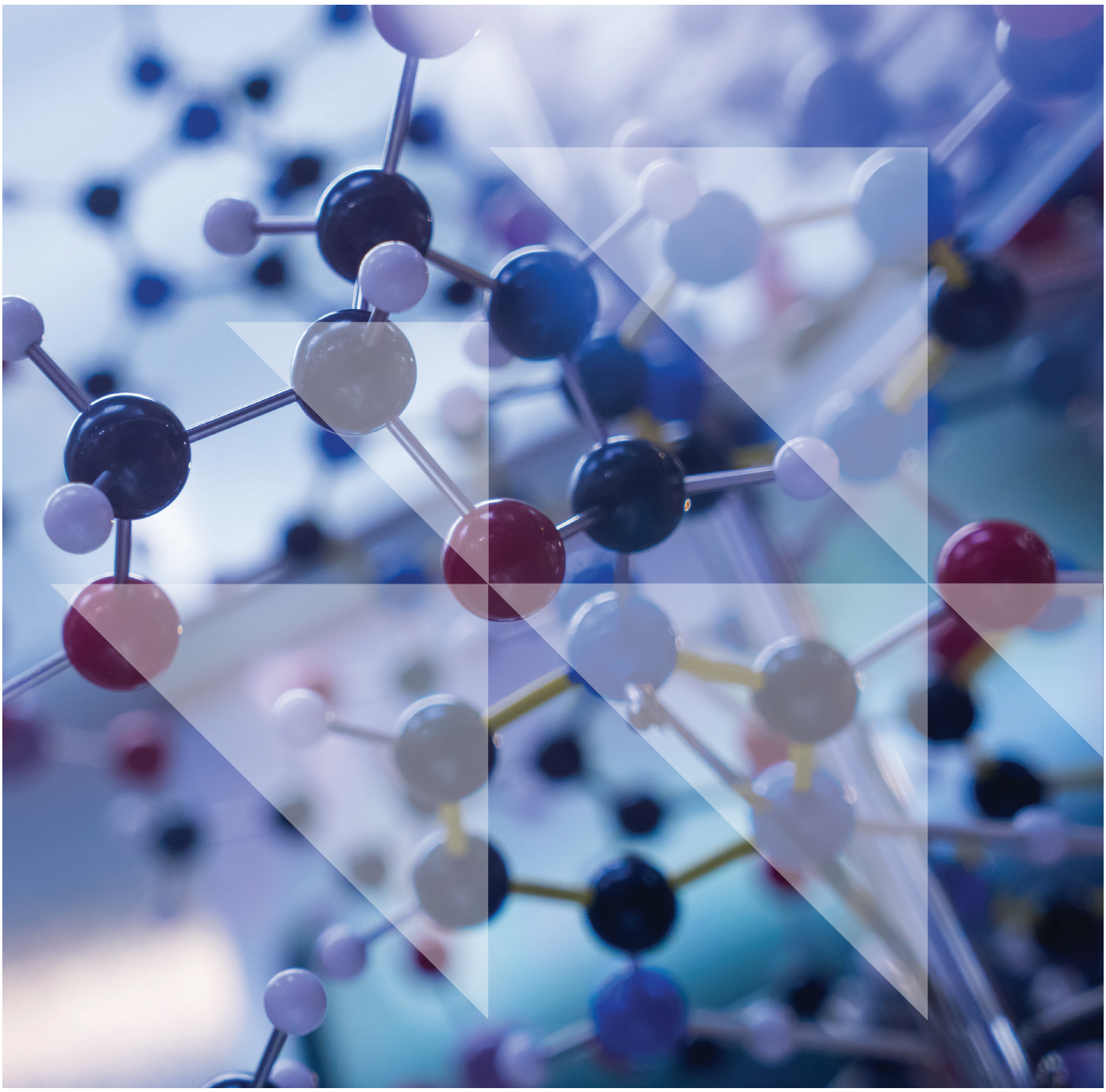
# Catalyst for change

## Which chemical companies are prepared for the low carbon transition?

October 2017



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# Linking climate-related metrics to earnings for chemical companies

This report updates and expands CDP's research and League Table for chemical companies, first published in August 2015. It ranks 22 of the largest publicly listed chemical companies on business readiness for a low carbon transition which in aggregate emit 276 Mt $CO_2$ emissions per annum, accounting for approximately 25% of emissions of the global chemical industry. Notable omissions are the Chinese chemical industry and the petrochemical businesses of oil & gas companies.

The chemicals industry is a large energy user, with petrochemicals accounting for 11% of total annual energy use (28% of industrial use) and accounting for 13% of global industrial $CO_2$ emissions (IEA 2017). At the same time, chemical products and processes are intertwined with a number of industries and products, including energy efficient and low carbon products and processes in other sectors – around 95% of manufactured products rely on chemistry (ICCA).

Large scale chemical plants and integrated facilities have been targeting energy efficiency improvements of 2% annually over a number of years, leaving only incremental gains (0.5% - 1.5%) to be made on existing plants.

This industry covers a diverse group of companies from pure play petrochemical companies, diversified companies with business models based on horizontal and vertical integration and speciality companies servicing a range of end markets from nutrition, healthcare, electronics and autos.

A number of chemical products also enter the value chain of different industries at different points. This creates complexity and a lack of transparency, presenting challenges for policy makers and estimates of Scope 3 emissions.

There are four key areas assessed in the League Table, which have been aligned with recommendations for company reporting from the G20 Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD):

**Transition risks:** We assess companies' exposure based on emissions intensity, energy intensity and Scope 3 emissions in the value chain.

**Physical risks:** We assess companies on use and withdrawal of water as well as water quality and governance metrics.

**Transition opportunities:** We assess companies' progress and strategy in shifting towards a low carbon economy by looking at product and process innovation, low carbon revenues, R&D spend and use of renewable energy.

**Climate governance and strategy:** We analyze companies' governance frameworks including emissions reduction targets and alignment of governance and remuneration structures with low carbon objectives.

## Key findings

- **The chemicals sector performs well in terms of emissions and energy intensities** with most companies in the universe covered showing annualized improvements in emissions and energy efficiency of between 2-5% which flow directly to the bottom line.

- **Efficiency improvements are likely to continue, although the pace will be incremental in the short-term,** evidenced by much less ambitious targets for emissions intensity - even small changes in efficiency could be meaningful given the scale of operations.

- **High carbon risks remain for the sector in the medium to long term which require game changing technologies in feedstock and processes** which are a good 5-10 years away with current process innovation based on incremental improvements.

- **While transition and physical risks remain, the sector is found to be innovative** with potential to generate revenues from products and processes for customers transitioning to a low carbon economy, mitigating risks.

- **R&D % of sales for the sector is around five times higher than other industrial sectors,** supporting scope across the sector to capitalize on revenue streams from low carbon technologies.

- **The sector suffers from a lack of transparency evidenced by the lack of reporting on disaggregated data,** with a prolonged period of cross border M&A and vertical integration creating groups which are hard to analyze and regulate.

- **Regulation is likely to be uneven for this global sector** with European chemical companies facing tougher regulation from committed carbon emission cuts and potentially higher capex in the medium to long term.

- **Pressure from carbon regulation on consumer demand is limited** with packaging pollution the only likely source of a "diesel" moment for the sector as regulatory pressures increase for a circular economy.

- **The importance of water to operations differs significantly** across the sector, reflecting the heterogeneity of the industry.

- **China is a large part of the chemical sector** – while Chinese chemical companies have been omitted from this analysis, they are big drivers to the supply and demand for chemicals for our universe with the upcoming Chinese ETS creating potential disruption for the sector.

- **AkzoNobel** is a clear leader, outperforming all other companies by a clear margin across most metrics.

- Lowest ranked are **Formosa and LyondellBasell**

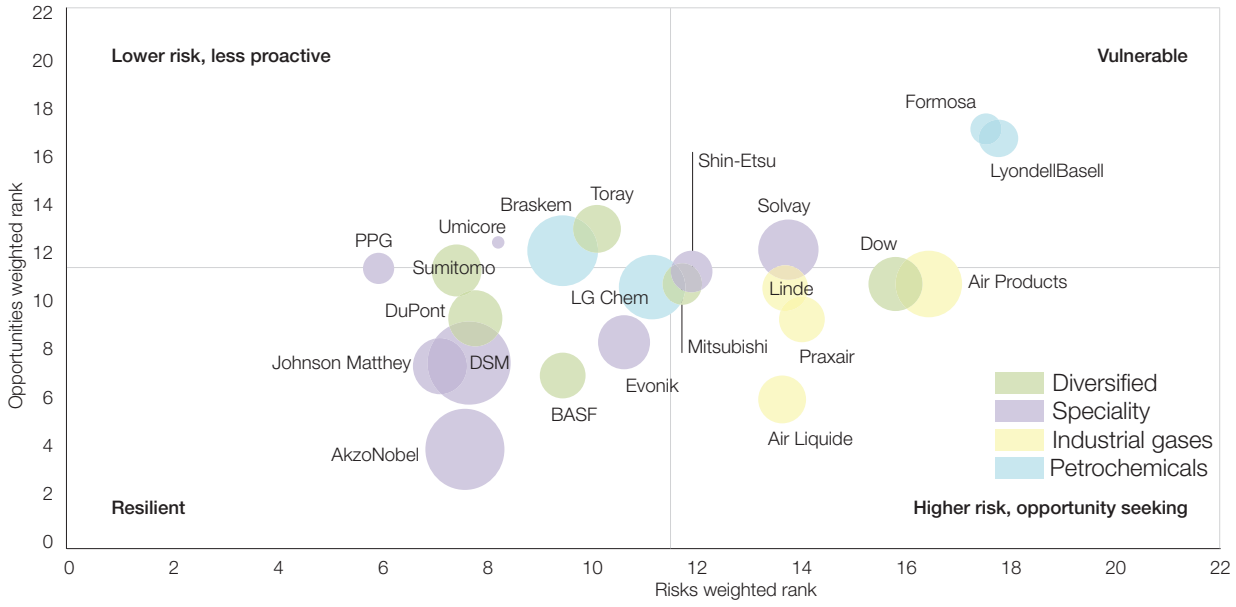
The summary League Table below presents headline company findings. It is based on detailed analysis across a range of carbon and water-related indicators which could have a material impact on company performance. The League Table is designed to serve as a proxy for business readiness in an industry which will undergo significant change as governments increase efforts to implement the Paris Agreement. Companies placed towards the bottom are deemed less prepared for a low carbon transition.

## Figure 1: League Table summary

| League Table rank | Company | Ticker | Classification | Country | Average market cap Q2 2017 (US$bn)(i) | 2016 Emissions (S1+2 $CO_2$ million tonnes) | League Table score | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy | Company classification by revenue (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | AkzoNobel | AKZA NA | Speciality | Netherlands | 20.7 | 3.7 | 5.7 | B | A | A | A | |
| 2 | DSM | DSM NA | Speciality | Netherlands | 12.8 | 1.5 | 6.8 | B | B | B | A | |
| 3 | Johnson Matthey | JMAT LN | Speciality | UK | 7.4 | 0.5 | 7.8 | B | A | B | C | |
| 4 | DuPont | DD US | Diversified | USA | 64.4 | 6.3 | 8.8 | B | C | B | C | |
| 5 | BASF | BAS GR | Diversified | Germany | 88.3 | 20.8 | 9.1 | C | B | B | C | |
| 6 | Sumitomo Chemical | 4005 JP | Diversified | Japan | 9.2 | 6.5 | 9.5 | B | C | C | C | |
| 7 | PPG | PPG US | Speciality | USA | 27.1 | 1.8 | 9.7 | A | C | C | D | |
| 8 | Evonik | EVK GR | Speciality | Germany | 15.2 | 6.4 | 9.8 | C | C | B | C | |
| 9 | Braskem | BRKM5 BZ | Petrochemicals | Brazil | 8.3 | 10.2 | 9.8 | C | A | D | B | |
| 10 | LG Chem | 051910 KS | Petrochemicals | South Korea | 18.6 | 9.1 | 10.2 | C | B | C | B | |
| 11 | Air Liquide | AI FP | Industrial gases | France | 46.0 | 25.2 | 10.6 | C | D | B | C | |
| | *DowDuPont (ii)* | *DWDP US* | *Diversified* | *USA* | *159.7 (ii)* | *41.8* | *10.8* | | | | | |
| 12 | Toray | 3402 JP | Diversified | Japan | 14.3 | 5.6 | 11.4 | B | D | D | C | |
| 13 | Mitsubishi Chemical | 4188 JP | Diversified | Japan | 12.0 | 14.5 | 11.7 | C | B | C | D | |
| 14 | Shin-Etsu | 4063 JP | Speciality | Japan | 37.7 | 6.2 | 11.8 | C | C | C | D | |
| 15 | Umicore | UMI BB | Speciality | Belgium | 7.2 | 0.7 | 11.9 | B | D | D | E | |
| 16 | Praxair | PX US | Industrial gases | USA | 36.0 | 21.2 | 11.9 | D | C | B | C | |
| 17 | Solvay | SOLB BB | Speciality | Belgium | 13.8 | 13.2 | 12.1 | C | D | D | B | |
| 18 | Linde | LIN GR | Industrial gases | Germany | 33.4 | 25.8 | 12.2 | D | B | C | C | |
| 19 | Air Products | APD US | Industrial gases | USA | 31.2 | 30.2 | 12.7 | E | C | C | B | |
| 20 | Dow | DOW US | Diversified | USA | 68.0 | 35.4 | 12.9 | D | D | C | C | |
| 21 | LyondellBasell | LYB US | Petrochemicals | USA | 35.3 | 21.7 | 16.5 | E | E | E | D | |
| 22 | Formosa Plastics | 1301 TT | Petrochemicals | Taiwan | 19.0 | 9.0 | 16.9 | E | D | E | D | |
| Weighting | | | | | | | | **35%** | **10%** | **35%** | **20%** | |

(i) Average market cap for last 12 months up to Q2 2017
(ii) Dow and DuPont completed merger to form DowDuPont on 1st Sep 2017. Average market cap is calculated for Sep 2017.
Source: CDP

## Figure 2: Opportunity vs. risk for low carbon transition




Bubble size: Larger bubble = stronger performance on climate governance & strategy
Source: CDP

# Overview

This report sets out the context for the chemicals sector to achieve decarbonization pathways set out by institutions such as the International Energy Agency (IEA) and Dechema (Society for Chemical Engineering and Biotechnology), to meet policy objectives under the Paris Agreement for a 2°C target by 2100.

The chemicals industry is a large energy user and its products are widely used across a number of sectors in the economy including in terms of providing low carbon products and solutions to other industries – this makes the sector both part of the carbon problem and the solution for decarbonization of the industrial sector.

GHG emissions from the sector are not linked just to energy use in chemical processes but are by-products of using fossil fuel feedstocks. Feedstocks account for around 60% of the energy use for the highly carbon intensive processes in production of petrochemical products with processes 40% (IDB 2013). Shifting to a low carbon pathway will therefore require addressing the high energy intensive processes employed but also the use of feedstock – both require a material shift from current practices.

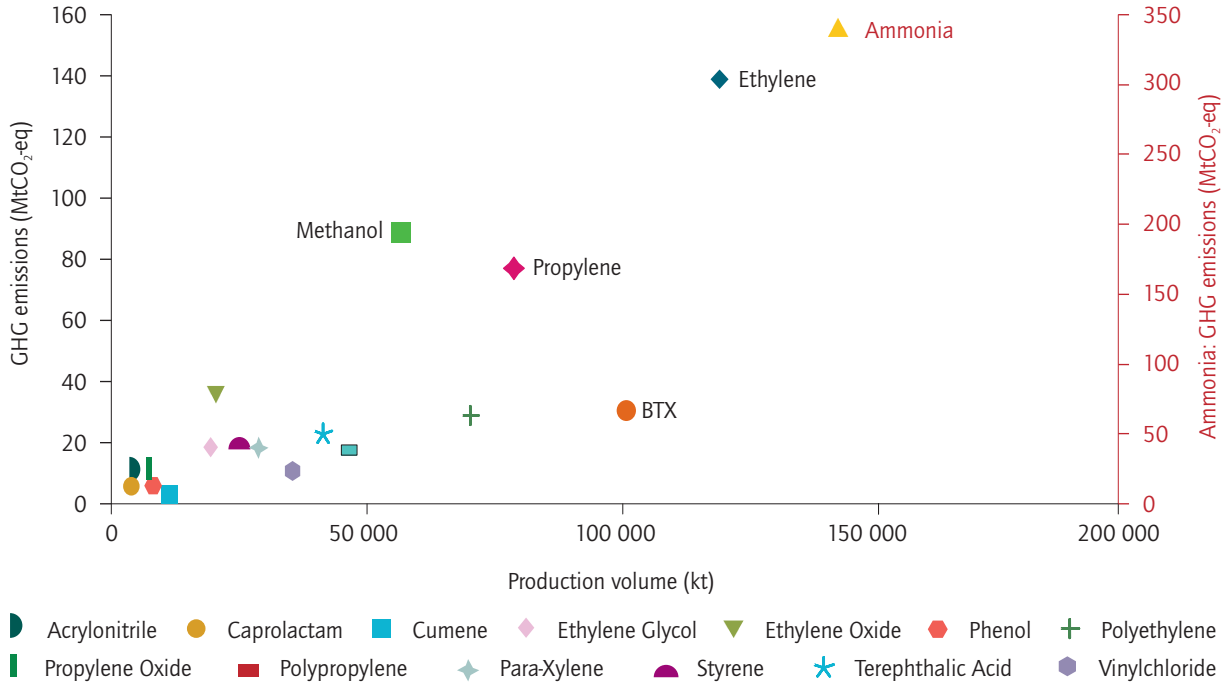
The landscape for the chemical industry has seen significant change in the last decade driven by mergers and acquisitions as chemical companies have followed their customers and become more global and vertically integrated. The availability of cheap shale gas in the US and stranded gas in the Middle East has spurred investment in new petrochemical plants in these regions. These new plants offer scope for higher process and energy efficiencies against older plants in Europe which have seen mainly retrofitting, giving these plants a relative cost and carbon advantage based on lower emissions intensity both from a process and feedstock perspective.

In addition, the capital at risk, even for the highly capital-intensive end of the sector, has a lower "stranded assets"/capital write down risk because of the low rate of substitution for petrochemical feedstocks used and transformed right through the supply chain. Companies that have pursued a strategy of vertical integration have also arguably created business models which are more protected from carbon regulation. The degree of protection depends on the level of commoditisation, with the higher end speciality chemicals tied to consumer end markets related to health, safety and food security being most protected.

The regulatory landscape for the sector varies by region with the EU being most ambitious with targets to reduce carbon emissions by 80-90% by 2050 from 1990 levels. Should the European chemical industry be constrained by these policy ambitions, they will be faced with higher capital requirements to change current plants and processes estimated in a recent Dechema study to be between €17-26.7bn per annum against €2bn on a business as usual basis. Regulation in China through the forthcoming Emissions Trading Scheme could also change the dynamics for the sector as China is a big consumer and producer of a range of chemicals and the ETS could result in either a shift to higher value less intensive chemicals or a closure of old polluting plants creating more import demand for basic chemicals.

The industry is diverse with 1,000s of products making the regulatory task a challenge. However, the manufacture of 18 products account for 80% of energy demand and 75% of greenhouse gases (IEA 2017) and the processes which make these 18 building blocks for the industry are the main focus for finding decarbonization pathways.

**Figure 3: Global GHG emissions versus production volumes of top 18 large-volume chemicals, 2010**




Note: GHG emissions for olefins in this figure represent that of the steam cracking process. Ammonia is presented on a different axis on the right.

Source: Low carbon energy and feedstock for the European Chemical Industry (Dechema, 2017)

Best Possible Technologies offer scope for significant energy savings from 14% to 48% by 2050 depending on deployment rates of incremental to optimistic, against a business as usual scenario which shows energy intensity plateauing at around 11 GJ/tonne (Dechema). These improvements are key to decarbonization as business as usual assumes an absolute rise in energy consumption of 186% to 17.5 EJ and a 194% rise in GHG emissions of 1.7 Gt by 2050. However, there are 130 different industrial processes used to manufacture these 18 products which are generally proprietary making the deployment of best possible technologies (BPT) more difficult to gauge.

Bio-feedstocks will be part of the carbon mitigation for the sector, however, current large scale adoption is limited by the supply of sustainable bio-feedstock and broader environmental considerations in terms of competition with agriculture and impacts on biodiversity.

In this report we cover a range of chemical companies, from petrochemical companies such as Braskem, which are at the high volume commoditized end of the market where large scale integrated facilities bring efficiency gains, to a highly diverse group such as Dow (now DowDuPont) which spans agricultural science to consumer solutions, performance materials & chemicals to performance plastics. In addition, we include less carbon intensive companies from a Scope 1+2 perspective such as DSM with a focus on nutrition and health and Johnson Matthey and Umicore which are involved in auto catalysts and an emerging battery business into electric vehicles. We have also included the industrial gases companies which produce large volume high purity gases such as hydrogen which serve industries such as the refining industry in producing ultra-low sulphur diesel.

The degree of emissions intensity varies across this group with the commoditized petroleum and industrial gases at the beginning of the value chain being more intensive and the speciality chemicals further down the value chain less intensive. However, it is important to recognize the chemical route that runs through these products to assess the risk to carbon regulation. Here, Scope 3 estimates provide some insight into the climate risk in the value chain – we estimate that for this universe of companies two thirds of GHG emissions are Scope 3 emissions in the value chain. A large proportion of the companies outside the industrial gases are exposed to the petroleum route which produces ethylene and propylene, basic building blocks which go on to produce a range of plastics and resins which go into a number of end markets not least electric cars.

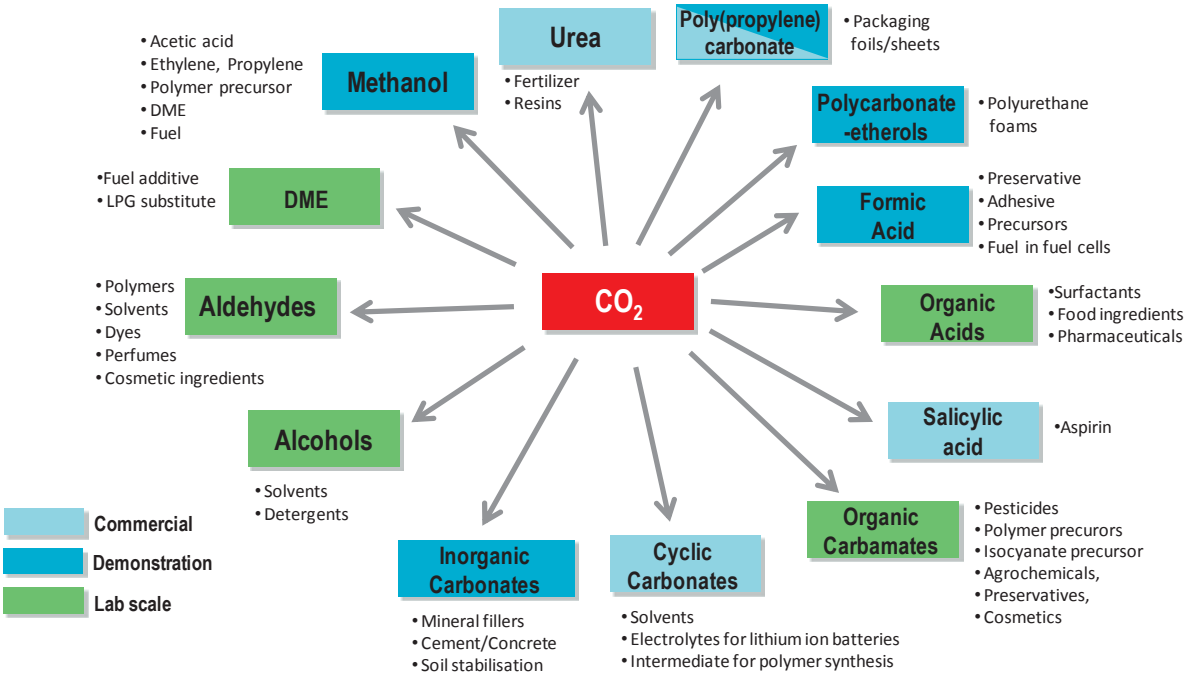
Industrial gases are also highly energy intensive in the production of gases such as hydrogen which would result in higher transition risk purely on an emissions intensity point of view. However, they are well placed on transition opportunities including into a new hydrogen economy, highlighting the inherent conflict of the sector as being part of the carbon problem and solution.

We have not formally assessed storm or weather event risk as a physical risk for this report but recent hurricanes and storm damage expose the vulnerability of petrochemical plants that are typically located along the coast. At the peak of recent storms, 61% of US ethylene production was reported to have halted. Dow, which had strengthened its flood and storm protection capabilities, were better placed than others to continue operations.

The diversity of the sector has presented a challenge in identifying a standard decarbonization pathway. We have used our approach of using transition risks and opportunities, physical risk and governance to position companies based on their carbon intensive nature as well as their scope for innovation and commitment to transition to a low carbon economy.

From an investment perspective, the short-term focus from carbon emissions comes through energy and emissions intensity which have a significant impact on costs. There is also upside from growing revenues from low carbon products and processes. The medium to long term will bring higher capex requirements for process changes to align with decarbonization pathways.

**Figure 4: Target products of chemical $CO_2$ utilisation routes and status of deployment**



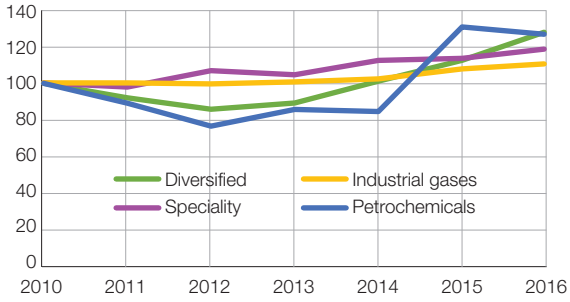

Source: Low carbon energy and feedstock for the European Chemical Industry (Dechema, 2017)

# Key findings

## Operating Risks

Emissions and energy intensities are key metrics for operating costs for the industry and provide a good indication of cost and margin trends which have been robust across most sub-sectors of the industry (see Figure 5).

**Figure 5: EBITDA margin trends (indexed to 2010)**




Source: Bloomberg, company reports

- **Diversified and speciality companies cut operational emissions and energy intensity** with speciality companies performing the best with annualized emission intensity reductions of 2-7% from 2009 to 2016 – Umicore and Shin-Etsu went against this trend.

- **Speciality chemical companies generally have stronger emission targets than other sub-sectors, indicative of significant short to medium term potential for cost-effective cost reductions** – This group has energy costs ranging from approximately 2.5% for Johnson Matthey to 12.5% for Solvay, so an emissions reduction target for the latter will provide better cost savings.

- **Industrial gas companies by contrast have seen an annualized rise in emissions and energy intensities based on revenues** but show flat growth against gross profits – this is a worrying trend as the industrial gas group has high energy cost at between approximately 22.5% for Linde ranging to 45% for Air Liquide. However, contractual arrangements may allow companies to pass on some or all of these costs to customers.

- **Industrial gas companies have lower targets in percentage terms than other subsectors.** This suggests there may be a lower level of cost-effective emissions reductions remaining to be exploited by these companies.

- **The petrochemical sub-group has relatively low energy costs** compared to industrial gases at around 5% to 17.5%. Emissions intensity cuts will require material change in feedstocks and process change not just from energy management.

- **Braskem showed the best performance with their new plant portfolio** and LyondellBasell and Formosa the poorest both on historic performance and governance and future target setting.

## Opportunities

The group performs well on transition opportunities and is found to be innovative based on general R&D spend, low carbon revenue and product innovation. This would reinforce the important role the sector plays in providing low carbon solutions and point to scope for potential revenues in this area.

- **The universe as a whole has a high R&D expenditure as a proportion of sales** compared to other industry groups at a multiple on average of around five times against a sector like steel. Sumitomo and DuPont are leading in this metric, with R&D making up 7.6% and 7% of expenditure respectively. DSM and AkzoNobel report that between 80-100% of their total R&D expenditure is within low carbon products.

- **The exposure to low carbon revenues is high for the sector** with speciality and industrial gas companies performing the best. Of the 6 specialist companies reporting on this metric the range is between 23-59%. DSM leads this group with more than 50% of low carbon revenues.

- **Dow, prior to the merger with DuPont, led the diversifieds with 40% of reported low carbon revenues against DuPont at 10%** - this would put the combined group in a good position in terms of growth in low carbon revenues.

## Long-term climate resilience

- **Only one of the companies, AkzoNobel, has a commitment for zero carbon by 2050 for Scope 1+2 emissions** with a 25% reduction per tonne of product which includes Scope 3 emissions.

- **Most companies assessed fail to meet the principles and recommendations for Science Based Targets** - except AkzoNobel and LG Chem. Several companies use base years that have long past, not in line with SBTi recommendations of using a more up to date base year to improve performance going forward.

- **Resilience tests through forward-looking climate scenario analysis are yet to become common industry practice** and are lacking in this sector.

- **Four companies disclose the internal price of carbon used with AkzoNobel using the highest price at between €50-135/t.** Seven companies use an internal price but do not disclose the level, with BASF and DuPont ranking better in this group based on evidence of applying multiple price scenarios.

- **Chemical companies have substantial and diverse supply chains** - based on disclosure and CDP estimates, two-thirds of GHG emissions are Scope 3 and a lack of disclosure could indicate risks and potential cost of not managing value chain emissions.

# Company highlights

**#1 AkzoNobel** comes first by a comfortable majority, scoring well on a number of metrics. AkzoNobel scores particularly well in transition opportunities and governance and strategy, with a strong commitment to decarbonization through its long-term Science Based Target.

**#2 DSM** focuses on nutrition and healthcare and performs well on several metrics, including having over 50% of its revenues coming from low carbon products. The company has a relatively high exposure to Scope 3 emissions in its value chain but also has the highest transparency on this metric.

**#3 Johnson Matthey** have been a clear beneficiary of environmental trends with their autocatalysts business positioned to tighter emission regulations and now transitioning with batteries to growth in EVs. They rank well on transition risk and opportunities as well as governance.

**#4 DuPont** prior to its merger performs well on transition opportunities with a high spend on R&D at 7% of its sales and is second to BASF in product innovation. The company does not do as well on low carbon revenues with 10% of revenues considered low carbon, against 40% at Dow. On governance and strategy, the company performs the best out of the diversifieds sub-group.

**#5 BASF** is the best performing diversified chemical company for emissions intensity showing the steepest decline in emissions intensity relative to revenues in its group and coming third overall across the sector. The company also performs well on transition opportunities, ranking well on product and process innovation but less well on measures of low carbon revenue and use of renewable energy.

**#6 Sumitomo Chemical** performs well on R&D with the highest R&D spend of all companies at 7.23% of net sales - this does not appear to be followed through in product innovation where it ranks last. The company is the best performing of the diversifieds in transition risk with the lowest Scope 3 emissions intensity. For physical risk, the company performs well on water quality metrics with its COD intensity showing the steepest decline over the last five years. The company does well on governance in terms of data assurance.

**#7 PPG** ranks first in transition risk with steep cuts in emissions intensity over the last 8 years with low current intensities. It ranks second best for Scope 3 emissions in the speciality group but does less well on transition opportunities and has poor water governance. The company had a shareholder resolution filed in 2016 asking for sustainability metrics to be put into executive compensation which was withdrawn on the basis that this will be addressed.

**#8 Evonik** does well on transition opportunities, coming third best overall for process innovation and R&D spend. The company performs poorly on Scope 3 emissions coming third last for Scope 3 emissions intensity in the speciality chemical sub-group and close to the bottom for water withdrawal and COD intensity.

**#9 Braskem** performs best of the petrochemical group with the steepest decline in emissions intensity of all the companies, reflecting their pro-active management of energy use and thus scoring well on the use of renewable energy. The company performs well on water governance, is ranked best overall for water withdrawal and does generally well on governance and strategy metrics coming third overall, leading the petrochemical sub-group.

**#10 LG Chem** is the best prepared of the petrochemical companies in terms of governance and strategy and is the only company apart from AkzoNobel to have a long-term emissions reduction target. LG Chem also performs well relative to the other petrochemicals on product innovation and low carbon revenue at 15%, with its downstream business exposure in speciality chemicals including in batteries for EVs.

**#11 Air Liquide** performs well on transition opportunities, coming second overall and first of the industrial gases. The company scores well on product innovation and is involved in numerous initiatives related to the hydrogen economy. The company also has a renewable target of 50% by 2020. The industrial sub-group does less well on transition risk given industrial gases high energy intensities, with Air Liquide performing the best of the group for this category. The company, however, performs poorly in terms of emissions target setting, disclosing one narrow target representing 2.5% of Scope 1 emissions.

**#12 Toray** performs well on transition risk and is the third best of the diversifieds for this category but comes at the bottom on the list for transition opportunities. The company also performs poorly on governance on board level expertise and for failing to have an internal carbon price.

**#13 Mitsubishi Chemical** is the second worst prepared for transition risks of the diversifieds with the highest growth in energy intensity of the group. The company performs well on transition opportunities, ranked third amongst the diversifieds and coming fourth overall in product innovation. The company is the lowest ranked of the diversifieds for climate governance and strategy.

**#14 Shin-Etsu** performs badly on transition opportunities with the second worst ranking for both product and process innovation and does not disclose on exposure to low carbon revenues. The company performs well on energy intensity under transition risks and is third in Scope 3 intensity of the speciality group.

**#15 Umicore**, like Johnson Matthey, has good exposure to low carbon markets with its autocatalysts and batteries for EV. However, the company has poor disclosure across various metrics. The company performs well on transition risk with the lowest absolute emissions intensity of all companies. The company performs poorly on governance and strategy coming at the bottom of the rankings with no emissions target disclosed and fails to report on any categories on Scope 3 emissions.

**#16 Praxair** ranks second best of the industrial gases in managing transition risks, only marginally ahead of Linde in this sub-group. On transition opportunities, the company performs well on its use of renewable energy but performs less well on R&D spend to sales and is the 5th lowest of 22 companies. While the company does well on climate related remuneration, linking 13.5% of executive bonuses to non-financial KPIs which include specified climate change components, it does not use an internal carbon price.

**#17 Solvay** is the worst ranked of the speciality chemicals in managing transition risks and ranked second last for transition opportunities, ranking better on production innovation than process innovation. The company has the second highest coal use of all companies. On the positive side Solvay is linking up to 20% of the CEO's bonus to sustainable development performance and is introducing a link between GHG emissions targets and LTI grants.

**#18 Linde** performs badly on transition risk, ranking fourth worst overall for emissions intensity. The company ranks well for process innovation in transition opportunities with the highest spend in the industrial gases sub-sector for R&D spend.

**#19 Air Products** is ranked last of the whole group for transition risks with the worst ranking for emissions intensity. This ranking is not offset by its performance in transition opportunities, coming last among the industrial gases through its poor performance in process innovation. The company is the best performer of its sub-group in terms of governance and strategy and fifth overall.

**#20 Dow** does well on climate governance with board level expertise and use of an internal carbon price, ranking second for the diversifieds for all governance metrics. However, the company performs poorly for managing transition risks and is the worst performing of its sub-sector for emissions and energy intensity metrics.

**#21 LyondellBasell** performs third worst overall for transition risks with lack of data for emissions intensity data over time and third worst overall for energy intensity. The company has the highest energy cost of the petrochemicals group at approximately 17.5% of operating expense and its emissions reduction targets covers a time period which has passed. LyondellBasell also performs badly on transition opportunities, coming second from the bottom for this category as well as doing poorly in Scope 3 emissions intensity, coming fifth from bottom.

**#22 Formosa Plastics** is the worst performer in transition risks based on high use of coal (72% of its operations). The company also performs badly in transition opportunities where it ranks second last of all companies. The company has relatively poor disclosure and governance with emissions reduction targets that refer to time periods that have already expired.

# Company selection and classification

Companies were selected from a list of the largest publicly listed global chemical companies, based on 2016 market capitalization and those that responded to CDP's 2017 climate change information request. 13 of the companies that featured in CDP's 2015 chemicals report are included again. In addition, we have added the 4 major industrial gas companies, three petrochemical companies and two speciality chemicals companies. Several companies that reported to CDP in 2017 were omitted, such as pure-play agricultural and pharmaceutical chemical companies, due to the reclassification or merging of some of these companies.

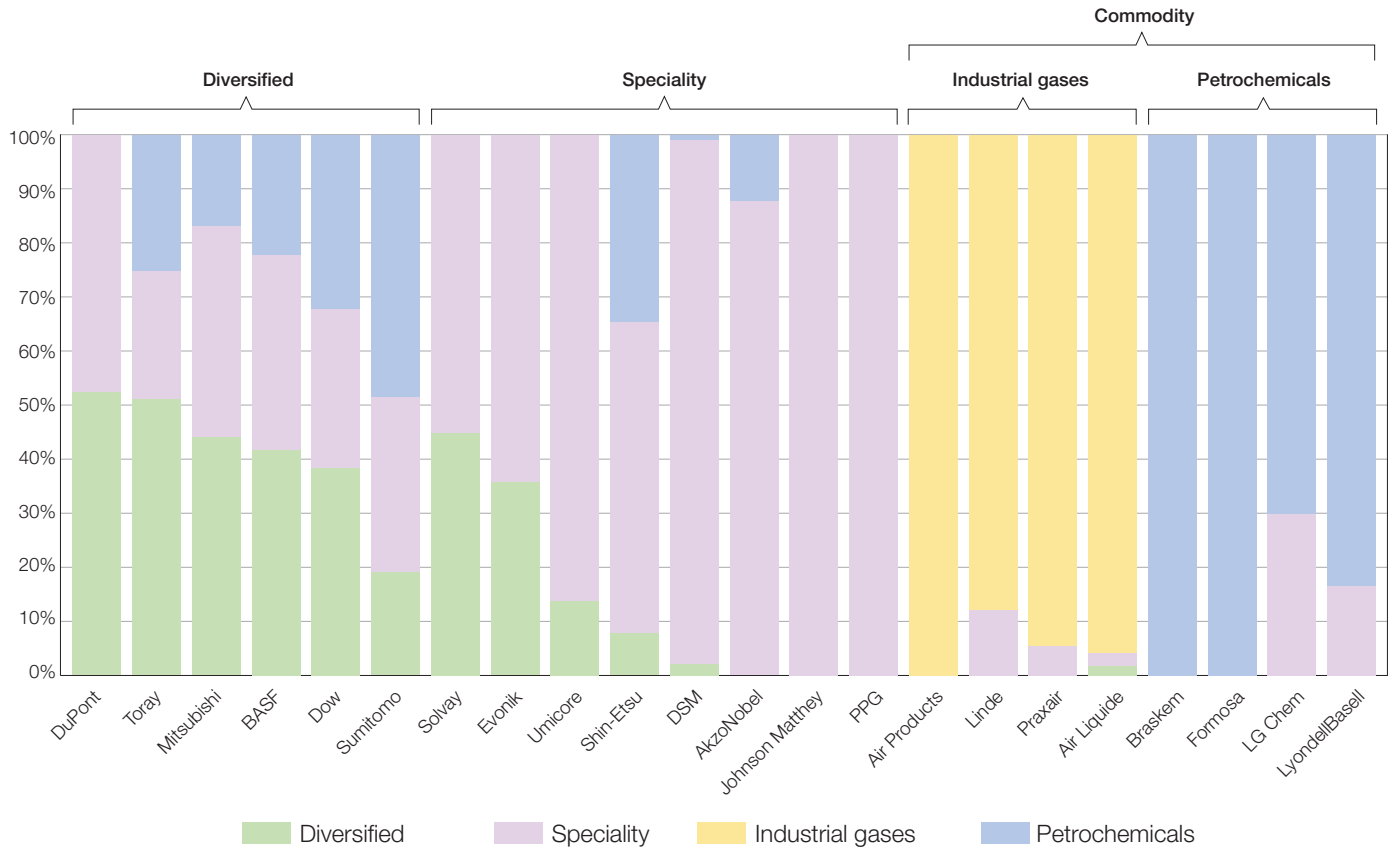
Due to the diverse mix of commodities, products and processes within the chemicals industry, the universe of companies is divided into subsectors in an attempt to compare companies with similar business models. Ultimately companies are ranked as a homogenous industry but with the acknowledgment that the industry is complex and a like-for-like comparison can be problematic.

Companies are subdivided according to the following classifications based on revenue splits taken from the Bloomberg Industry Classification System (BICS) and in accordance with correspondence with companies.

- Diversified chemicals: Companies manufacture a diverse range of chemical products ranging from commodity and base chemicals such as petrochemicals to intermediate products and speciality chemicals. Vertical integration is common throughout this group.
- Speciality chemicals: Companies produce chain end products in low volumes with high value-add. These chemicals are used in a wide variety of products, including fine chemicals, additives, advanced polymers, speciality paints, pigments, and coatings.
- Commodity chemicals: Companies produce bulk commodities in high volumes and at low value-add. These include products such as industrial gases or petrochemicals.
  - Industrial gases: Companies produce high volumes of gases for use in a variety of industries. Gases are produced with high purity levels and include argon, carbon dioxide, hydrogen, nitrogen and oxygen.
  - Petrochemicals: Petrochemicals derive from crude oil or natural gas. Petrochemicals form the building blocks for a number of products used throughout the organic chemicals value chain including plastics, fertilizers and synthetic rubber and fibers.

Figure 6 illustrates how companies within the report are split and highlights the difficulty in classifying companies with such diverse portfolios.

**Figure 6: Company classification by revenue (%)**




Source: CDP, company reports

## Non-responding companies

We highlight the following companies as non-responders to CDP's 2016 climate change questionnaire and are therefore not included in this report. We encourage investors to raise this lack of transparency in discussions with company management.

**Figure 7: Non-responders to CDP**

| Company | Country | Average market cap Q2 2017 (US$bn) (i) | First approached by CDP | Public disclosure of carbon emissions | Business focus |
|---|---|---|---|---|---|
| Asian Paints | India | 16.0 | 2007 | Yes | Manufactures, sells and distributes paints and coatings |
| Covestro | Germany | 15.3 | 2016 | Yes | Supplier of high-tech polymers |
| Ems-Chemie Holding | Switzerland | 14.8 | 2007 | No | Manufactures high performance polymers and speciality chemicals |
| Petronas Chemicals | Malaysia | 13.3 | 2010 | Yes | Manufactures olefins, polymers, fertilisers, methanol and other basic chemicals |
| Nippon Paint | Japan | 11.4 | 2009 | Partial | Paint and paint products manufacturing company |

(i) Average market cap for last 12 months up to Q2 2017

Source: CDP

## Linking our findings to investment choices

We recognize that investment decisions are based on a multitude of different factors and that some of these can be misaligned with emissions-reduction efforts. Our League Table identifies company readiness for the transition to a low carbon economy and the physical impacts of global warming. We would flag that companies towards the bottom of our League Table are higher risk investments from a climate change perspective than those towards the top.

# Methodology

We score each company based on a number of metrics which are ranked and then weighted within each key area (see table below for metric weightings within each key area). We then grade each area from A to E based on these weighted ranks. We calculate the overall League Table score by collating the weighted ranks for each key area.

Each of the key areas has a separate chapter within this report. We disclose the precise methodology for how we rank each metric in an appendix.

**Figure 8: A summary of key areas, associated metrics and weights within the League Table**

| Key area in League Table | Financial impact | Metrics | Key area weighting | Metric weighting within key area |
|---|---|---|---|---|
| Transition risks | • Emissions intensity directly impacts operating costs through raw material and energy cost - significant operating cost.<br>• Highly energy intensive sector with high energy costs directly impacting cost base.<br>• Impact of Scope 3 emissions will vary depending on the type of end market - plastic packaging most at risk. | • Scope 1+2 emissions intensity of operations (level and trend)<br>• Energy intensity of operations (level and trend)<br>• Scope 3 emissions intensity | 35% | 40%<br>40%<br>20% |
| Physical risks | • Water use is varied across sub-sectors and companies, with impact not easily to evaluate.<br>• A key risk is event risk from storms - this can disrupt operations and result in new capex requirements. | • Water withdrawal intensity of operations<br>• Water consumption intensity of operations<br>• Chemical oxygen demand (COD) intensity of operations<br>• Water governance | 10% | 35%<br>15%<br>15%<br>35% |
| Transition opportunities | • Significant opportunities exist to grow revenues from product innovation.<br>• Process innovation using catalysts could significantly improve energy efficiency and de-risk from carbon regulation.<br>• Opportunity to grow revenues from low carbon products. | • Low carbon product innovation scorecard<br>• Low carbon process innovation scorecard<br>• Low carbon revenue<br>• R&D spend as % of sales<br>• Renewable energy use | 35% | 20%<br>20%<br>10%<br>25%<br>25% |
| Climate governance and strategy | • Long-term target setting provides insights on ability of companies to align to a low carbon pathway.<br>• More ambitious target setting could signal better prospects for efficiency and cost savings.<br>• Investment in emerging and game changing technologies required for a 2°C pathway will require a significant step up in capex. | • Emissions reduction targets scorecard<br>• Carbon emissions data verification<br>• Transparency of value chain emissions (Scope 3) and engagement<br>• Climate-related remuneration<br>• Board level climate expertise<br>• Use of internal $CO_2$ price<br>• CDP score | 20% | 25%<br>10%<br>20%<br>20%<br>10%<br>10%<br>5% |

Source: CDP

# For further study

Areas for further research include:

- The impact of Chinese chemical companies in the global landscape for decarbonization for the chemicals sector.
- The potential for CCS and CCU for the chemicals sector as a risk and opportunity.
- The progress in process and feedstock technology to act as game changers for decarbonization of the industry.

# Transition risks

- The higher emissions and energy intensity of the petrochemicals and industrial gas sub-sectors have a significant impact on the ranking for companies within these groups. However, there is a clear difference between the leaders such as LG Chem and Braskem vs Formosa Plastics for petrochemicals and Air Liquide and Air Products for industrial gases.
- The speciality chemicals sub-sector performs the best with much lower emissions and energy intensities which are partially offset by Scope 3 emissions intensities for the leaders in this group – PPG leads the way with Umicore, Johnson Matthey and DSM closely ranked behind.
- In the diversified category Sumitomo come first, ranking slightly ahead of DuPont (pre-merger).

## Overview

As previously highlighted, the universe of companies included in the chemicals sector is diverse. Emissions and energy intensity metrics, therefore, risk comparing very different types of companies – in the box below we discuss in more detail the trap of falling into this apples and pears comparison and the issues around what goes into the denominator when making these comparisons (see box on page 14).

The chemicals industry uses highly emissions and energy intensive processes, particularly for upstream commodity processes such as steam cracking in the manufacture of petrochemical building blocks such as ethylene and propylene and the production of industrial gases such as hydrogen used in industries such as refining. As described in greater detail in our section on processes for chemical building blocks (see box on page 20), emissions for petrochemical products come from feedstocks (fuel 60%), processes (steam production 35%) and the use of grid power, with the majority of emissions (95%) coming from feedstock and process rather than electricity.

There is a strong incentive to improve efficiency in the industry to reduce costs – this is evidenced in our findings where most companies have seen a decline in emissions and energy intensive rates over the last 7 years. Emissions intensities have fallen by 2.5% to 7% annually from 2009 to 2016 for a number of companies in the petrochemical and chlorine routes. Industrial gas companies by contrast have seen a growth in their emissions intensity rising by 0.8% to 4.5%. A similar pattern is seen with energy intensive trends. Speciality chemical companies have a lower absolute intensity level with most companies managing down their intensity levels with a few notable exceptions.

We use three metrics to evaluate companies on their transition risks – emissions intensity which uses Scope 1+2 emissions of a company, energy intensity and Scope 3 emissions (value chain) intensity. For calculating emissions and energy intensity, revenues and gross profits have been used to normalize emissions intensity on a constant currency basis to strip out any currency impacts. In addition, trends rather than absolute emissions intensity metrics are used, so that companies are not being assessed at one point in time but over a five year period. Revenues and gross profit were selected as the most readily available for normalization rather than volume.

We have included estimates of Scope 3 emissions intensity – in this sector it provides a means of evaluating the upstream exposure for companies which have moved up the value chain but still rely on highly emissions and energy intensive building blocks.

**Metric 1) Emissions intensity:** This metric evaluates the extent to which companies have reduced their operational emissions intensity over the period 2009 - 2016 and identifies the companies with the lowest current Scope 1+2 emissions intensity level. This metric is a composition of a number of sub-metrics described in the methodology section in Appendix III. Revenues and gross profits have been used to normalize emissions intensity on a constant currency basis to strip out any currency impacts. Trends rather than absolute emissions intensity metrics are used.

**Metric 2) Energy intensity:** The metric evaluates the extent to which companies have reduced the energy intensity of their operations over the period 2009 - 2016. This used a similar approach to the emissions intensity measure where both revenues and gross profits were used to normalize on a constant currency basis. Again, trends rather than absolute intensity levels were used in the scoring system with this metric.

**Metric 3) Scope 3 Emissions Intensity:** Emissions in the value chain were estimated for companies which could either be in the upstream or downstream end of the sector. These emissions provide a means to assess the potential risks for companies from regulation that lie outside their company boundary but that could impact upstream pricing and downstream demand.

**Figure 9: Transition risks summary**

| Company | Classification | Emissions intensity | Energy intensity | Scope 3 | Overall weighted rank | Transition risks rank | Transition risks grade |
|---|---|---|---|---|---|---|---|
| PPG | Speciality | 1 | 1 | 8 | 4.1 | 1 | A |
| Sumitomo | Diversified | 11 | 1 | 2 | 6.1 | 2 | B |
| Umicore | Speciality | 6 | 5 | 5 | 6.8 | 3 | B |
| DuPont | Diversified | 7 | 6 | 4 | 7.2 | 4 | B |
| Johnson Matthey | Speciality | 3 | 4 | 21 | 7.4 | 5 | B |
| DSM | Speciality | 2 | 6 | 18 | 7.8 | 6 | B |
| AkzoNobel | Speciality | 4 | 10 | 11 | 8.2 | 7 | B |
| Toray | Diversified | 8 | 3 | 22 | 9.2 | 8 | B |
| BASF | Diversified | 5 | 8 | 18 | 10.2 | 9 | C |
| Evonik | Speciality | 9 | 9 | 15 | 10.3 | 10 | C |
| Braskem | Petrochemicals | 10 | 13 | 5 | 10.7 | 11 | C |
| Shin-Etsu | Speciality | 13 | 12 | 9 | 11.8 | 12 | C |
| LG Chem | Petrochemicals | 16 | 16 | 1 | 12.2 | 13 | C |
| Mitsubishi | Diversified | 12 | 11 | 16 | 12.7 | 14 | C |
| Air Liquide | Industrial gases | 17 | 17 | 3 | 13.3 | 15 | C |
| Solvay | Speciality | 15 | 15 | 12 | 13.7 | 16 | C |
| Praxair | Industrial gases | 21 | 14 | 9 | 14.8 | 17 | D |
| Linde | Industrial gases | 19 | 18 | 7 | 15.0 | 18 | D |
| Dow | Diversified | 14 | 19 | 17 | 15.7 | 19 | D |
| LyondellBasell | Petrochemicals | 18 | 20 | 18 | 17.5 | 20 | E |
| Air Products | Industrial gases | 22 | 21 | 14 | 18.1 | 21 | E |
| Formosa | Petrochemicals | 20 | 22 | 12 | 18.6 | 22 | E |
| **Weighting** | | **40%** | **40%** | **20%** | | | |

Note: In calculating the weighted rank in this table, we use the weighted ranks for each area (where relevant). We display non-weighted ranks in this summary for simplicity only
Source: CDP

# Highlights

Based on the main weighting given to emissions and energy intensity, the less intensive higher value speciality chemical companies perform best with the industrial gas and petrochemical companies performing the worst.

However, the inclusion of Scope 3 emissions estimates increases the transition risk for the higher added value sector.

### Speciality Chemicals

- Five out of eight of the speciality chemicals sub-group come in the top 10 for this ranking with PPG, Umicore and Johnson Matthey in the top 5. This group has low absolute emissions intensity of less than 5%.
- The speciality chemicals sub-group performs much worse on estimated Scope 3 emissions with DSM and Johnson Matthey in the bottom half of the table on this ranking.
- Evonik, Shin-Etsu and Solvay perform less well, reflecting their higher emissions and energy intensive intermediate chemical and resin businesses. Solvay is a particular laggard in this group – despite having 55% in speciality chemicals, it is highly emissions and energy intensive.

### Diversified Chemicals

- Sumitomo does the best in this sub-group coming second overall and leading DuPont which comes fourth overall. Sumitomo performs particularly well on energy intensity.
- This sub-group does well on transition risks with four companies in the top 10 including Toray and BASF.
- Dow and Mitsubishi lag the sector with Dow's emissions and energy intensities much higher than the rest of the diversified group and almost five times that of DuPont who they have merged with.

### Petrochemicals

- Braskem leads this group of four companies, ahead of LG Chem. LG Chem is more energy intensive than Braskem but does have the lowest Scope 3 emissions intensity of all the companies.
- LyondellBassell and Formosa Plastics lag the other two companies with higher emissions and energy intensities, reflecting their exposure to the higher intensive upstream activities.

### Industrial Gases

- This sub-group performs poorly on emissions and energy intensity as would be expected given the high energy intensity of producing gases such as hydrogen. Air Liquide leads this group performing better than Praxair and Linde where performance is relatively similar.
- Air Products performs the worst and is second from the bottom only ahead of Formosa, the worst performing petrochemical company.

# The problem of comparing the GHG performance from emissions intensity measures

Carbon emissions from companies, either $CO_2$ or GHG emissions, are usually measured through Scope 1 emissions (directly emitted by the company) and Scope 2 emissions (indirectly emitted through the use of electricity). To compare the performance of companies' Scope 1+2 emissions within a peer group, an emissions intensity figure is calculated. This looks like a straightforward and intuitively acceptable way for comparing companies if you have a homogenous group of companies where both the numerator and denominator lends itself to comparing apples with apples instead of apples with pears.

An obvious problem arises when comparing a diverse range of companies in a sector which is not homogenous. This is often the case from the diversified mining companies to the chemicals sector where comparisons are compounded further both from the range of processes (130 processes to produce 18 of the most carbon intensive chemicals), feedstocks and the degree of vertical integration.

However, the problem can also arise when comparing companies in a superficially more homogenous sector such as industrial gases as argued by a new paper on measuring GHG intensity in the Journal of Environmental Investing[1], both in evaluating the numerator and the denominator.

As the paper argues, the denominator problem relates to what is the best normalization factor to make sensible comparisons between companies, with revenues often being chosen as one which is easily available and most directly comparable. However, the problem arises when revenues are impacted by other factors which are non-operational such as currency fluctuations and or changes in operations as a result of mergers, acquisitions and disposals. This can also be a problem with portfolio carbon footprinting (see Figure 10 for an illustration of the Dow and DuPont merger).

Adjustments therefore need to be made such as applying a constant currency so that currency distortions are stripped out. In addition, a trend in emissions intensity performance may offer a better insight into performance than a one period measure. Ideally, the denominator should be measured by the volume/tonnes of product which will strip out price and currency distortions assuming the same type of product is being compared. Lack of granular data, however, can make this problematic.

The paper goes on to argue that having both Scope 1 and Scope 2 emissions in the numerator can be misleading as the latter is outside the company's control, comes mainly from aggregated electricity used where the power generation mix is not always accurately measured and by counting both the utilities emissions as company's emissions there is a risk of double counting. However, this is a less compelling argument when looking at how companies are positioned for a low carbon economy.

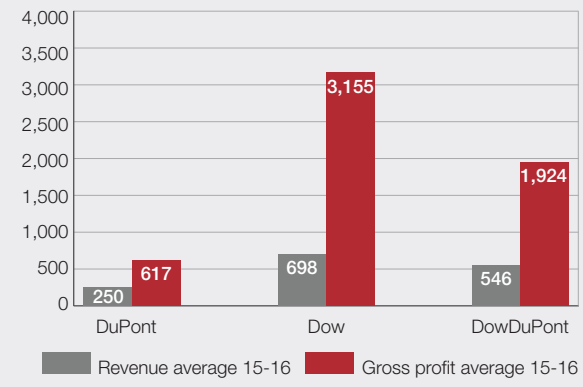
Regulators looking to decarbonize economies at global, country or state level have focussed on power generation as a key area to deliver cuts in carbon emissions. High energy intensive industries are also the focus of carbon regulation and therefore measuring and understanding Scope 2 emissions is key to understanding company exposure. Locating these facilities where there is a source of low carbon electricity is a solution. This arguably may not always be available for industrial gas companies looking to place their hydrogen producing facility for customers in states or countries with a higher fossil fuel mix in power generation. Companies such as Air Liquide overcame this with an industrial customer in India by co-investing in solar power working in a modular way with storage solutions.

In this report, we have recognized the diversity of the companies within the chemicals industry and the difficulty of using emissions intensity as a way of ranking performance using constant currency as well as emissions intensity trends. It is also important to understand the level of intensity of sub-sectors of the industry and ultimately the transition risk to a low carbon economy with Scope 3 emissions providing a fuller picture of emissions in the value chain.

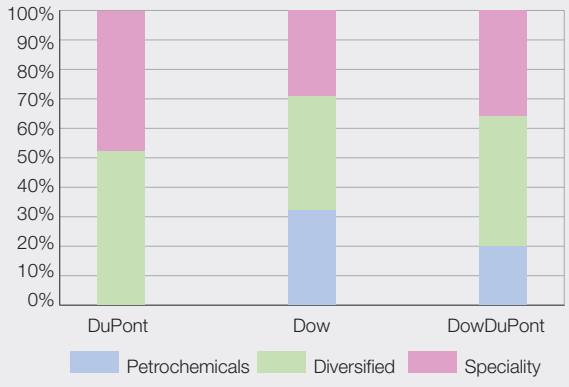
Due to a lack of data we were unable to compare our sample of companies using tonne of product as the denominator.

**Figure 10: Illustration of Dow and DuPont merger**

Emissions intensity (t $CO_2e$/US$m) - Average 2015-2016



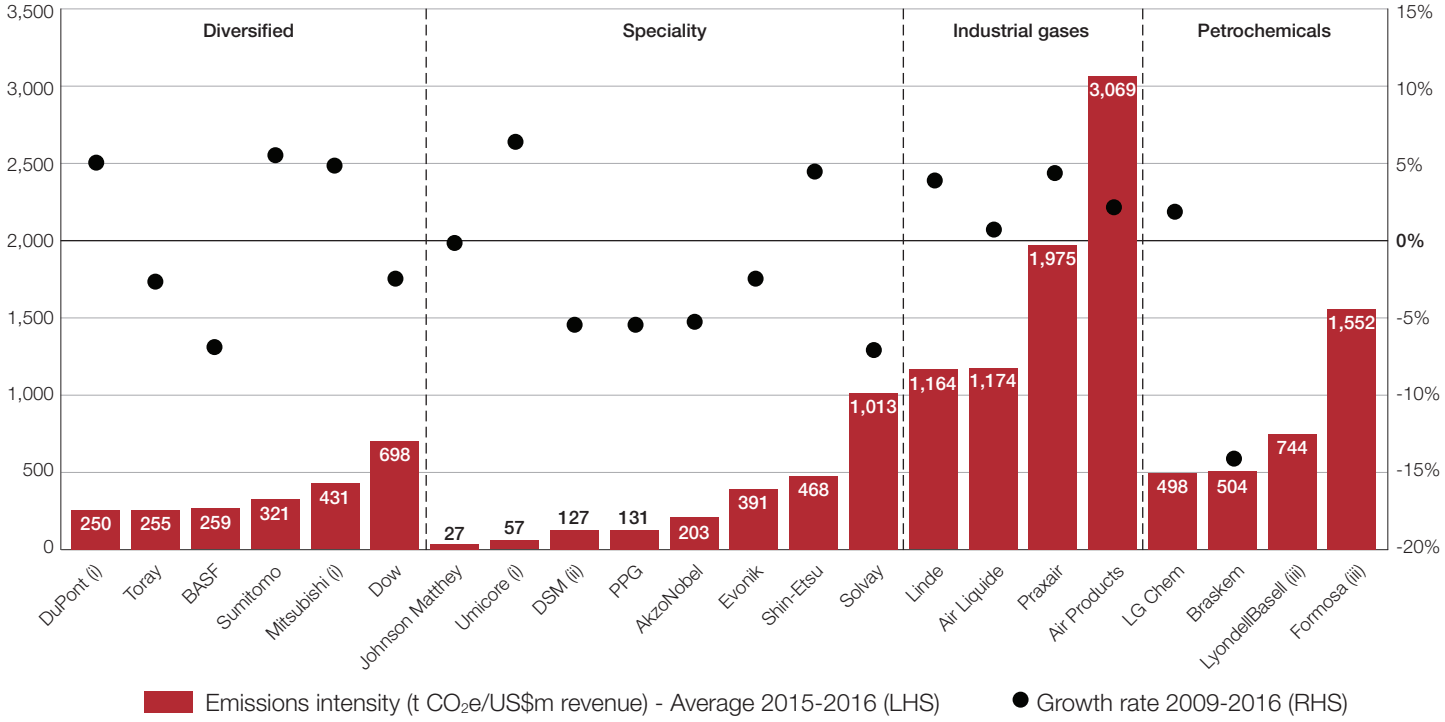

Company classification by revenue (%)




Source: CDP, company reports

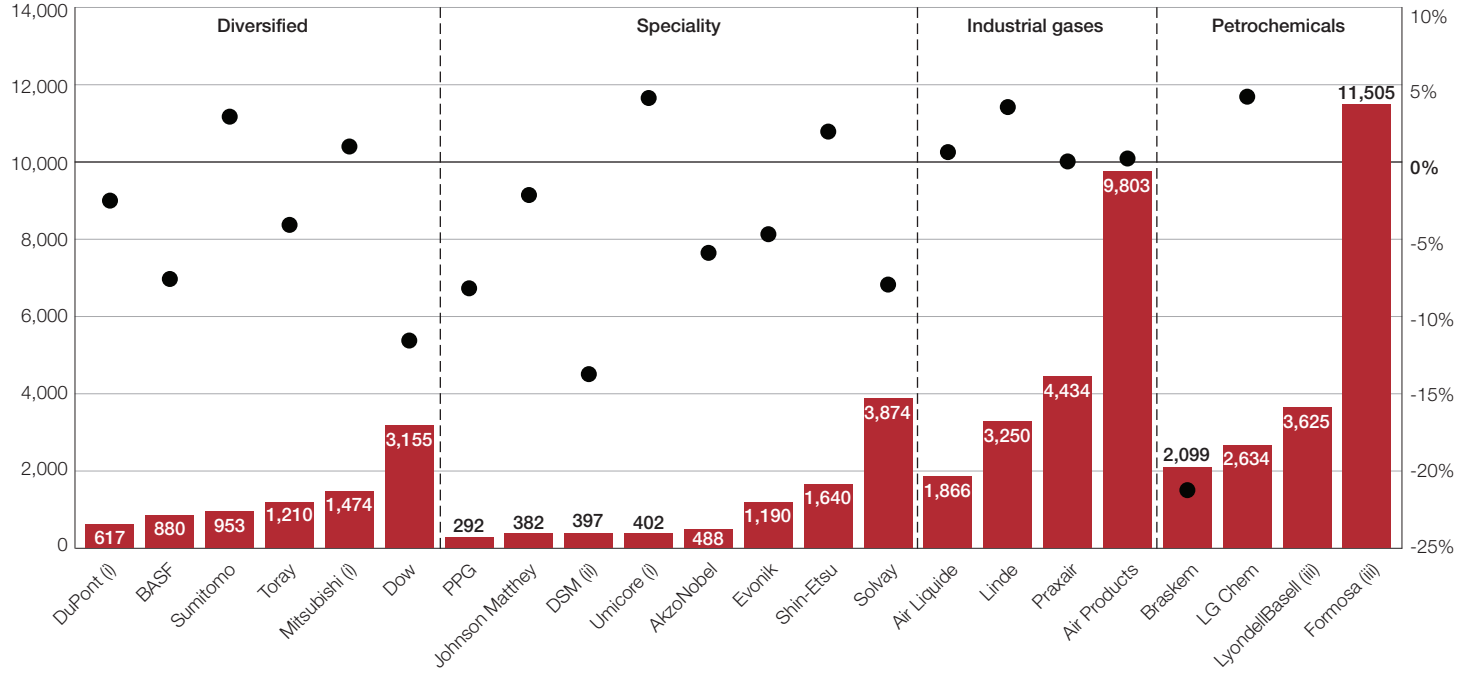
1. Proposing Constant Currency as a Revenue Based Denominator to Measure Greenhouse Gas Intensity: A Case Study from the Industrial Gas Sector (Krut et al., 2017)

## Figure 11: Emissions intensity (Scope 1+2) by revenue



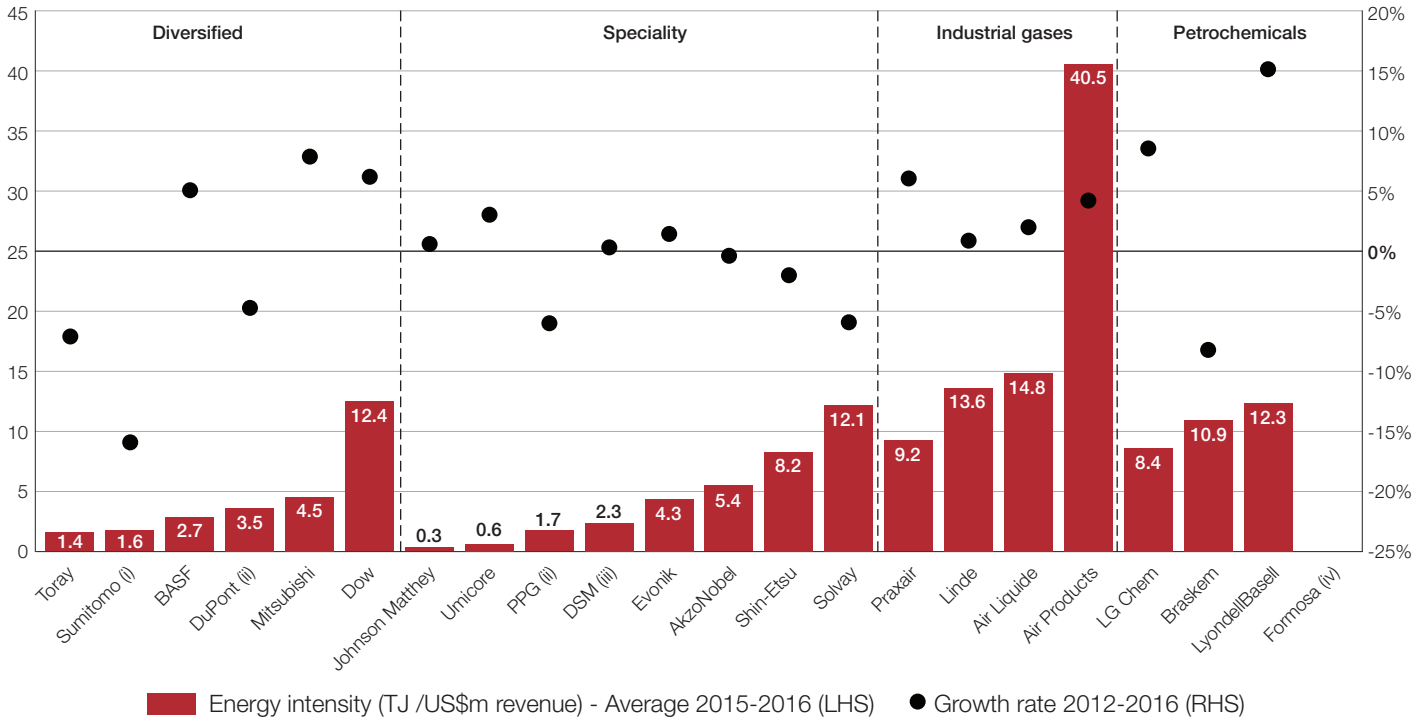

(i) Growth rate 2010 – 2016 for DuPont, Mitsubishi and Umicore
(ii) Growth rate adjusted to account for deconsolidation of DSM Fibre intermediates
(iii) Insufficient data to calculate growth rate for LyondellBasell and Formosa
Source: CDP, company reports

## Figure 12: Emissions intensity (Scope 1+2) by Gross profit




(i) Growth rate 2010 – 2016 for DuPont, Mitsubishi and Umicore
(ii) Growth rate adjusted to account for deconsolidation of DSM Fibre intermediates
(iii) Insufficient data to calculate growth rate for LyondellBasell and Formosa
Source: CDP, company reports

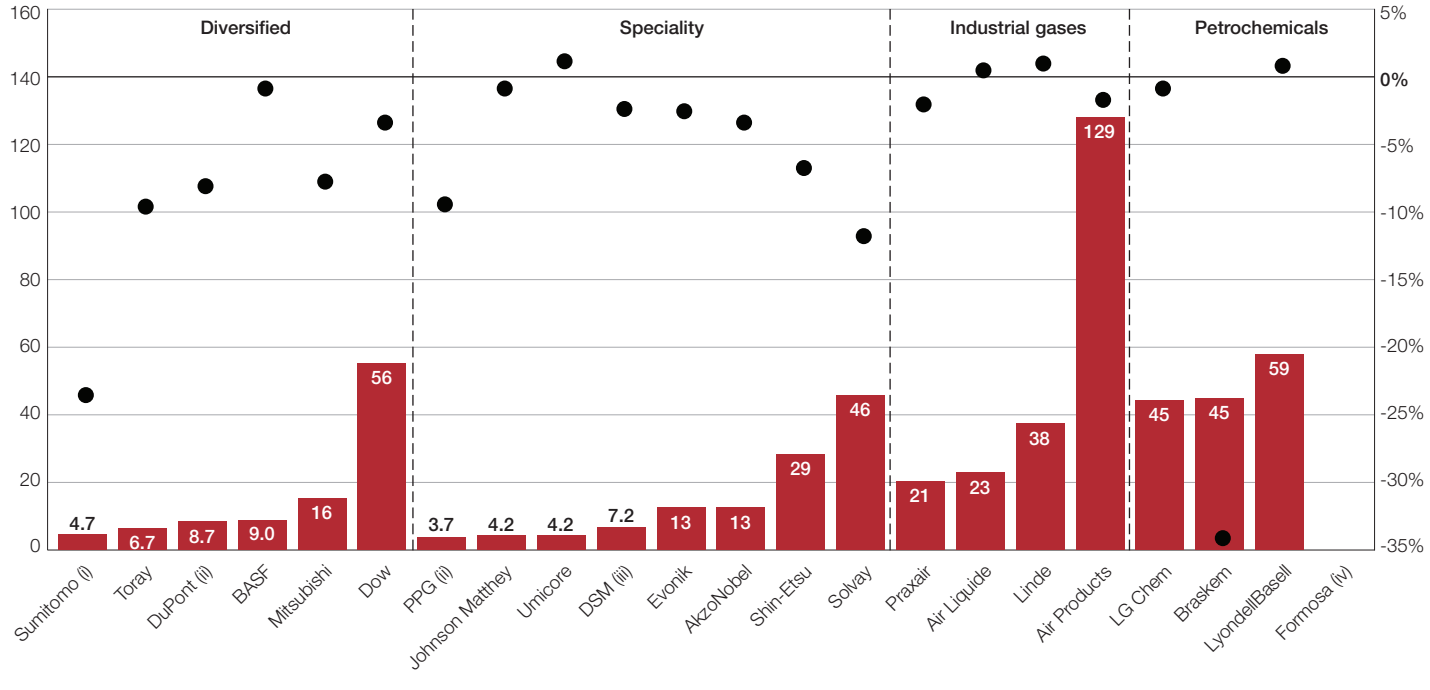
## Figure 13: Energy intensity by revenue




(i) Growth rate 2012 - 2015 for Sumitomo
(ii) Growth rate 2013 - 2016 for DuPont and PPG
Source: CDP, company reports

(iii) Growth rate adjusted to account for deconsolidation of DSM Fibre intermediates
(iv) No data available for Formosa

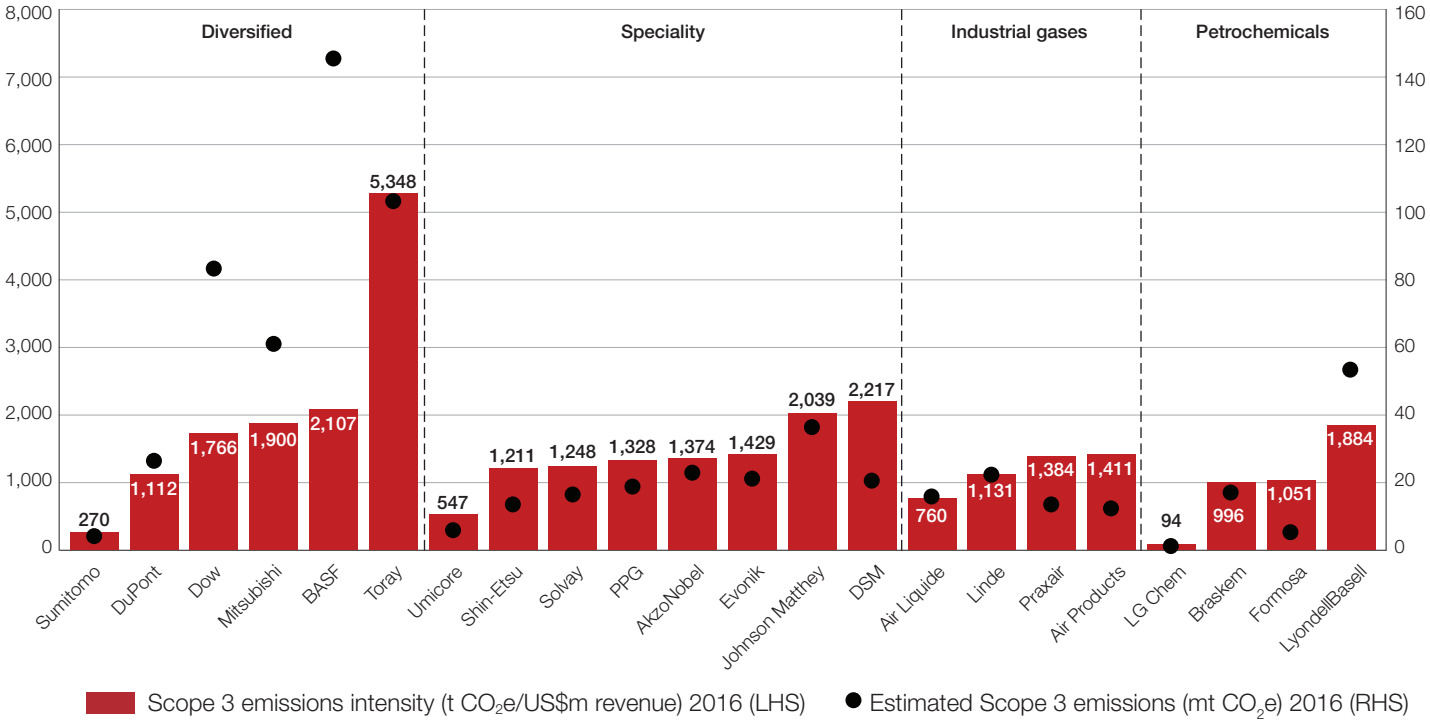
## Figure 14: Energy intensity by Gross profit




(i) Growth rate 2012 - 2015 for Sumitomo
(ii) Growth rate 2013 - 2016 for DuPont and PPG
Source: CDP, company reports

(iii) Growth rate adjusted to account for deconsolidation of DSM Fibre intermediates
(iv) No data available for Formosa

**Figure 15: Scope 3 emissions intensity by revenue**




Source: CDP, company reports

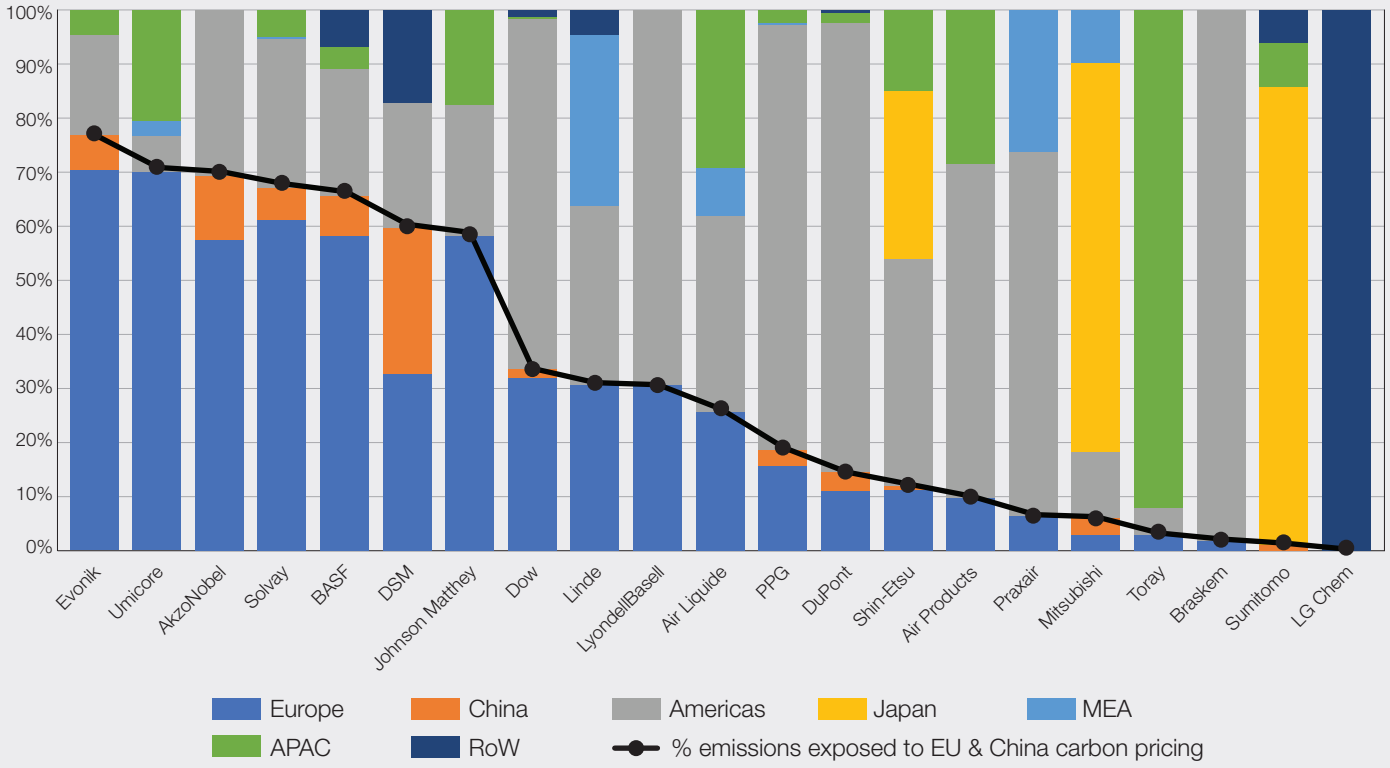
# Carbon Pricing - it may all depend on China's incoming ETS

The companies featured in this report operate across a number geographies that regulate and price operational carbon emissions differently. The European chemicals industry has been subject to the EU ETS for several years and China is set to implement its national carbon trading scheme later this year which will cover the chemical sector.

Currently, implemented global carbon pricing schemes cover around 13%[2] of global greenhouse gas emissions, whereas the companies in our study have, on average, between a quarter and a third of operational emissions exposed to existing and announced carbon trading schemes (see Figure 16 below).

Japan (yellow) and Americas, primarily USA (grey), are the highest emitting regions with little or no ETS coverage that the 22 company sample operate within.

**Figure 16: Scope 1+2 Emissions split by geography**




(i) No data available for Formosa Plastics
Source: CDP, company reports

The price of carbon in trading schemes globally is significantly below the levels needed to make large-scale carbon abatement economically viable. Some companies apply 'internal' or shadow carbon prices well in excess of prevailing ETS market prices (see Metric 6 in Climate Governance & Strategy). Recent research by Schroders has placed the carbon value at risk or 'Carbon VaR' of chemical companies as high 100% of cash earnings from US$100/t carbon price[3].

Compounding low prices, signals to market actors are further muted by the tendency for companies to receive emissions permit allocations for the majority of their emissions, creating an oversupply in the marketplace.

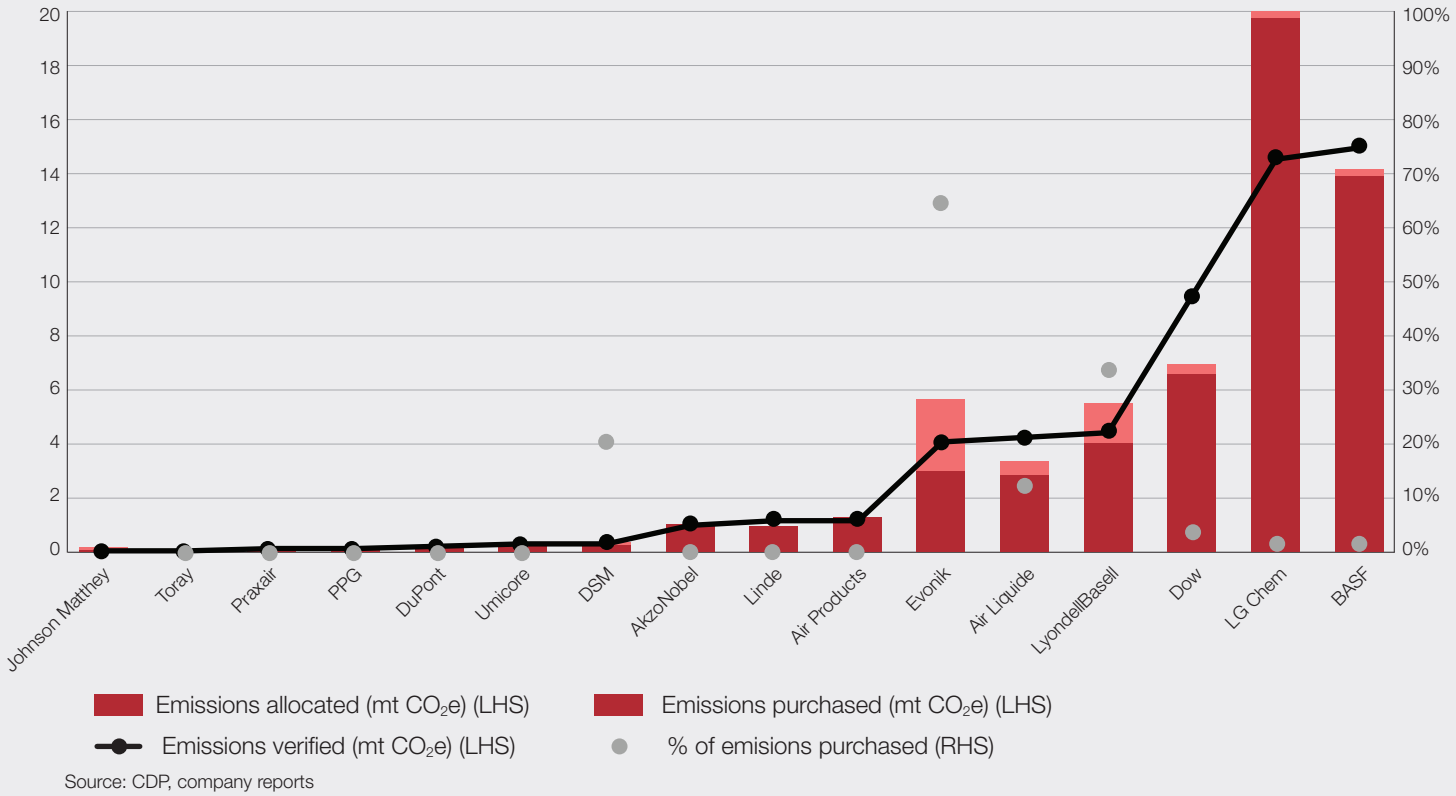
The 22 companies in the report reported approximately 160m tonnes of $CO_2$ equivalent as Scope 1 emissions in 2016. Over one in three of those emissions, or 56m tonnes, were verified under a ETS or emissions trading scheme in 2016. Just over 5.5m tonnes of emissions allowances were purchased by the companies, implying that on averages they paid for around 10% of the emissions that are covered under an ETS – with the remainder given as free allocations. The grey data points in the below graph denote the proportion of allowances that companies purchased. This contrasts with other sectors such as electric utilities in Europe that are having to typically purchase more than 80% of their emission allowances.

**Figure 17: Average ETS prices under different themes**

| ETS schemes | ETS prices USD / t $CO_2$ |
|---|---|
| EU ETS | 6.4 |
| South Korea | 19.3 |
| California | 13.6 |
| Quebec | 13.8 |
| Shanghai | 2.0 |
| **Average** | **11.0** |

2. State and Trends of Carbon Pricing (World Bank, 2016)
3. Climate change - redefining the risks (Schroders, 2017)

**Figure 18: Emission allowances purchased and allocated**




Source: CDP, company reports

**Figure 19: ETS emissions, verification and purchases**

| | |
|---|---|
| Scope 1 emissions of companies (2016) | 162m tonnes $CO_2$ |
| Emissions verified under ETS schemes | 56m tonnes $CO_2$ |
| Emissions allowances purchased | 5.6m tonnes $CO_2$ |

Due to its inherently diverse and heterogenous nature, carbon pricing will impact different companies in a range of manners and to differing extents. For large electricity users, the extent to which carbon pricing and policy affects electricity supply and prices will be of primary concern. Companies that are large direct Scope 1 emitters will focus on the chemical industry's inclusion in trading scheme and the cost of marginal units of carbon emissions. Other considerations will be made for companies that have a large down or upstream carbon footprint

As has been highlighted in previous publications, to be an effective tool in pricing in the externalities of climate change, carbon pricing needs to be more widespread and with firmer pricing mechanisms. Currently emissions allowances purchased by companies in the EU ETS, Korean and Californian ETS schemes represent and expense of less than 0.5% of company EBITDA in 2016.

# The main chemical routes and building blocks

## Petroleum is one of the main building blocks for the chemical industry

Steam cracking or pyrolysis is the major process route which splits and breaks up large hydrocarbon (HC) feedstocks such as naphtha and ethane into high value molecules such as ethylene and polyethylene (olefins) which in turn are feedstocks for other chemical processes and products. **The three groups of primary petrochemical products are olefins, aromatics (including benzene, toluene and xylene) and synthesis gas which is used in ammonia and methanol[i]. The production of HVCs (high value chemicals), ammonia and methanol accounted for 73% of the chemicals and petrochemicals sector's total energy use in 2014[ii].**

Most of the major components of the steam cracker design are similar to early plants developed in the 1940s with design upgrades and improvements since then with the majority focused on the furnace which is the most energy intensive end accounting for 60-65% of total energy use in the energy process.

Of the 60/40 split between feedstock and process, only 5% of grid power goes into the process so this part of the industry does not have the same scope to decarbonise in the same way as other energy intensive industries where energy use is linked to the composition of energy in the grid.

Plants have been upscaled through the years as larger plants offer more energy and capital efficiency (IDB 2013). In general, more than 10 furnaces are utilised in a single ethylene plant with capacity ranging from 1 mt p.a. to more than 1.5 mt p.a. This level of scale demonstrates the benefits of energy efficiency gains and the capital intensity of this part of the value chain.

Even state of the art technology deployment limits the degree of energy reduction required from steam cracking due to the high volume high energy demand of this non-catalytic process. An emerging technology (time frame 2018 – 2021) offering significant energy savings is catalytic cracking - the first state of the art catalytic cracking plant using naphtha to produce olefins has been set up in China and consumes 20% less energy than the current world average for existing steam cracking plants and 30-40% compared to older existing crackers[iii].

**Methanol which is another energy and carbon intensive chemical is made from either natural gas (80%) or coal (mainly in China)** – it is used in various commercial applications and is used in transportation fuel to reduce tail pipe emissions. Methanol can also be made from a number of bio-feedstocks and waste making it one of the most flexible chemical commodities. In the production of methanol, natural gas is heated, desulfurized, mixed with steam and fed into a synthesis gas reactor. This three part process is modular, consumes 60% of capex and consumes the majority of energy.

**Ammonia accounts for one of the largest shares of chemical products produced from hydrocarbons.** It is the main element in the value chain for producing fertilisers such as urea fertiliser, ammonium nitrate and ammonium phosphate as well as being used in a wide range of industrial applications such as synthetic resins, polyurethanes and in refrigeration. Most ammonia technologies (47%) are based on the original Haber-Bosch process although there is differentiation in operating conditions and catalyst technology which is proprietary. A benchmarking exercise by the International Fertilizer Association (IFA) shows that there is still a gap in terms of energy efficiency from the average energy consumption of global plants of between 36-38 GJ/t $NH_3$ and the best in class of 30 GJ/t $NH_3$ and the thermodynamic limit of 18 GJ/t $NH_3$.

**Hydrogen is a key industrial gas for the refining sector** and modern large scale hydrogen plants use natural gas as both a feedstock and fuel. Steam Methane Reforming (SMR) produces hydrogen using natural gas and steam and emits $CO_2$ as a by-product. This is a highly energy intensive process with energy accounting for around 30% of the operating cost of industrial gas companies. An emerging technology (time-frame of 2018-2023) is the production of hydrogen using electrolysis[iii].

**Industrial chlorine is produced by the electrolysis of aqueous sodium chloride and this is called the chloralkali** process. Chlorine production co-produces hydrogen in significant amounts which can either be used as a chemical feed in downstream processes or burned to cover additional heat requirements in the plant. The chlorine process does not release any process specific $CO_2$ and its main carbon footprint is based on the amount of energy required for electrolysis. This route can therefore benefit from any low carbon sources of electricity – electricity accounts for around 50% of production costs[iii].

(i). Greenhouse Gas Emissions from New Petrochemical Plants (IDB, 2013)
(ii) IEA - Energy Technology Perspectives - 2017
(iii). Low carbon energy and feedstock for the European Chemical Industry (Dechema, 2017)

## Figure 20: Summary of the highest emitting chemical processes

| Chemical | GHG Type | Share of chemical GHG emissions | Number of major production processes | Production processes | Key end uses |
|---|---|---|---|---|---|
| Ammonia | $CO_2$ | 27% | 1 | Synthesis (Haber-Bosch process). | Fertiliser production. |
| Ethylene | $CO_2$ | 11% | 1 | Steam cracking (can use various fuel feedstocks). | Polyethylene production. |
| Methanol | $CO_2$ | 7% | 1 | Catalytic synthesis process (feedstock natural gas into a synthesis gas stream). | Pharma, fuel blending, plastics, paint, olefins, DME (vi). |
| Propylene | $CO_2$ | 6% | 3 | Mostly a by-product of ethylene steam cracking production. | Polypropylene production. Final uses include plastics, solvents, paints, and coatings. |
| Ethylene oxide | $CO_2$ | 3% | 1 | Direct oxidation (from ethylene). | Detergents, thickeners, solvents, plastics, and various organic chemicals such as ethylene glycol. |
| BTX (i) | $CO_2$ | 2% | 2 | Produced from two main feedstocks: Reformates from catalytic reforming in refineries; Steam cracker pyrolysis gasoline. | Chemical feedstock. |
| Polyethylene | $CO_2$ | 2% | 1 | Polymerization of ethylene. | Primary use in packaging. |
| Propylene oxide | $CO_2$ | 1% | 2 | Produce through either hydrochlorination or oxidation. | Converted to polyols for the production of plastics with the remainder hydrolyzed into propylene glycol. |
| Acrylonitrile | $CO_2$ | 1% | 1 | Propylene ammoxidation: Feedstocks and air are reacted in a fluidized bed in the presence of a catalyst. | Textiles. |
| Nitric acid | $N_2O$[iii] | 7% | 1 | Produced through chemical reactions in two main phases: Oxidation and absorption (Ostwald process). | Mostly produced for on-site consumption for e.g. fertilisers production. |
| Adipic acid | $N_2O$ | | 1 | Manufactured from a cyclohexanone/ cyclohexanol (v) mixture which is oxidised by nitric acid in the presence of a catalyst. | Nylon 6-6 Resins & Fibers ( automotive and electronic applications). |
| Caprolactam | $N_2O$ | 1% | 1 | Beckmann rearrangement: Oxidation of cyclohexane ($C_6H_{12}$) followed by a catalytic rearrangement. | Nylon-6 (used to produce, for example, textiles). |
| HCFC-22 (ii) | HFC-23[iv] | 14% | 1 | Reaction of chloroform ($CHCl_3$) and hydrogen fluoride (HF) in the presence of antimony pentachloride ($SbCl_5$) catalyst. | As a refrigerant in air-conditioning systems, a blend component in foam blowing feedstock for the manufacturing of synthetic polymers (e.g. Teflon). |

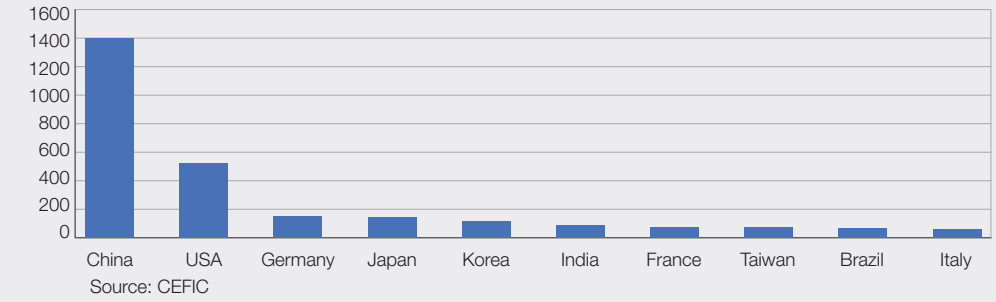
(i) Benzene, toluene and xylene
(ii) Chlorodifluoromethane
(iii) Nitrous oxide
(iv) Fluoroform
(v) Cyclohexanone, $(CH_2)_5CO$, and Cyclohexanol, $(CH_2)_5CHOH$
(vi) Dimethoxyethane

Source: CDP, IPCC

# The importance of the Chinese chemical industry

China, through its rapid industrialization in the last decade, now dominates the world chemical landscape, accounting for 40% of global sales in chemicals against 12% in 2005 and is the largest country by sales (CEFIC – 2015). This has been at the expense of the EU which has shrunk from 28.2% to 14.7% of sales and NAFTA (US, Canada, Mexico) which has fallen by 25.3% and 16.5%.

**Figure_21a: Chemical sales by country – 2015 (€bn)**



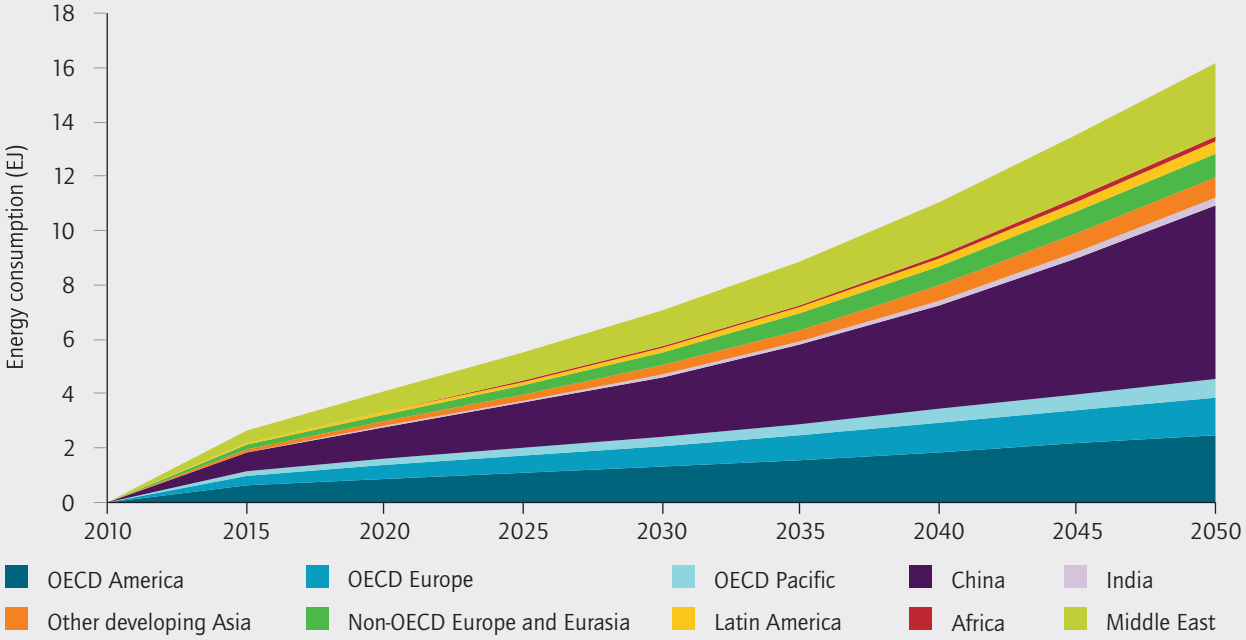

Source: CEFIC

China is now an important market for export sales and has a large domestic chemicals industry although there is little visibility on the structure of the Chinese domestic market. According to the ICCA, China was the eighth largest importing nation and the twelfth largest exporting nation for chemicals with the US as the leading exporter into China with EU sales being predominantly within the EU (71%).

China is said to be the largest plastic producing and consuming country in the world since 2010. China has been a large importer of plastics and plastic products and this ranked as China's fourth largest import category in 2012. Based on an international survey of ethylene steam crackers in 2015, China had 13.9 bt/year of nameplate capacity – 10% of global capacity. 50% of these have been 100% naphtha or a combination of naphtha and gas oil but there is no information on the feedstock for the other plants. The concern is that as China has access to coal that this has been a readily available feedstock and more carbon intensive than ethane or naphtha.

Based on their regional analysis, the IEA in their technology roadmap for the industry estimate that over half of the energy savings for the industry for a 2°C is expected to come from China (8.4EJ) and the Middle East (4.8EJ), with OECD countries contributing to less than a third of energy savings[4].

**Figure 21b: Energy savings by region in the Low-Demand Case**




Note: Excludes changes in feedstock use.
Source: IEA.

The upcoming Chinese ETS will include chemicals and petrochemicals among the 8 sectors being targeted, including all industrial units with thresholds of greater than 26,000 t $CO_2$. There is no breakdown of emissions by sectors, with all industrial processes estimated at 1,297 Mt $CO_2$ equivalent or 12% of total emissions targeted[5]. The scheme will require validation of emissions from a number of industrial processes in China and should provide greater transparency on the structure of the chemicals industry in China and better targeting of the more polluting plants.

4. IEA Technology Roadmap – Energy and GHG Reductions in the Chemical Industry via Catalytic Processes – 2013
5. International Carbon Action Partnership – August 2017 – https//icapcarbonaction.com

# Physical risks: Water resilience

- Braskem rank first for water resilience. Braskem have reduced their water withdrawal intensity at the greatest pace over the last five years, cutting their intensity relative to revenue by 13% and their intensity relative to gross profit by 39%.
- AkzoNobel and Johnson Matthey come second and third respectively. AkzoNobel come second for water governance and policy and water consumption intensity metrics with Johnson Matthey ranking first for both water withdrawal and water consumption intensity metrics.
- Dow and LyondellBasell occupy the two places at the bottom of the water resilience table. LyondellBasell, ranked last, disclose very little water data while Dow perform poorly across the water metrics, with a significantly higher water withdrawal intensity than any other company.

## Overview

Globally, water is becoming an increasingly scarce resource due to a changing climate, increased urbanization and rapid population growth. Currently, more than a billion people live in water scarce regions and by 2025 up to 3.5 billion people, nearly half of the worlds' population, could be experiencing water scarcity[6].

Water scarcity can lead to higher supply costs and a higher likelihood of water shortage issues, especially for highly water intensive industries. The chemical industry uses relatively large quantities of water, primarily for cooling, steam generation and chemical processing[7]. In Europe, the chemical and refinement industries are responsible for 50% of all water used by the manufacturing industry and represents 6% of the total freshwater abstracted[8].

Moreover, chemical processes can pose risks through the generation of large quantities of wastewater, which can be contaminated with hazardous and toxic substances. Reducing water usage and contamination through innovative water risk management strategies can improve operational efficiency and lower operating costs, minimizing the impact of regulations and water supply shortages.

In this chapter, we assess companies' water resilience based on publicly available resources and company responses to the CDP 2017 water questionnaire. Cumulatively, we believe that these metrics give an overall indication of companies' exposure to and management of water related risks and opportunities.

- **Metric 1) Water withdrawal intensity:** Water withdrawal intensity is used to evaluate companies' dependency on water supply and the associated risk of business disruption in the event of water supply issues. This metric focuses on current water withdrawal intensities per unit of revenue and gross profit as well as the extent to which companies have reduced their withdrawal intensities over the period 2012-2016.
- **Metric 2) Water consumption intensity:** Water consumption intensity is used to evaluate a company's net impact on the watershed or aquifer. This metric focuses on current water consumption intensities per unit of revenue and gross profit as well as the extent to which companies have reduced their consumption intensities over the period 2013-2016.
- **Metric 3) COD (Chemical oxygen demand) intensity:** COD intensity is a measure of water and wastewater quality. It is the amount of oxygen required to oxidize organic water contaminants to inorganic end products. This metric focuses on current COD intensities per unit of revenue and gross profit as well as the extent to which companies have reduced their COD intensities over the period 2012-2016.
- **Metric 4) Water governance and policy:** We form a ranking based on a variety of metrics relating to companies' water risk assessment and management based on their responses to the 2017 CDP water questionnaire and other company disclosures. The scorecard includes: disclosure to CDP, water data verification, water supply chain engagement, water risk assessment, water governance, water policy and water related targets and goals. Companies are scored out of 100 with high scores indicating better placed companies.

6. http://www.wri.org/our-work/topics/water
7. Chemicals – Sustainability Accounting Standards Board (SASB, 2015)
8. Report on Chemistry-Water synergies (Perez, M. et al., 2011).

**Figure 22: Water resilience summary**

| Company | Classification | Water withdrawal intensity | Consumption intensity | COD intensity | Water governance | Overall weighted rank | Water resilience rank | Water resilience grade |
|---|---|---|---|---|---|---|---|---|
| Braskem | Petrochemicals | 1 | 7 | 19 | 3 | 5.4 | 1 | A |
| AkzoNobel | Speciality | 10 | 2 | 4 | 2 | 5.8 | 2 | A |
| Johnson Matthey | Speciality | 1 | 1 | 8 | 10 | 6.2 | 3 | A |
| BASF | Diversified | 13 | 3 | 11 | 1 | 6.9 | 4 | B |
| DSM | Speciality | 7 | 8 | 17 | 5 | 7.4 | 5 | B |
| LG Chem | Petrochemicals | 6 | 6 | 8 | 8 | 7.7 | 6 | B |
| Mitsubishi | Diversified | 15 | 5 | 4 | 6 | 8.6 | 7 | B |
| Linde | Industrial gases | 18 | 10 | 6 | 4 | 9.1 | 8 | B |
| DuPont | Diversified | 11 | 4 | 22 | 9 | 10.1 | 9 | C |
| Air Products | Industrial gases | 7 | 15 | 3 | 15 | 10.5 | 10 | C |
| Praxair | Industrial gases | 14 | 13 | 7 | 11 | 11.3 | 11 | C |
| Evonik | Speciality | 19 | 11 | 18 | 7 | 11.8 | 12 | C |
| Sumitomo | Diversified | 16 | 17 | 1 | 12 | 12.2 | 13 | C |
| Shin-Etsu | Speciality | 9 | 17 | 20 | 13 | 12.5 | 14 | C |
| PPG | Speciality | 3 | 17 | 12 | 19 | 12.6 | 15 | C |
| Toray | Diversified | 5 | 17 | 10 | 20 | 13.4 | 16 | D |
| Umicore | Speciality | 4 | 17 | 12 | 21 | 13.5 | 17 | D |
| Formosa | Petrochemicals | 12 | 12 | 12 | 18 | 13.7 | 18 | D |
| Solvay | Speciality | 17 | 13 | 21 | 14 | 14.1 | 19 | D |
| Air Liquide | Industrial gases | 21 | 9 | 2 | 17 | 14.9 | 20 | D |
| Dow | Diversified | 20 | 16 | 12 | 16 | 16.0 | 21 | D |
| LyondellBasell | Petrochemicals | 21 | 17 | 12 | 21 | 18.7 | 22 | E |
| **Weighting** | | **35%** | **15%** | **15%** | **35%** | | | |

Note: In calculating the weighted rank in this table, we use the weighted ranks for each area (where relevant). We display non-weighted ranks in this summary for simplicity only
Source: CDP

# Highlights

## Overall

- Braskem are best placed to deal with water risks across all sub-sectors, ranking first overall for water resilience. They top the rankings for the water withdrawal intensity metric and come third overall for water governance. Despite Braskem ranking first for water resilience, their fellow petrochemical LyondellBasell occupies last place. LyondellBasell are the only company to not respond to the CDP water questionnaire and this lack of disclosure costs them dearly.

- The speciality chemicals perform well, occupying three of the top five places for water resilience. AkzoNobel and Johnson Matthey come second and third respectively, AkzoNobel demonstrating very strong water governance and policies with Johnson Matthey consuming the least water on an intensity basis by a factor of 40 relative to revenue and seven relative to gross profit.

- The diversified chemicals have a broad range of rankings, stretching from BASF in 4th overall to Dow who rank 21st. Notably, BASF rank top for their water governance and polices while Sumitomo Chemical rank first for COD intensity. Dow perform poorly across the water metrics, especially so in the water withdrawal intensity metric where they come last of the reporting companies with considerably the highest current intensities.

- Three of the four industrial gases are grouped together between 8th and 11th place, with the anomaly being Air Liquide who come 20th. Despite Air Liquide's impressive COD intensity score, they rank last overall for the water withdrawal metric and score poorly on the water governance, particularly for a lack of water data verification.

## Diversified chemicals

- BASF come first for water resilience analysis of the diversified chemicals, mainly down to their very strong performance for water governance and policy. BASF score 83 out of 100 on the water governance and policy scorecard, the highest of all chemical companies. They come top overall for water disclosure, water data verification and water risk assessment.

- Dow is the weakest of the diversified group as highlighted and its current withdrawal intensities are quite considerably the highest of all chemical companies, both relative to revenue and gross profit.

- Generally, the diversified chemicals score well in regards to water consumption, occupying three of the top five overall places in the scoring. BASF perform the best of the diversified chemicals with the lowest intensity relative to revenue and joint lowest intensity relative to gross profit with DuPont.

- Sumitomo Chem rank first overall for COD intensity, demonstrating the steepest decline of all companies from 2012-2016 both relative to revenue (14% fall) and gross profit (22% fall). DuPont perform worst of the all companies regarding COD intensity, being the only diversified chemical to show a growth in COD intensity from 2012-2016 (9% growth relative to revenue and 6% relative to gross profit) and having considerably higher current COD intensities than any other diversified chemicals company.

## Speciality chemicals

- AkzoNobel and Johnson Matthey are the best speciality chemicals across the water related metrics. AkzoNobel rank first for COD intensity and water governance and policy with Johnson Matthey coming first for water withdrawal intensity and water consumption intensity metrics.

- Solvay perform poorly across the water metrics, coming last for COD intensity and second last for water withdrawal intensity. Umicore come just above Solvay, having the worst water consumption intensity and water governance.

- Speciality chemicals occupy three of the top four places in the water withdrawal intensity metric, with Johnson Matthey, PPG and Umicore coming second, third and fourth respectively. Although there are limited falls in intensity since 2013, the absolute intensity figures are minimal when compared with other chemical sub-sectors.

- Based on water consumption, Johnson Matthey have both the lowest current intensity figures relative to revenue and gross profit. Moreover, Johnson Matthey also show the steepest decline in consumption intensity of the speciality chemicals, their intensity falling 14% relative to revenue and 12% relative to gross profit from 2013-2016.

- All speciality companies have cut COD intensities from 2012-2016, with the only company not doing so, Johnson Matthey, actually stopping their reporting of COD in 2014, such was its minimal recordings.

- AkzoNobel demonstrate the best water governance and policies relative to other speciality chemicals, scoring 82 out of 100 on the water governance scorecard. They score particularly well in water data verification, water risk assessment and water targets and goals, including being the only company in the report to have a water quality target.

- PPG are ranked lowest of the speciality chemicals for their water governance and policy, scoring 39 out of 100. They come last of the speciality chemicals for water data verification, water supply chain engagement, water risk assessment, water governance and water targets and goals.

## Industrial gases

- Linde are the best performing industrial gas across water related metrics, scoring the highest for the water governance section but are ultimately not too far ahead of Air Products and Praxair. Air Liquide are seen to be least well placed to dealing with water risks of the industrial gases, coming last in both the water withdrawal intensity and water governance and policy metrics, the two highest weighted metrics in the water section.

- Air Products are the best performing industrial gas for water withdrawal intensity with an intensity of just 6 megalitres per USD million of revenue and 19 megalitres per USD million of gross profit, roughly a fifth of their peers relative to revenue and between a quarter and a fifth of their peers relative to gross profit.

- Generally, the industrial gas sector performs extremely well with regards to COD intensity, occupying four of the top seven places across all twenty-two chemical companies assessed. Air Liquide are the best performing of the four industrial gases with the lowest COD intensity of all companies relative to gross profit and the second lowest relative to revenue, beaten only by Air Products.

- Linde demonstrate the greatest water governance and policies of the industrial gases with 73 out of 100 on the water governance and policy scorecard, scoring full marks for water data verification and water policy. Linde's water policy is company-wide, incorporated within the group sustainability policy and has performance standards for both direct operations and suppliers.

## Petrochemicals

- Braskem rank first of all twenty-two companies for water resilience. They perform the best of all chemicals regarding water withdrawal intensity, displaying the steepest decline in water withdrawal intensities in the last 5 years with a 13% fall relative to revenue and a 39% fall relative to gross profit. Braskem are also the best scoring petrochemical for water governance and policies with company-wide risk assessment, receiving full marks for data verification while also performing extremely well in water risk assessment and water policy sections of the scorecard.

- LyondellBasell come last on the overall water resilience section, owing to the fact that they do not respond to the CDP water questionnaire and generally have poor water disclosure.

- LG Chem have the best water consumption intensities of the petrochemicals with the lowest consumption intensity relative to revenue and second to Braskem relative to gross profit. The water consumption intensity of LG Chem has fallen 4% relative to revenue from 2013-2016 and 17% relative to gross profit, with Braskem cutting their consumption intensities for revenue and gross profit by 10% and 37% respectively.

# Measuring water quality

Water quality is a critical issue for companies in the chemical industry. Approximately 47% of wastewater produced in the domestic and manufacturing sectors is untreated, particularly in South and Southeast Asia, but also in Northern Africa as well as Central and South America[9].

There are numerous methods for assessing water quality in the chemicals industry, with one of the most widely used measurements being the chemical oxygen demand (COD). COD is the amount of oxygen consumed to chemically oxidize organic water contaminants to inorganic end products. To measure COD, an oxidant is added to a water sample. Once oxidation is complete, the amount of oxidant remaining in the solution is measured to calculate the concentration of organics in the sample. COD is expressed in mg/L, which indicates the mass of oxygen consumed per liter of solution[10].

However, certain chemical companies prefer other water quality measurements, such as biological oxygen demand (BOD). The BOD test measures the oxygen demand of biodegradable pollutants whereas the COD test measures the oxygen demand of biodegradable pollutants plus the oxygen demand of non-biodegradable oxidizable pollutants.

While there are numerous regulatory risks associated with water quality, there are also opportunities presented through the need to address this major global environmental challenge. Markets & Markets claim that the water treatment chemicals market will be worth $57bn by 2022, with market leaders BASF, Ecolab, Solenis, Kemira and AkzoNobel best placed to capitalise[11].

# Hurricanes impacting the chemicals sector

During late August and early September, Hurricanes Harvey and Irma made landfall across the Caribbean, Central America and the U.S. Gulf Coast. Bloomberg were reporting that Texas and Louisiana accounted for 80% of U.S. chemicals output[12], and with numerous low lying chemical plants across the Gulf Coast, there was widespread damage to the chemical industry. At its height, around 61% of U.S. ethylene production was halted[13], leaving companies like Formosa Plastics unable to meet commitments for polyethylene, polypropylene and PVC production[14].

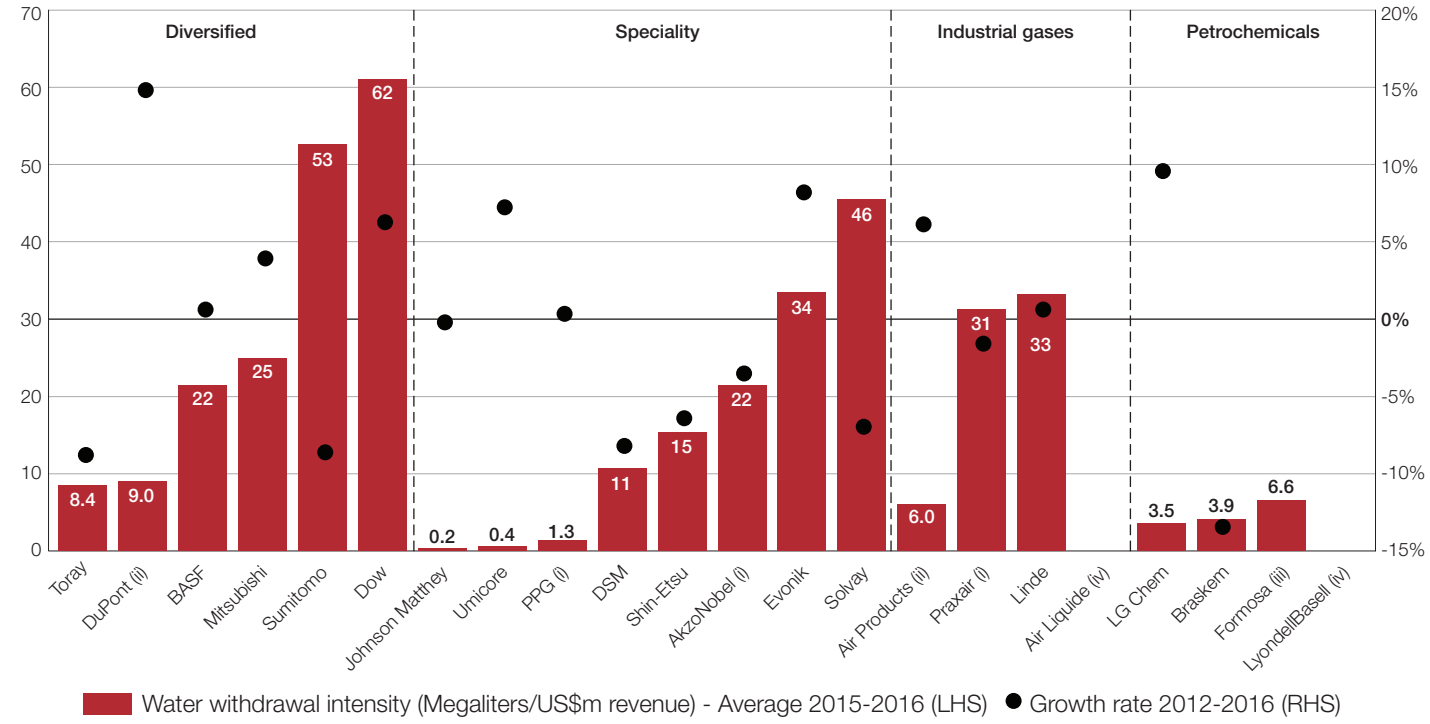
Moreover, the rising water levels caused by the flooding left 19.5 tonnes of organic peroxides at an Arkema plant in Crosby, Texas without necessary cooling capabilities[15]. This led to the volatile chemicals exploding and subsequently a large fire engulfed the plant. Arkema are now being sued for at least $1 million for failing to take adequate steps to avoid the fire at the Texas plant[16].

Despite the extensive damage to numerous chemical plants across the Gulf Coast, chemical companies have in fact been adapting to enhanced climatic risks. As an example, Dow has been working with The Nature Conservancy to strengthen its flood and storm protection capabilities as it aims to deliver $1 billion in net present value from projects that are good for business and good for nature by 2025[17].

Although the total financial cost of the damage caused by the hurricanes has not yet been estimated, Harvey and Irma have still dented earnings outlooks for the sector. The Financial Times reports that earnings at chemical companies are now forecast to shrink 4.3% in Q3 2017, compared with an expected increase of 2.7% from earlier this September[18].

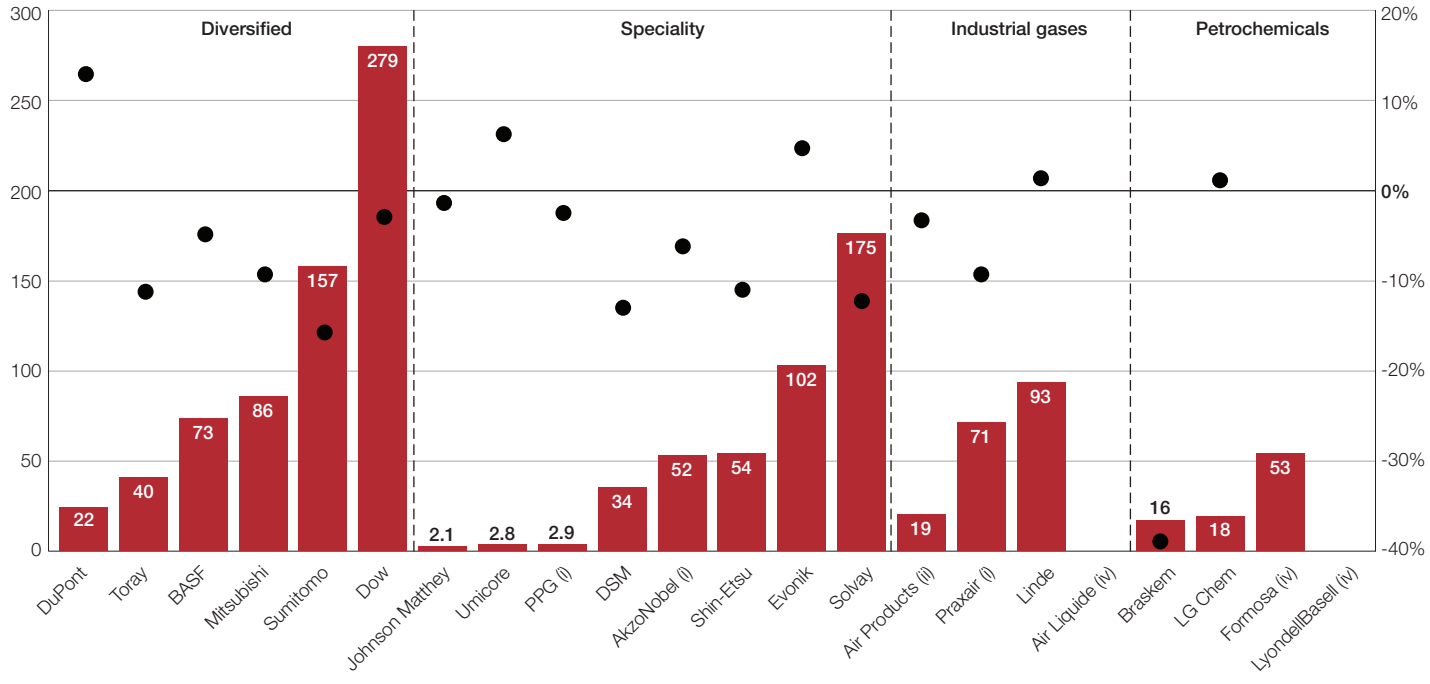
9. Domestic and industrial water uses of the past 60 years as a mirror of socioeconomic development (Florke et al., 2013)
10. Merckmillipore.com
11. Water Treatment Chemicals Market by Type, End User, Region - Global Forecast to 2022 (Markets and Markets, 2017)
12. Hurricane Harvey impacts chemicals – Bloomberg (29th Aug 2017)
13. https://www.petrochemwire.com/Frames/Events/Storm/HarveyUpdate.html
14. Formosa Plastics unable to supply some customers after Harvey – Bloomberg (30th Aug 2017)
15. Hurricane Irma's chemicals fallout could be worse than Harvey's – Bloomberg (8th Sep 2017)
16. https://www.cnbc.com/2017/09/07/arkema-sued-over-injuries-in-chemical-plant-fire-after-hurricane-harvey.html
17. http://www.dow.com/en-us/news/press-releases/dow-and-tnc-release-study-highlighting-the-importance-of-green-infrastructure
18. Hurricanes dent earnings outlook for chemicals, insurance and airline industries – Financial Times (15th Sep 2017)

## Figure 23: Water withdrawal intensity by revenue



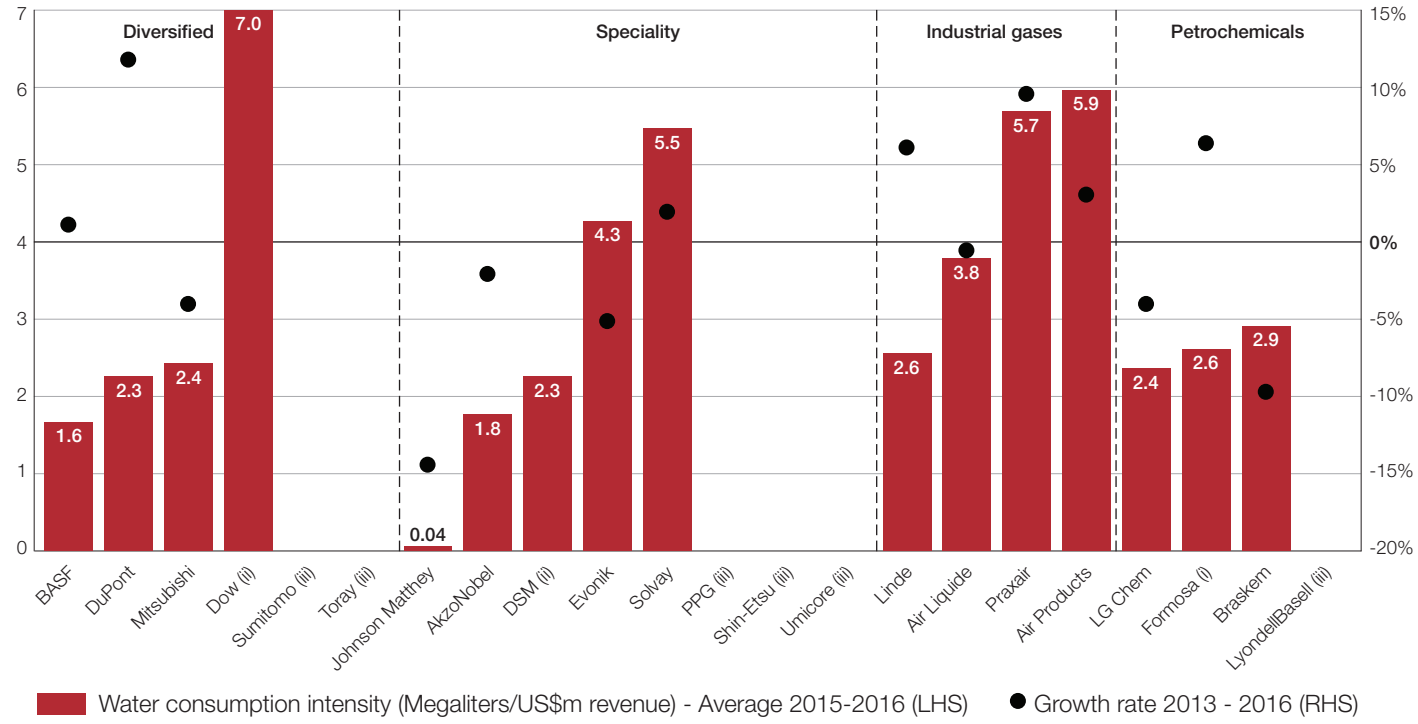

(i) Growth rate 2013-2016 for PPG, AkzoNobel and Praxair
(ii) Growth rate 2014-2016 for Air Products
(iii) Insufficient data to calculate growth rate for Formosa Plastics
(iv) No data for Air Liquide or LyondellBasell
Source: CDP, company reports

## Figure 24: Water withdrawal intensity by gross profit



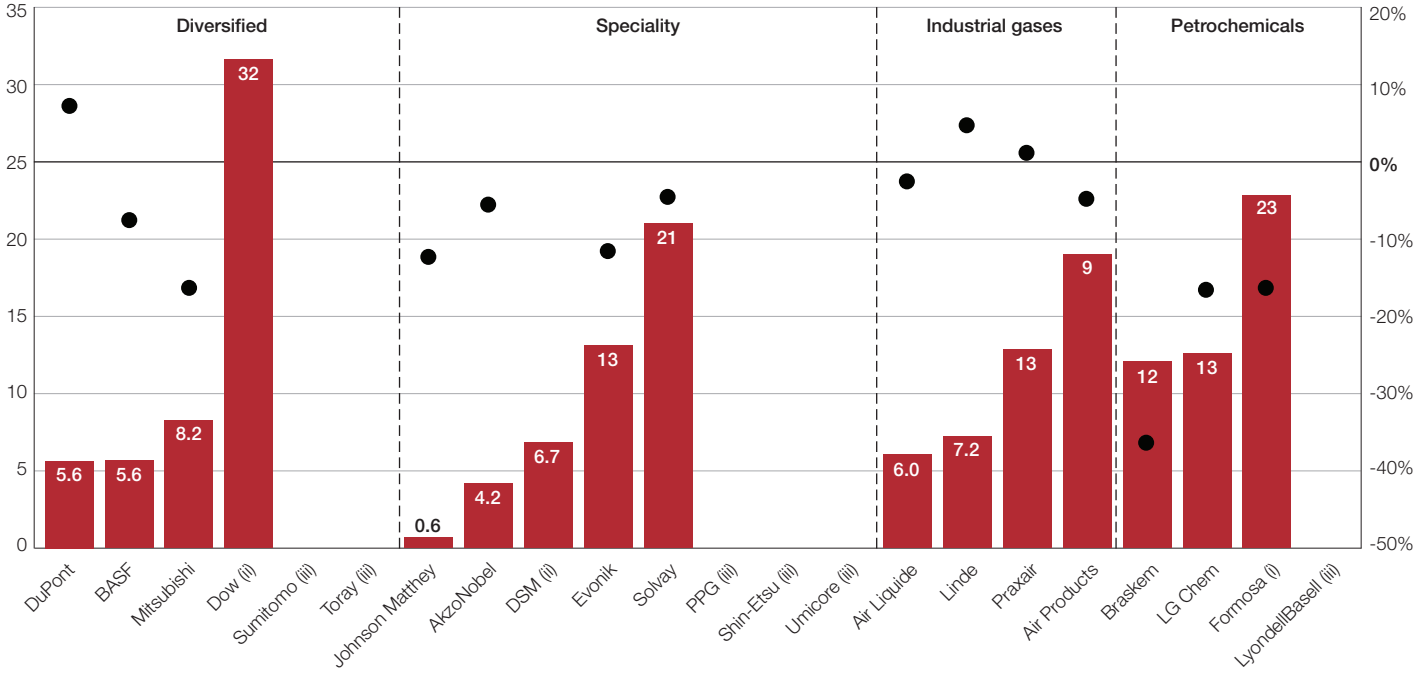

(i) Growth rate 2013-2016 for PPG, AkzoNobel and Praxair
(ii) Growth rate 2014-2016 for Air Products
(iii) Insufficient data to calculate growth rate for Formosa Plastics
(iv) No data for Air Liquide or LyondellBasell
Source: CDP, company reports

## Figure 25: Water consumption intensity by revenue



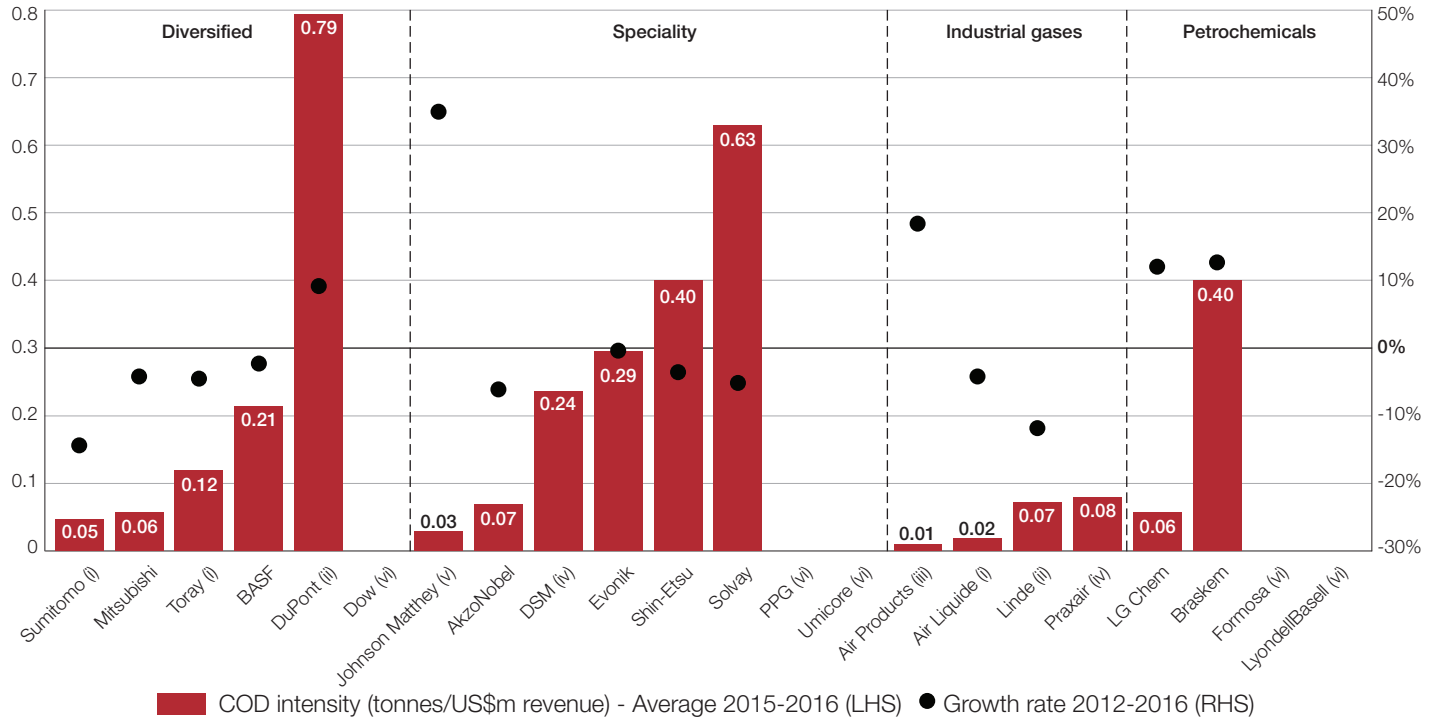

(i) Growth rate 2013-2015 for Formosa Plastics
(ii) Insufficient data to calculate growth rate for Dow and DSM
(iii) No data for LyondellBasell, PPG, Shin-Etsu, Sumitomo, Toray or Umicore
Source: CDP, company reports

## Figure 26: Water consumption intensity by gross profit




(i) Growth rate 2013-2015 for Formosa Plastics
(ii) Insufficient data to calculate growth rate for Dow and DSM
(iii) No data for LyondellBasell, PPG, Shin-Etsu, Sumitomo, Toray or Umicore
Source: CDP, company reports

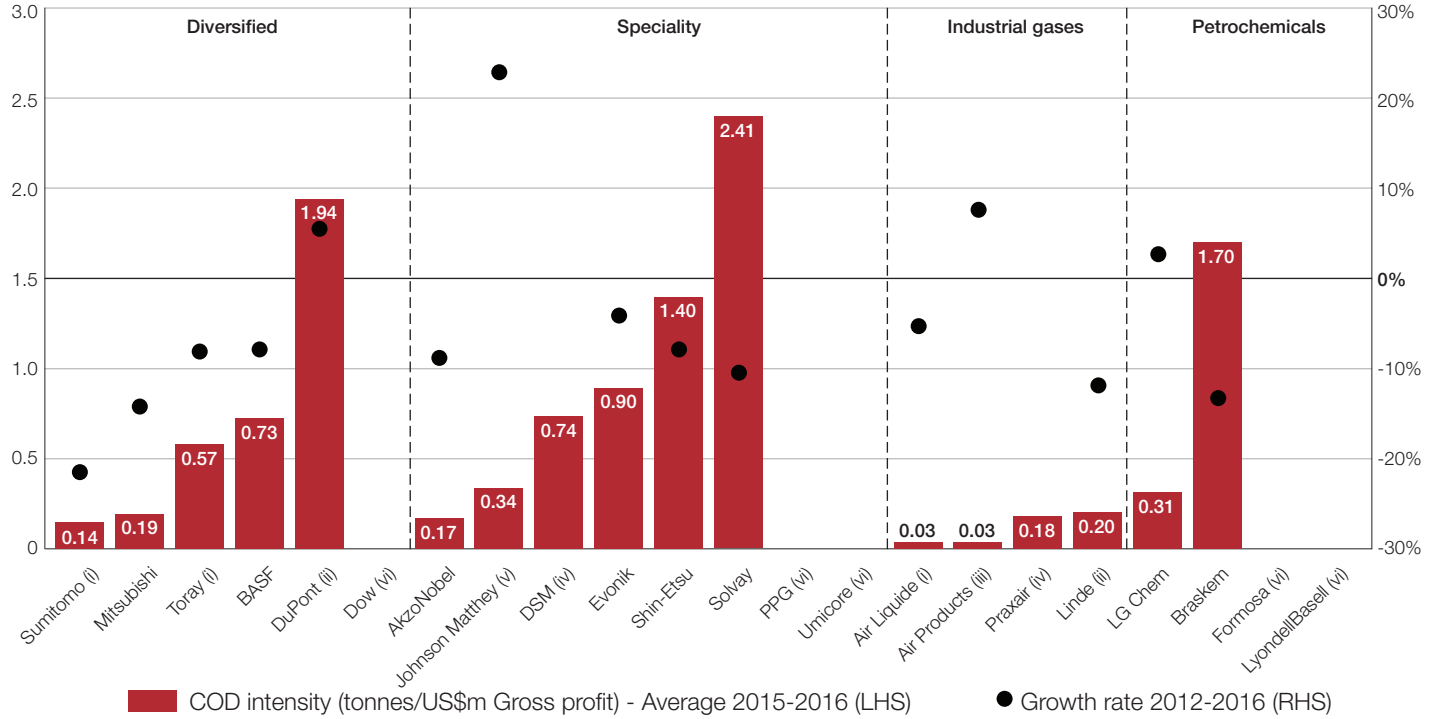
## Figure 27: COD intensity by revenue




(i) Growth rate 2012-2015 for Sumitomo, Toray and Air Liquide
(ii) Growth rate 2013-2016 for DuPont and Linde
(iii) Growth rate 2014-2016 for Air Products
(iv) Insufficient data to calculate growth rate for DSM and Praxair
(v) 2014 COD intensity and growth rate 2012-2014 for Johnson Matthey
(vi) No data for Formosa Plastics, LyondellBasell, PPG, Dow or Umicore

Source: CDP, company reports

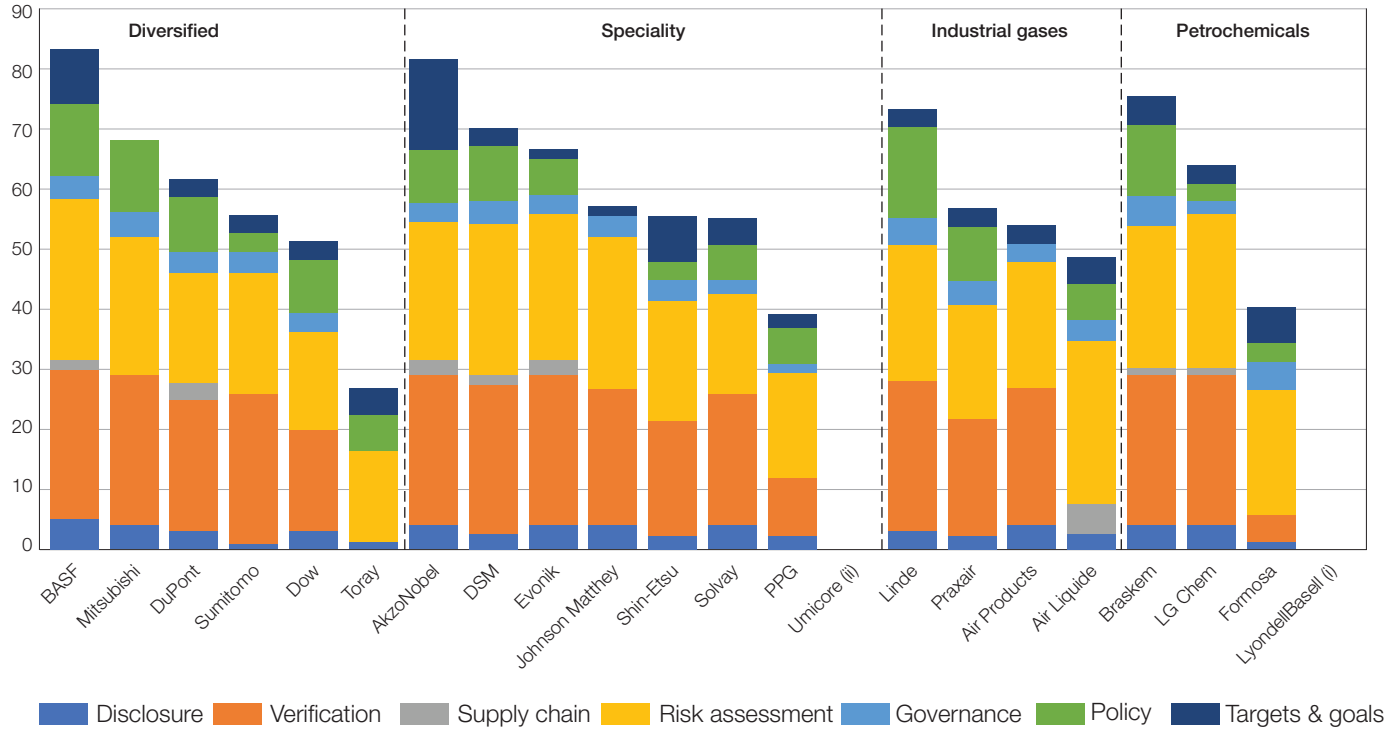
## Figure 28: COD intensity by gross profit




(i) Growth rate 2012-2015 for Sumitomo, Toray and Air Liquide
(ii) Growth rate 2013-2016 for DuPont and Linde
(iii) Growth rate 2014-2016 for Air Products
(iv) Insufficient data to calculate growth rate for DSM and Praxair
(v) 2014 COD intensity and growth rate 2012-2014 for Johnson Matthey
(vi) No data for Formosa Plastics, LyondellBasell, PPG, Dow or Umicore

Source: CDP, company reports

**Figure 29: Water governance score[i]**




(i) Scored out of 100 where companies with higher scores receive higher rankings
(ii) LyondellBasell and Umicore did not answer the 2016 or 2017 CDP water questionnaire
Source: CDP, company reports

# Water stress analysis

In a relatively water intensive industry, water use in the chemicals sector is primarily focused on cooling. Although, cooling has reduced risks for water contamination and environmental impact, water dependency remains a critical issue for the sector. With that in mind, numerous chemical companies have undertaken their own water stress analysis, assessing the risks that they face both now and potential risks that they could face in the future.

At CDP, we have attempted to assess the water stress risk of the chemical companies on a plant by plant basis using the Aqueduct global water stress risk mapping tool, developed by the World Resources Institute (WRI). The Aqueduct tool assesses water stress conditions based on physical water quantity and quality indicators and regulatory and reputational risks.

Unfortunately, not all site location data has been provided and thus only thirteen of the companies are considered in this water stress analysis. Consequently, this is not a weighted metric.

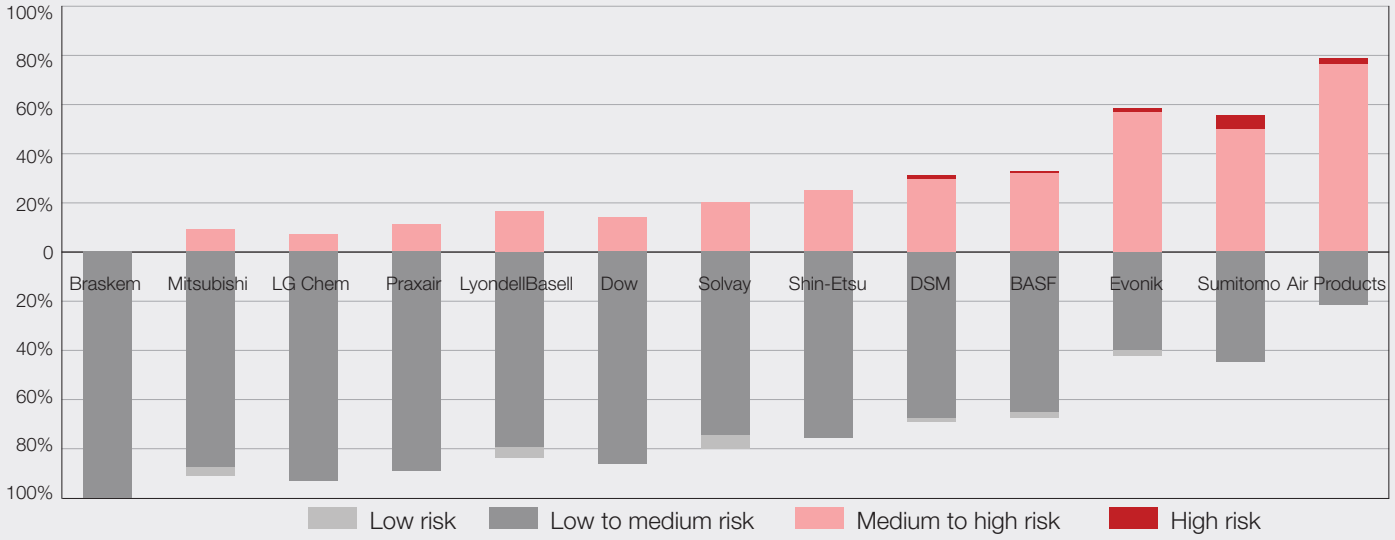
What the analysis shows nonetheless, is that Braskem have 100% of their sites in low to medium areas of water risk, ranking first, which correlates with their overall water resilience performance.

Least well prepared for current water stress risks based on the Aqueduct tool is Air Products. Air Products have 76% of sites in medium to high areas of water risk and 2% in high risk areas, the highest combination of the two highest risk categories by 20 percentage points.

Ranking second and third last respectively are Sumitomo Chemical and Evonik, with combined scores of 55% and 58% in medium to high and high water risk areas.

Moreover, Sumitomo Chemical have 5% of sites in high risk water areas, the most exposed proportion of plants in the highest water risk category of all companies assessed.

**Figure 30: Current asset water stress exposure**




Source: CDP, WRI, company reports

# Transition opportunities

- The Chemical Industry is a large part of the industrial carbon emissions problem but is also uniquely positioned to be part of the solution.
- Compared to other sectors such as steel, the sector is pro-active in finding low carbon technologies and products as solutions with an R&D spend for leaders at around 4%, with a few such as DuPont and Sumitomo at above 7% compared to steel averaging 0.5%.
- A number of companies have upside opportunity from low carbon revenues with DSM and AkzoNobel leading followed closely by Air Liquide, Dow, Evonik and Air Products.
- Formosa and LyondellBasell in petrochemicals are clear laggards in the group with high transition risks from carbon intensive processes not being countered by a pro-active policy to seek transition opportunities.

## Overview

In this section, we look at five metrics to evaluate how well positioned companies are to transition to a low carbon economy – product innovation, process innovation, low carbon revenues, R&D spend as a % of sales and use of renewable energy. While the industry itself has been keen to project avoided emissions as a metric to evaluate their contribution to the decarbonization equation, there is not sufficient data for this metric to be assessed consistently across companies.

The industry is relatively innovative with high-levels of R&D to net sales with two companies above 7%, 11 companies spending 2-4%, 4 companies between 1-2% and only 5 companies spending less than 1%. This compares with 12 out of 14 companies in steel with R&D to sales of less than 1% (CDP Steel Report 2016).

Process efficiency within the sector has been limited to incremental energy and emissions intensity savings rather than the game changing technologies for a step change in high intensive processes in the upstream part of the value chain. This is the start of the main chemical streams in petrochemicals, hydrogen, ammonia, methanol and chlorine providing the building (see box on Building blocks for the sector). Radical change will also require using bio-feedstocks instead of fossil fuel feedstock which remains constrained. There is limited transparency in what scope there is to improve processes as this is part of the competitive advantage for companies in the sector.

Product innovation is much more widespread across all sub-sectors from energy saving lighting, light weighting of autos, energy savings for superconductors, materials for use in renewable technologies to the production of bio-based products, catalysts and enzymes to improve carbon efficiencies. These customer solutions have had a positive direct impact when products have been commercialized and add to the percentage of low carbon revenues.

The area of carbon capture and storage (CCS) and carbon capture and use (CCU) is a focus of research and opportunity for the sector. As discussed in the box on page 40, CCS is an integral technology in long-term energy scenarios and is expected to capture 12% of forecast global emissions with power generation and industrial sectors such as chemicals being the main users of CCS (IEA 2017). The actual deployment of CCS is low relative to these expectations – the chemical sector has been active in finding solutions to make CCS more economic while at the same time looking at ways of using $CO_2$ emitted as waste as an input as feedstock or process application, both inside and outside the sector. Any breakthrough in this area would offer companies within the sector significant revenue potential.

The use of electricity in the fuel mix is different across the sub-sectors in the industry based on the fuel feedstock element and process, with lower scope for electricity use for petrochemical processes than for downstream speciality chemicals. Within the companies with higher electricity usage, there were only a small group of companies using renewable energy sources – this could relate to constraints related to high temperature processes which was not easily captured in the data analysis. Coal was still being used by a limited group of companies in this universe with Formosa Plastics being the only large-scale user of coal at 70% and Solvay at 33%.

Digitalisation is also a big theme for the sector, with a report by PWC[19] suggesting that chemical companies plan to invest 5% of annual revenue in digital operations solutions in the next five years. Digitalization offers revenue potential from technologies such as 3D printing, scope for data analytics within their product and supply chain and robotics offering scope for operational activities.

- **Metric 1) Product innovation:** We assess companies on publicly disclosed products judged to be favorable in contributing to a low carbon transition. Products are assessed on their efficacy in directly or indirectly reducing emissions within the chemicals industry or other industries by contributing to energy savings, emission reductions or replacement of materials.

  Products are grouped into the following subsectors and assessed using a scorecard approach. Companies are scored out of 100 with high scores indicating better placed companies:

  - Bio-based production – products manufactured from biological/renewable products as a replacement feedstock
  - Efficiency improvement applications – products that result in direct or indirect energy savings such as light-weight materials, additives such as catalysts and oxygen and materials that induce energy efficiencies
  - Renewable energy applications – products that are used within renewable energy applications
  - Battery/energy storage applications – energy storage products such as batteries or materials for use in batteries
  - Hydrogen applications – hydrogen used as an alternative to more environmentally damaging products
  - Pollution reduction products – products that reduce the emittance of pollutants and harmful chemicals

- **Metric 2) Process innovation:** Companies are assessed on processes that allow the chemicals industry to reduce emissions within their direct operations or within their supply chains and go beyond business as usual practices or the maintenance or upgrading of plants, as well as information regarding emissions and energy reducing initiatives.

  Processes are grouped into the following subsectors and assessed using a scorecard approach. Companies are scored out of 100 with high scores indicating better placed companies:

  - Carbon capture and storage/use - CC(U)S – processes that trap $CO_2$ produced within the chemical process or utilizing carbon in further processes
  - Process efficiency and technological optimization – processes that result in maximized energy savings in direct operations and through the supply chain
  - Renewable energy and low carbon feedstocks – use of renewable and bio-based feedstocks as sources of energy supply and feedstocks
  - Recycling materials and reduction/use of waste materials – processes that utilize waste and/or recycled materials
  - Emissions/energy reducing initiatives – companies that are part of initiatives that push for emissions reductions and energy efficiencies through collaboration with stakeholders within the industry and external partners
  - Digitization – Companies with established digitization initiatives within their operations

- **Metric 3) Low carbon revenue:** We assess companies on low carbon revenue based on CC3.2a C5 in the CDP questionnaire, where companies are asked to disclose the % revenue from low carbon products in the reporting year.

- **Metric 4) Research and development (R&D):** We rank companies on their average R&D expense to sales ratio over the period 2014-2016 as well as the % range in which R&D spend is considered to be in low carbon products.

- **Metric 5) Renewable energy:** We look at how companies are meeting their energy needs and rank them based on their renewable and coal share of their total energy use. We also rank companies on the strength of their energy reduction targets and their commitment to RE100.

19. https://www.pwc.com/gx/en/industries/energy-utilities-resources/publications/industry-4-0-chemicals-key-findings.html?_ga=2.96959254.841627300.1507130061-1307229567.1504882399

**Figure 31: Transition opportunities summary**

| Company | Classification | Product Innovation | Process innovation | Low carbon revenue | R&D | Renewable energy | Overall weighted rank | Transition opportunities rank | Transition opportunities grade |
|---|---|---|---|---|---|---|---|---|---|
| AkzoNobel | Speciality | 8 | 1 | 2 | 6 | 1 | 4.1 | 1 | A |
| Air Liquide | Industrial gases | 5 | 5 | 3 | 14 | 3 | 6.1 | 2 | B |
| BASF | Diversified | 1 | 4 | 16 | 5 | 15 | 7.1 | 3 | B |
| Johnson Matthey | Speciality | 3 | 9 | 7 | 15 | 5 | 7.4 | 4 | B |
| DSM | Speciality | 13 | 7 | 1 | 1 | 16 | 7.6 | 5 | B |
| Evonik | Speciality | 12 | 3 | 3 | 3 | 20 | 8.4 | 6 | B |
| Praxair | Industrial gases | 11 | 6 | 13 | 19 | 2 | 9.3 | 7 | B |
| DuPont | Diversified | 2 | 21 | 14 | 7 | 6 | 9.4 | 8 | B |
| Linde | Industrial gases | 19 | 2 | 17 | 13 | 9 | 10.6 | 9 | C |
| LG Chem | Petrochemicals | 6 | 19 | 12 | 8 | 12 | 10.7 | 10 | C |
| Mitsubishi | Diversified | 4 | 13 | 17 | 11 | 19 | 10.8 | 11 | C |
| Air Products | Industrial gases | 10 | 12 | 6 | 17 | 13 | 10.8 | 11 | C |
| Dow | Diversified | 16 | 18 | 3 | 8 | 7 | 10.8 | 11 | C |
| Shin-Etsu | Speciality | 15 | 11 | 17 | 8 | 11 | 11.3 | 14 | C |
| Sumitomo | Diversified | 22 | 14 | 11 | 2 | 8 | 11.3 | 15 | C |
| PPG | Speciality | 17 | 10 | 8 | 12 | 14 | 11.4 | 16 | C |
| Braskem | Petrochemicals | 9 | 17 | 15 | 22 | 4 | 12.1 | 17 | D |
| Solvay | Speciality | 7 | 15 | 9 | 15 | 21 | 12.2 | 18 | D |
| Umicore | Speciality | 14 | 8 | 17 | 18 | 17 | 12.5 | 19 | D |
| Toray | Diversified | 20 | 22 | 10 | 3 | 10 | 13.0 | 20 | D |
| LyondellBasell | Petrochemicals | 18 | 20 | 17 | 21 | 18 | 16.7 | 21 | E |
| Formosa | Petrochemicals | 21 | 16 | 17 | 20 | 22 | 17.1 | 22 | E |
| Weighting | | **20%** | **20%** | **10%** | **25%** | **25%** | | | |

Note: In calculating the weighted rank in this table, we use the weighted ranks for each area (where relevant). We display non-weighted ranks in this summary for simplicity only

Source: CDP

# Highlights

- The majority of the companies perform well on transition opportunities with 8 out of 22 companies ranked at B and better with AkzoNobel being a clear winner with the only company scoring an A rating, scoring well on process innovation, low carbon revenues and use of renewable energy. Clear laggards are LyondellBasell and Formosa ranking poorly across all metrics.
- The universe as a whole scores well on innovation with a high R&D expenditure as a proportion of sales compared to other industry groups. Sumitomo and DuPont are leading in this metric, with R&D making up 7.6% and 7% of expenditure respectively. DSM and AkzoNobel report that between 80-100% of their total R&D expenditure is within low carbon products.
- Innovation in the sector is also captured in our scoring on product innovation, with all sub-sectors ranked in the top 10. BASF ranks top in this metric followed closely by DuPont, Johnson Matthey, Mitsubishi, Air Liquide and LG Chem – the close grouping of the companies highlights the level of product innovation in the sector.
- BASF ranks top in product innovation with low carbon products across the spectrum of subsectors. Through its Verbund principle, BASF also produces a number of pollution reduction products including catalytic converters.

## Speciality Chemicals

- Four out of the seven speciality chemicals come in the top 10 for this ranking with AkzoNobel a clear winner. Johnson Matthey, DSM and Evonik also perform well with Johnson Matthey scoring highly for product innovation and low carbon revenues, underscoring their strategy in autocatalysts and battery technology for EVs. DSM also do well in low carbon revenues and have their R&D spend at 4.17% of revenues.

- Evonik does much better against these metrics ranked 6th, against 10th on transition risk, with innovation making them more resilient to carbon risk.

- Umicore and Solvay lag in these metrics with the former ranking on par with Johnson Matthey on R&D spend, but lacking in disclosure on low carbon revenues and product innovation.

- Solvay, which is a leader in providing materials to a number of renewable energy technologies, does not score highly on transition opportunities.

## Diversifieds

- BASF and DuPont are the best performing diversifieds, both scoring highly for product innovation where they are ranked 1 and 2 respectively. Toray perform the worst, with low rankings for both product and process innovation, although R&D spend relative to net sales is above the sector's average, at 2.9%.

- DuPont, which has a high R&D spend at 7.04% and does well in product innovation, does not perform as well in process innovation and low carbon revenues.

## Industrial Gases

- This sub-sector ranks well in this section with Air Liquide ranked number 2 overall. Three out of four industrial gas companies are in the top 10.

- The industrial gases companies with their hydrogen businesses are leaders in the drive for a hydrogen economy. Air Liquide and Air Products are deploying hydrogen fueling stations worldwide, while Linde and Praxair provide hydrogen for use in desulphurization with various industries, including oil refinery and transportation.

## Petrochemicals

- The petrochem sub-sector is a laggard in terms of R&D spend. LG Chem with its downstream industrial batteries and electronic chemicals is a leader with 2.7% spend vs less than 0.5% for Formosa, LyondellBasell and Braskem. LG Chem produces an innovative carbon nanotube that can be applied in multiple functions to improve energy efficiency.

- AkzoNobel rank first in transition opportunities. It is one of only two companies signed up to the RE100 initiative and is looking to source 100% of its energy from renewable sources by 2050. The company are clear leaders in process innovation and renewable energy use. Through its "Process Technology" platform, it has invested heavily in biofuels and alternative energy sources and is signed up to multiple process efficiency initiatives.

- Braskem is a leader in terms of use of the production of bio-based plastics at 5.4% of revenues higher than the industry at 1% of global sales.

# Plastics and the Circular Economy – a potential "diesel" moment for the plastics industry?

The explosion of plastics in our economy is a testament to living in today's material world where the flow of materials is linear and not circular. Plastics production is up around 21 times in the past 50 years to 311 Mt and expected to double again from here with plastics ingrained in our way of life and used across a number of industries from packaging, healthcare, construction, transportation and electronics.

Plastic packaging, which accounts for 26% of the total volume of plastics used, has come under increasing scrutiny as it clogs up our urban infrastructure and pollutes our oceans and seas – 8 Mt of plastics end up in our oceans every year and with over 150 Mt already in the ocean today, estimates are of 1 tonne of plastic for every 3 tonnes of fish by 2025. Do we really want to swim in this amount of plastic or have it enter our food chain?

According to the Ellen MacArthur Foundation, which has led the collaborative work of the plastics packaging industry, we are wasting 95% of the material value of plastic packaging, equivalent to losing US$80-120bn annually from the economy[20]. This report follows earlier work by the Foundation in 2013 on the circular economy on the economic value of plastics waste related to the global fast-moving consumer goods sector with US$2.6 trillion being dumped every year.

Clearly this is a system wide problem engrained in modern living practices rather than attributable to any one industry or sector of the economy but the problem needs to be addressed and industry participants cannot view this only as a downstream problem, particularly as primary production is facing carbon constraints. Is this going to be the "diesel" moment for the plastics industry which will have impact further up the value chain?

Plastics consume the majority of petrochemical products using 6% of global oil consumption a year with the carbon footprint of plastics set to grow on a business as usual scenario to 20% of total oil consumption and 15% of the annual carbon budget by 2050. Increased regulatory and consumer concern about plastics could result in the slow-down of growth of conventionally produced plastics or even shrinkage in the future according to McKinsey[21]. There has been growing global regulation of plastic bags with 25 countries across the world either banning or taxing single use plastic bags and regulation is growing on the use of plastic bottles.

The report on the new plastics economy calls for collaborative action to tackle this issue but also innovative thinking by industry – a theme that runs through the chemicals sector in addressing not just plastics pollution but achieving a decarbonization pathway.

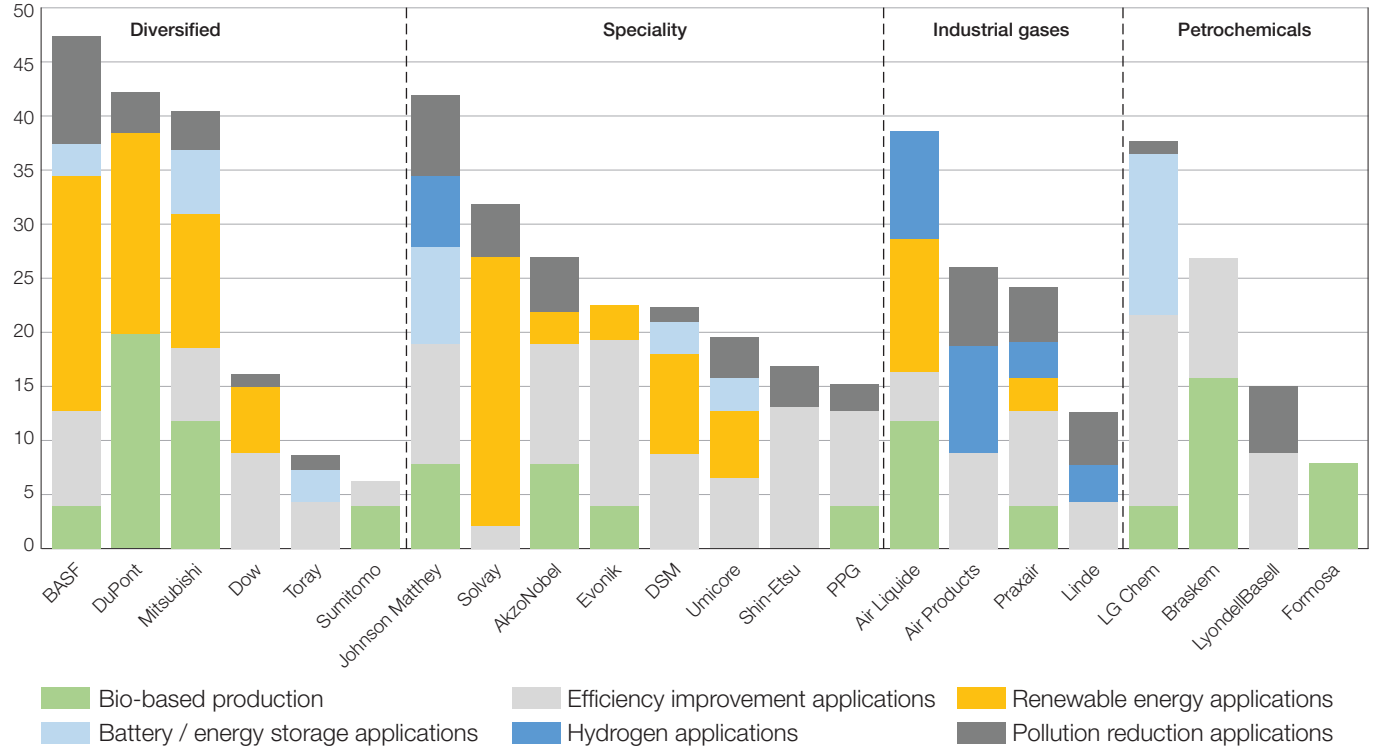
Tackling the plastics problem can come from a number of angles – reducing the amount of plastic used, improving the infrastructure for recycling of plastics and leakage into the environment (72% of plastic packaging is not recovered, 40% is landfilled and 32% leaks out of the collection system) or through changing from fossil fuel feedstock (currently 90%) used in making plastics – contributing 50% to the climate change impact of plastics.

Bio-based plastics account for less than 1% of total plastic production although demand for bio-based plastics are growing, driven by demand from large companies such as Coca-Cola[20] which intends to increase bio-PET content from 30% to 100% in the future. However, bio-PE is more expensive driven by raw material cost and higher processing requirements resulting in a 30% premium to fossil-based PE. Large scale adoption of bio-based feedstocks faces constraints such as land use, impact on agriculture and bio-diversity.

The ambition for the new plastics economy, in line with thinking on the circular economy, is that plastics no longer become waste but somehow re-enter the system as a resource – estimates in Europe are there that is scope for 53% of plastics packaging to be recycled economically. However, this will depend on the oil price and will require significant capital investment.

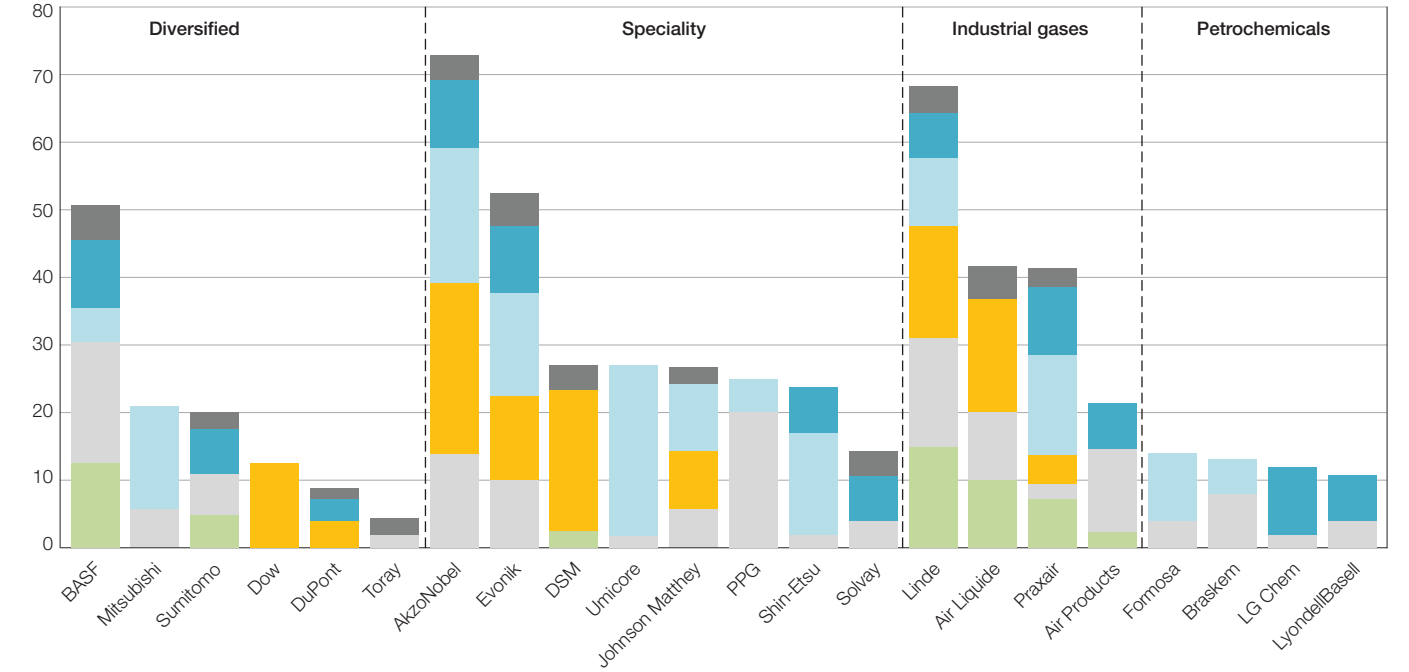
20. The New Plastics Economy – Rethinking the future of plastics (World Economic Forum, Ellen MacArthur Foundation and McKinsey & Company, 2016)
21. Chemicals 2025: Will the industry be dancing to a very different tune? (McKinsey, 2017)

**Figure 32: Product innovation score[i]**



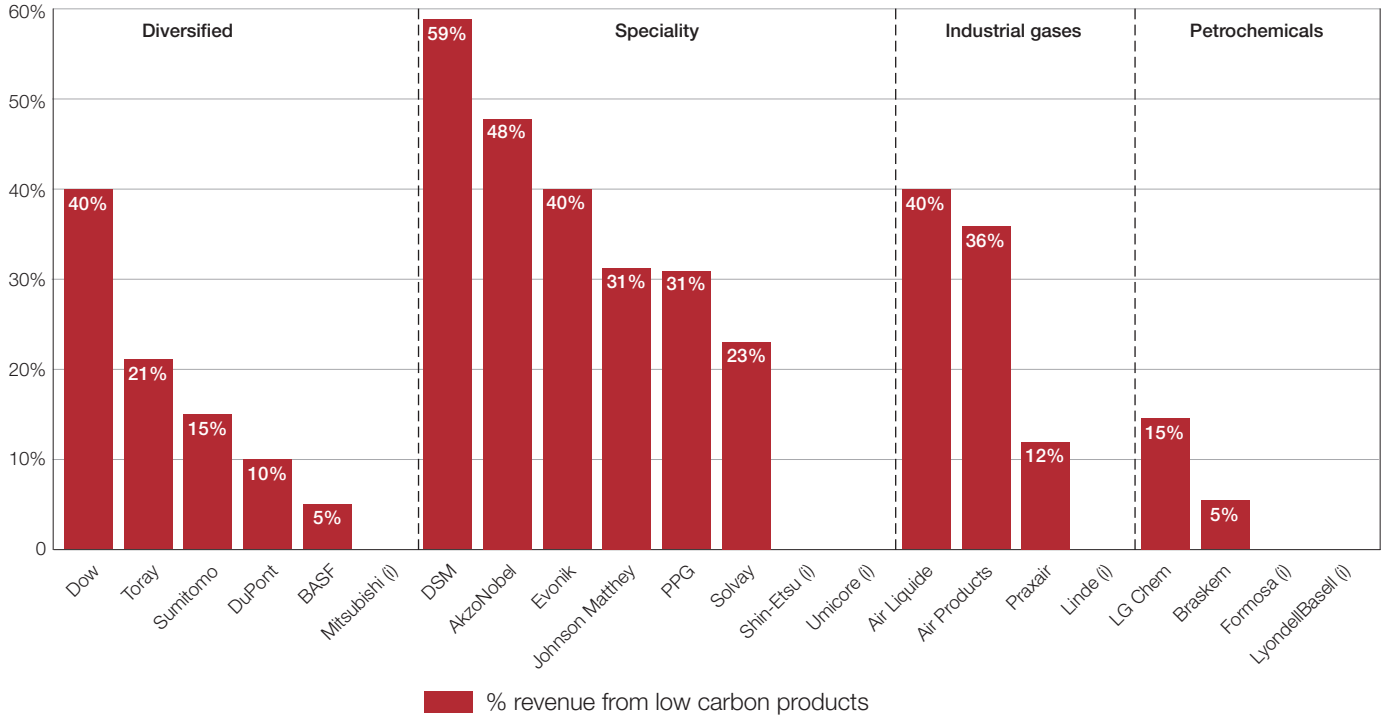

(i) Scored out of 100 where companies with higher scores receive higher rankings
Source: CDP, company reports

**Figure 33: Process innovation score[i]**



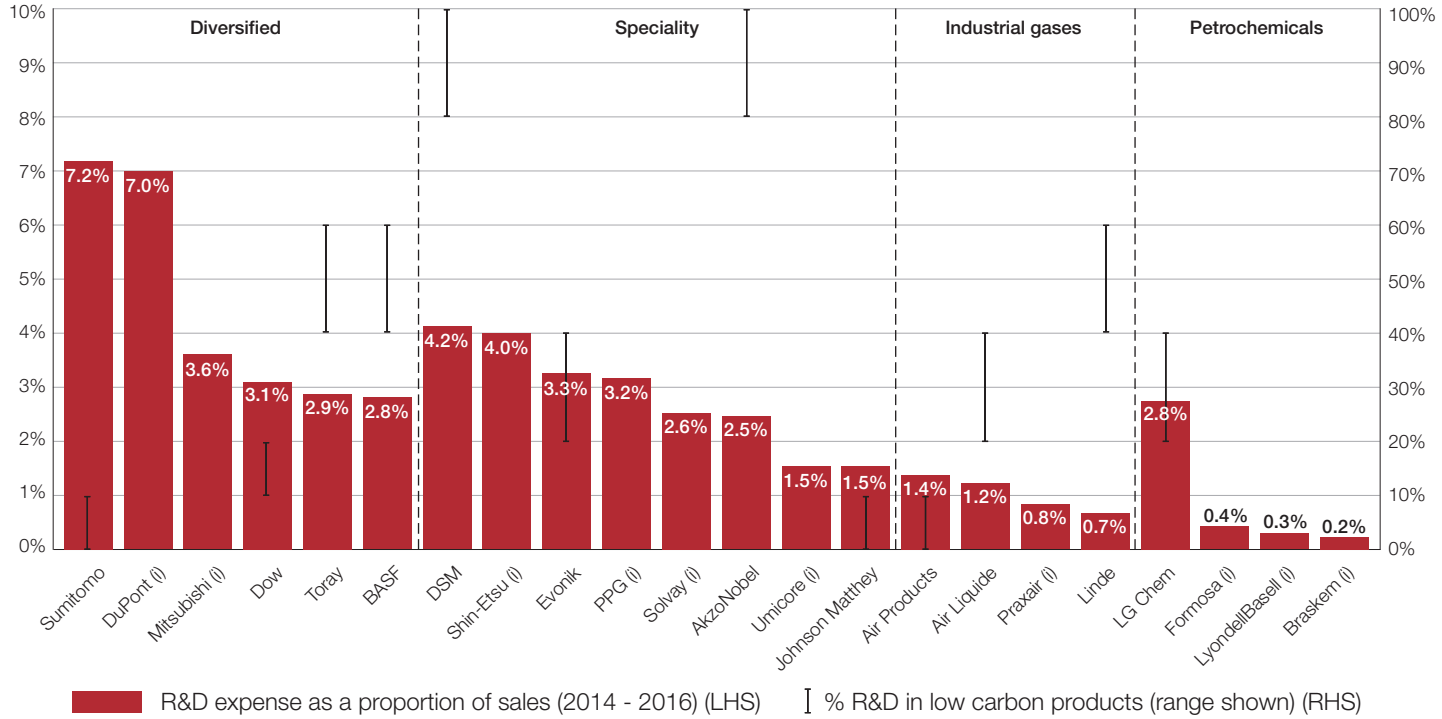

(i) Scored out of 100 where companies with higher scores receive higher rankings
Source: CDP, company reports

## Figure 34: Low carbon revenue



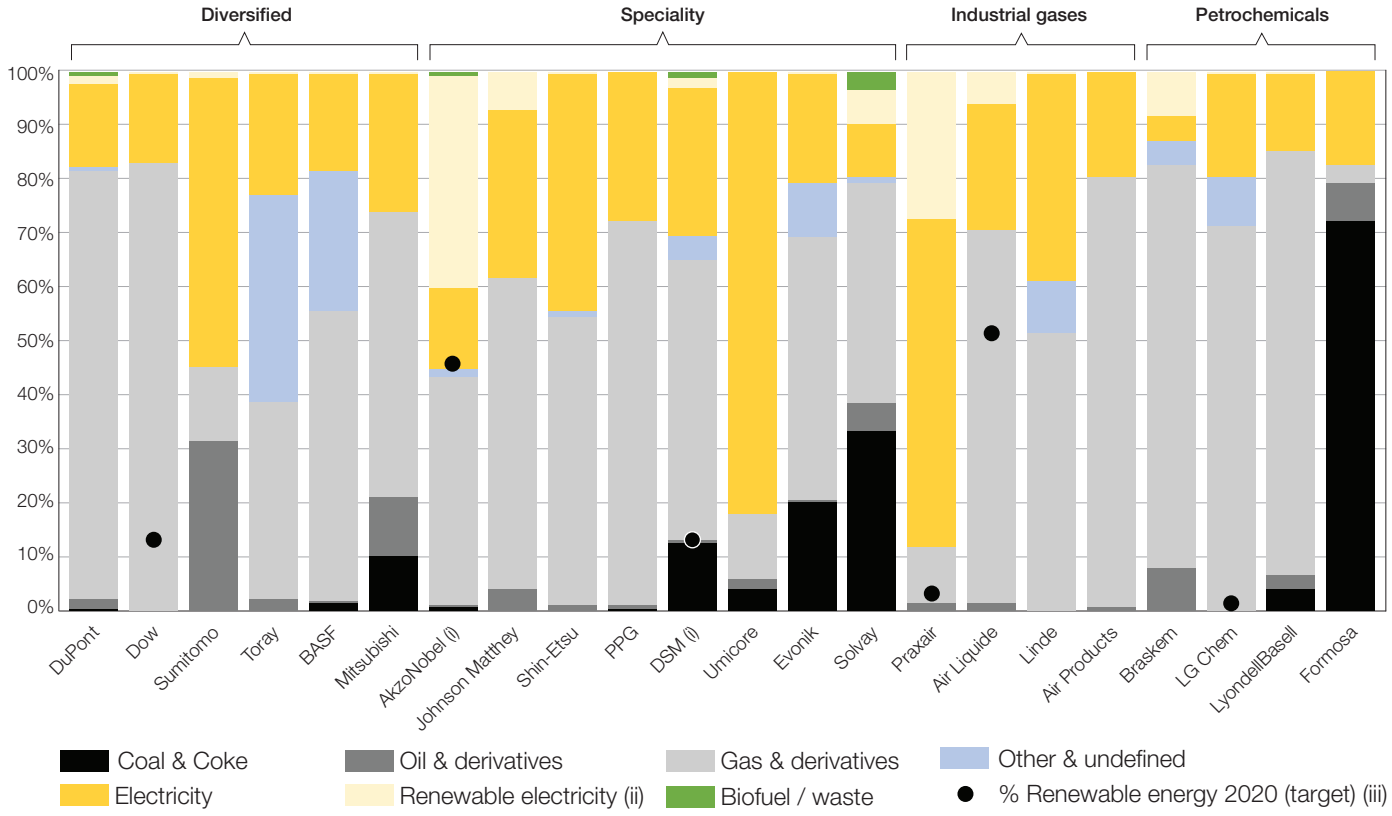

(i) No data available for Mitsubishi, Shin-Etsu, Umicore, Linde, Formosa and LyondellBasell
Source: CDP, company reports

## Figure 35: Research and development expense as a proportion of sales




(i) No data available for % R&D in low carbon products for DuPont, Mitsubishi, Shin-Etsu, PPG, Solvay, Umicore, Praxair, Formosa, LyondellBasell and Braskem
Source: CDP, company reports

**Figure 36: Energy consumption split by resource type (2016)**




(i) AkzoNobel & DSM are members of the RE100 initiative
(ii) Where data is available and / or reported in CC11.4 of CDP questionnaire
(iii) Where renewable energy target is available

Source: CDP, company reports

# Carbon Capture and Storage (CCS) – the crux to fossil fuel feedstock routes for the chemical industry

CCS is an important technology solution for a number of fossil fuel dependent industries from power generation industrial processes where waste $CO_2$ is captured, compressed and transported to a storage site where it is deposited and cannot re-enter the atmosphere. Carbon capture and storage (CCS) is considered an integral part of long-term low carbon energy systems solutions to meet carbon emission constraints in 2050. In their updated 2°C Scenario (2DS), the IEA estimate that the inclusion of CCS contributes to an overall reduction of 12% of emissions (94 Gt). Power generation is expected to be the main sector to deploy CCS, capturing 56% of estimated $CO_2$, with industry accounting for 31% - chemicals and petrochemicals are expected to capture 38% of CCS deployed by industry (IEA 2016, see Figure 37 & 38).

**Figure 37: IEA estimates for CCS in 2DS**

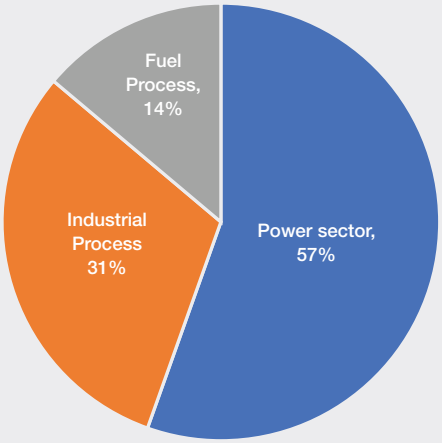
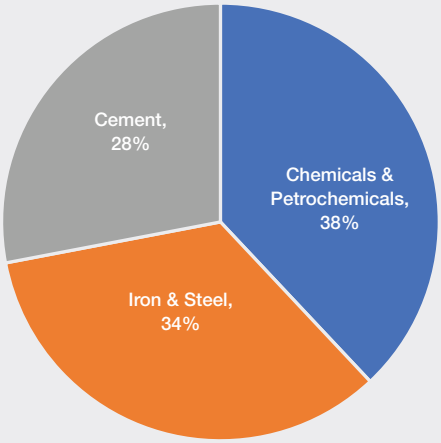



**Figure 38: Breakdown for industrial processes**




However, this theoretical expectation of how CCS technology may be deployed has not been met by practical implementation by the industries concerned. The current economics of CCS, against a weak regulatory pricing environment for $CO_2$, does not lend itself to an environment for investment in CCS. Prior to COP15 in Copenhagen there was considerable optimism in CCS with more than US$30bn in public funding announcements. However, only 10% of this has come through and a number of notable projects have been cancelled. CCS could arguably be replaced or reduced for decarbonization strategies for power generation with renewables with storage offering competitive solutions, this alternative is not available for processes within the chemical industry which are dependent on fossil fuels. Therefore, there should be a strong motivation for the industry to look for solutions and it is encouraging to see some early signs of initiatives being taken by the chemical industry for improving the economics of CCS and for CCU – using $CO_2$ either as feedstock on in other industrial applications.

BASF is working with JGC Corporation and INPEX Corporation in Japan to remove $CO_2$ from natural gas under high pressure which could enable a 25-35% reduction in the cost of $CO_2$ recovery and compression. BASF is also working with Linde on a pilot plant to capture $CO_2$ from flue gas at a coal fired power plant project run by the Department of Energy (DOE) in the US – the technology uses BASF's amine based solvent and process technology with a novel $CO_2$ capture process and engineering developed by Linde[22]. Air Products has also worked on a CCS demonstration project with the DOE on a larger scale project in Port Arthur with potential capture of 1 mt of $CO_2$ in an enhanced oil recovery project[23] and Praxair is also working with the DOE with its Seepar Trace Technology for CCS although commercialization is not expected before 2030[24].

For the chemical industry, the solution may be not just to invest in expensive CCS solutions but to look at ways of using waste $CO_2$ as feedstock or in other industrial applications. A number of companies within the sector are exploring this as an option with pilot projects in place. These involve collaboration with other industrial sectors such as power generation as a potential source of $CO_2$ to be used as a feedstock to make polyurethanes such as Bayer's pilot plant in Germany or Novomer working with DSM on a $CO_2$ based polycarbonate resin[25]. Air Liquide has also been active working with Solidia Technologies to provide new equipment for $CO_2$ injection that cures concrete with $CO_2$ instead of water which, if successful, is said to have the potential to reduce the environmental footprint by up to 70%[26].

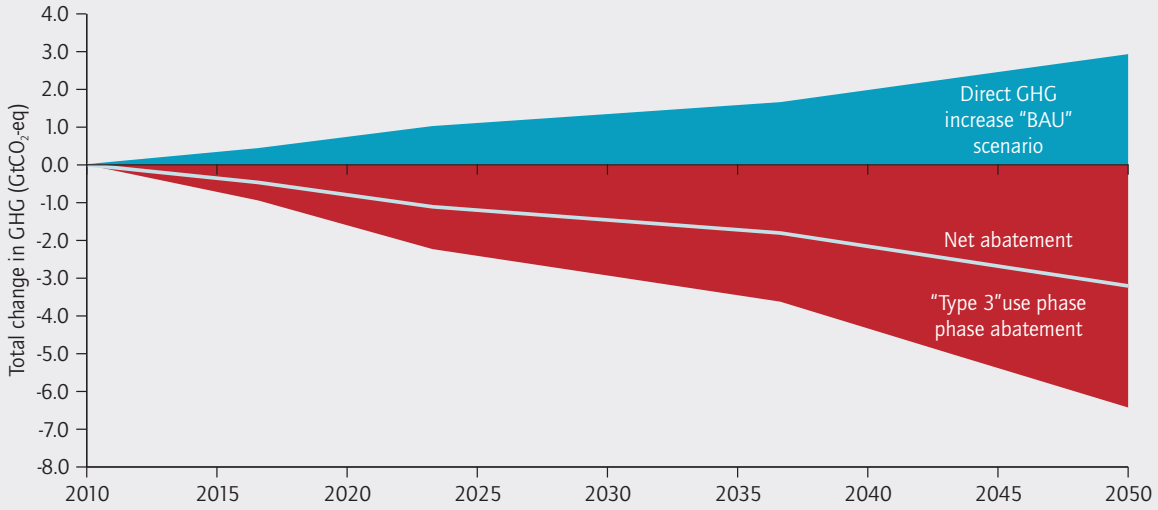
22. https://www.basf.com/us/en/company/news-and-media/news-releases/2016/07/P-US-16-086.html
23. http://www.airproducts.co.uk/Company/news-center/2013/05/0510-air-products-celebrates-texas-carbon-capture-demonstration-project-achievement.aspx
24. http://www.praxair.com/-/media/documents/reports-papers-case-studies-and-presentations/our-company/sustainability/ipcctable.pdf?la=en
25. http://www.icis.com/blogs/green-chemicals/2011/02/basf-bayer-co2-news/
26. https://www.airliquide.com/media/air-liquide-contributes-development-new-sustainable-concrete

# Avoided emissions

Various chemical industry products aid the reduction of GHG emissions compared to conventional products or compared to the market average. Under the terminology of the Greenhouse Gas Protocol international accounting tool, emission reductions of this kind are termed "avoided emissions"[27] (Figure 40).

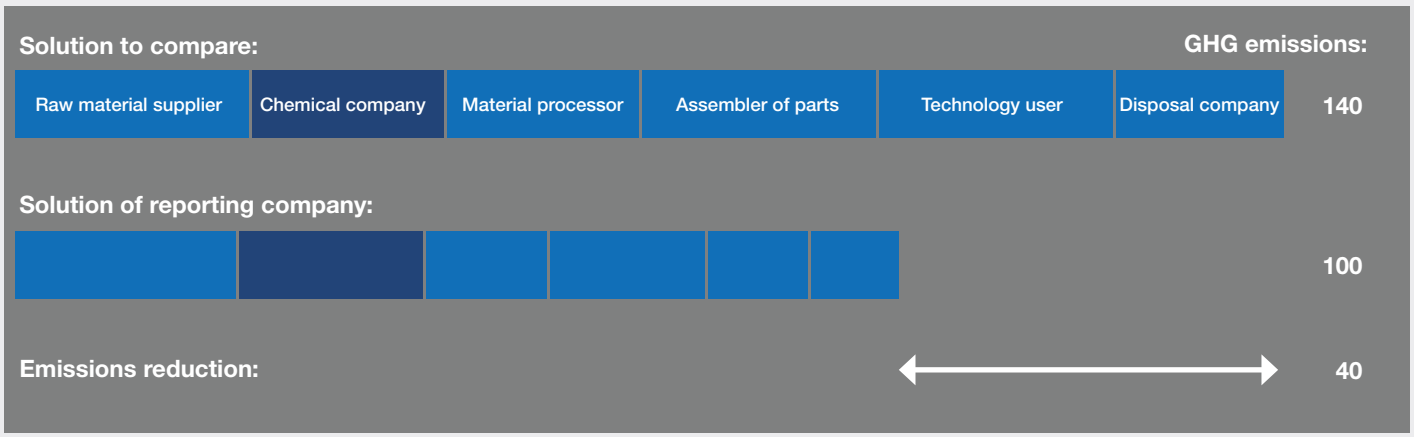
There is huge scope in the chemical industry for avoiding emissions while simultaneously increasing operational efficiency and production levels. A study compiling several life-cycle analyses showed that for every unit of carbon it emitted in 2005, the chemical industry's products and technologies enabled 2.1-2.6 units of $CO_2e$ savings (compared to non-chemical alternatives)[28]. Moreover, the potential for growth is highlighted by the fact that Europe's chemical industry has halved its Scope 1 emissions compared to 1990, while increasing production volumes by around 20% over the same timeframe[29].

**Figure 39: Potential GHG use-phase impact, using BAU direct emissions impact from this work and the McKinsey impact ratio of 2.1 t of GHGs saved/$t_{production}$**




To quantify emissions avoided by the chemical industry, the International Council of Chemical Associations (ICCA) and the World Business Council for Sustainable Development (WBCSD) have created guidelines to support chemical companies in assessing the greenhouse gas emissions avoidance potential of their products. Life cycle assessments are used to evaluate the environmental impact of products and technologies over their entire life cycle, including production, use and end of life-handling.

**Figure 40: Reduction in GHG emissions is represented by the difference between the life-cycle emissions from the solution of the reporting company and the solution to compare to**




Measuring avoided emissions of greenhouse gases over the value chain of products is an area where consistency of approach is essential. But, it has often given rise to debate among stakeholders. Numerous different approaches still exist to measure avoided emissions and thus comparison and consistency issues arise. It is hoped that the ICCA and WBCSD guidelines will provide a sector framework for the chemicals industry to measure its avoided emissions.

**Case study:** Air Liquide provides numerous products and services which enable its customers to reduce their own $CO_2$ emissions and environmental impact. For example, Air Liquide reduces the consumption of coke in blast furnaces through the injection of oxygen as well as using oxygen in electric furnace burners to considerably reduce their electricity consumption. In 2016, Air Liquide estimated that the use of oxygen in these two applications enabled its customers to avoid 11.2 million tons of $CO_2$ emissions[30].

27. Addressing the avoided emissions challenge (ICCA and WBCSD, 2013)
28. Innovations for Greenhouse Gas Reductions: A Life-Cycle Quantification of Carbon Abatement Solutions Enabled by the Chemical Industry (ICCA, 2009)
29. Understanding the challenges and opportunities for the chemical sector (European Climate Foundation, 2014)
30. Air Liquide Sustainable Development Report (2016)

# Climate governance & strategy

- For low carbon governance and strategy, DSM and AkzoNobel are deemed to be best positioned for the transition with Umicore and PPG least well positioned. Notably, the two highest and two lowest ranked companies for this section are all speciality chemicals, underlining the heterogeneity, even within sub-sectors, of companies assessed.
- Only two companies have long-term Science Based Targets in place – AkzoNobel and LG Chem. Moreover, several companies use base years that have long past, which is not in line with SBTi recommendations of using a more up to date base year to improve performance going forward.
- The majority of companies do not have an internal carbon price, fail to link climate KPIs to executive remuneration and do not have a board-level committee responsible for climate-risk.

## Overview

The shift to a low carbon world presents strategic challenges for chemical companies in terms of shifting from fossil fuel feedstocks and carbon intensive processes, which supply several key industrial materials including to low carbon technologies.

The G20 Financial Stability Board's Task Force on Climate-related Financial Disclosures has recently published its final recommendations, which could become the basis for nationally recommended or even mandated disclosures on climate risk and opportunity assessment going forward. There is also a growing awareness of the need for all sectors to put in place climate risk management strategies and disclose to investors and stakeholders in greater detail than ever before.

Against this background, companies will be increasingly asked how well positioned they are to transition to a low carbon economy by either presenting scenario

**Figure 41: Climate governance and strategy summary**

| Company | Classification | Emissions targets | Data assurance (Scopes 1 and 2) | Transparency of value chain emissions (Scope 3) | Climate remuneration | Board level climate responsibility and expertise | Use of internal carbon price | CDP Score | Overall weighted rank | Climate governance & strategy rank | Climate governance & strategy grade |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DSM | Speciality | 4 | 6 | 3 | 1 | 6 | 3 | A | 3.6 | 1 | A |
| AkzoNobel | Speciality | 1 | 2 | 11 | 2 | 8 | 1 | A | 4.1 | 2 | A |
| Braskem | Petrochemicals | 3 | 10 | 1 | 9 | 17 | 7 | A | 6.3 | 3 | B |
| LG Chem | Petrochemicals | 2 | 1 | 8 | 17 | 10 | 4 | A | 7.3 | 4 | B |
| Air Products | Industrial gases | 5 | 6 | 4 | 10 | 9 | 13 | A- | 7.5 | 5 | B |
| Solvay | Speciality | 5 | 6 | 18 | 3 | 21 | 2 | B | 8.5 | 6 | B |
| Johnson Matthey | Speciality | 9 | 10 | 12 | 13 | 2 | 13 | A- | 9.8 | 7 | C |
| DuPont | Diversified | 5 | 18 | 19 | 13 | 3 | 5 | A- | 9.9 | 8 | C |
| Evonik | Speciality | 5 | 6 | 5 | 22 | 10 | 13 | A- | 10.2 | 9 | C |
| Dow | Diversified | 15 | 19 | 10 | 5 | 1 | 10 | B | 10.2 | 10 | C |
| Sumitomo | Diversified | 10 | 16 | 15 | 10 | 14 | 7 | A- | 10.7 | 11 | C |
| Toray | Diversified | 12 | 21 | 6 | 10 | 14 | 13 | A- | 11.5 | 12 | C |
| Air Liquide | Industrial gases | 21 | 2 | 16 | 5 | 7 | 7 | B | 11.6 | 13 | C |
| BASF | Diversified | 16 | 10 | 7 | 17 | 10 | 5 | A- | 11.8 | 14 | C |
| Praxair | Industrial gases | 18 | 10 | 17 | 8 | 4 | 13 | A | 11.8 | 15 | C |
| Linde | Industrial gases | 14 | 10 | 13 | 7 | 17 | 13 | B | 11.9 | 16 | C |
| Shin-Etsu | Speciality | 17 | 2 | 2 | 21 | 14 | 12 | B | 12.5 | 17 | D |
| Mitsubishi | Diversified | 13 | 17 | 14 | 13 | 13 | 13 | B | 13.0 | 18 | D |
| LyondellBasell | Petrochemicals | 20 | 5 | 20 | 4 | 17 | 10 | F | 13.6 | 19 | D |
| Formosa | Petrochemicals | 19 | 15 | 9 | 16 | 17 | 13 | F | 15.1 | 20 | D |
| PPG | Speciality | 11 | 22 | 22 | 17 | 5 | 13 | D | 15.1 | 21 | D |
| Umicore | Speciality | 22 | 20 | 21 | 17 | 22 | 13 | F | 19.1 | 22 | E |
| Weighting | | **25%** | **10%** | **20%** | **20%** | **10%** | **10%** | **5%** | | | |

Note: In calculating the weighted rank in this table, we use the weighted ranks for each area (where relevant). We display non-weighted ranks in this summary for simplicity only

Source: CDP

analysis or commitments to long-term targets aligned to sector decarbonization such as Science Based Targets. Scenario based analysis is still in its infancy and while used more widely by sectors such as oil & gas, has not yet been used by chemical companies. In addition, Science Based Targets are also relatively underdeveloped compared with several other high-emitting industries. Key to the challenge is the heterogeneity of the chemicals industry, with many diverse products produced as well as processes employed.

In this section, we assess how companies are planning for a low carbon future through aligning their governance structure with the associated risks and opportunities presented by the transition. We rank companies on their climate governance and strategy using the following key metrics:

**Metric 1) Emissions reduction targets:** We assess the coverage and strength of each company's operational carbon emissions reduction targets when compared to science-based levels of ambition.

**Metric 2) Emissions data verification:** We form a scorecard that assesses the companies' emissions accounting procedures. This includes: level of third party verification and assurance, scope of verification and levels of uncertainty.

**Metric 3) Value chain emission transparency and supplier engagement:** We assess the extent to which companies disclose their upstream and downstream emissions as well as assessing how engaged companies are with their suppliers on their GHG emissions.

**Metric 4) Climate-related remuneration:** Companies are assessed on their alignment between climate-risk strategy performance and remuneration across long-term incentives and short-term annual bonus programs at the senior executive and board level as well as other climate-risk remuneration practices at broader corporate levels.

**Metric 5) Board level climate responsibility and expertise:** Companies were assessed on their board and executive climate responsibility performance across the areas of level of directors on the board with climate-relevant experience, the presence of climate-relevant committees (at board and/or executive levels) and overall quality of climate-risk management system.

**Metric 6) Use of an internal carbon price:** This metric is used to identify the extent to which internal carbon prices, as a proxy for climate regulatory action, are incorporated into future capital expenditure plans and other key business decisions.

**Metric 7) CDP Score:** The 2016 CDP Score (previously also known as CDP Performance Band) provides an aggregate measure of quality of climate-related disclosure and management systems addressing climate risks.

# Highlights

## Emissions reduction targets

- Only two companies have their long-term targets recommended by the Science Based Targets initiative (SBTi) - AkzoNobel's 2050 full decarbonization target and a 2030 LG Chem target.
- AkzoNobel has by far the most comprehensive and ambitious emissions reduction targets. Its long-term target is for zero carbon by 2050 in Scope 1+2 terms, while a 25% per tonne of product reduction target by 2020 includes not only Scope 1+2 emissions but also upstream and downstream Scope 3 "cradle to grave" emissions. It is the only company assessed that has a substantive Scope 3 target.
- By contrast, Umicore does not disclose emissions reduction targets. Though it makes reference to energy efficiency targets, it does not quantify them. As the only company with no quantified emissions reduction target, it ranks last.
- Speciality chemicals companies generally have stronger targets than other subsectors, indicative of significant short to medium term potential for cost-effective emissions reductions.
- Industrial gas companies have lower targets in percentage terms than other subsectors. This suggests there may be a lower level of cost-effective emissions reductions remaining to be exploited by these companies and that their short to medium term progress in reducing emissions is likely to be slow.
- Most companies assessed fail to meet principles and recommendations for science-based targets. It is exceptionally rare that chemicals companies set targets for Scope 3 emissions, which often comprise the largest share of their overall emissions profile. Based on disclosed data and CDP estimates, on average two-thirds of the emissions of chemicals companies assessed is in the Scope 3 category. SBTi guidelines state that for a company to be considered to have a science-based target, it should include a Scope 3 target if those emissions represent more than 40% of total emissions.
- Several companies have targets whose base years have long since passed which suggests less challenging ambitions beyond business as usual. Though these represent very long-term targets, the SBTi has noted the importance of a recent base year so that the target describes current and future efforts, rather than using a base year far in the past to take advantage of reductions that have already been made. Shin-Etsu and Toray in particular set targets relative to much higher 1990 emissions baselines, while Dow has also long been far below its 2005 base year emissions.

- DSM has a target with full Scope 1+2 coverage and implying emissions reductions of almost 3% per tonne of product annually. DSM is the only company assessed besides AkzoNobel to have made a significant renewable energy commitment through the RE100 initiative.
- Johnson Matthey also has an ambitious target to reduce emissions by 50% per unit of revenue over the 10 years to 2017, or 6.7% per year, though this excludes its precious metals businesses. PPG and Solvay also have targets implying significant year-on-year emissions reductions and with coverage Scope 1+2 emissions.
- Formosa and LyondellBasell disclose targets in their CDP responses in 2017, but these refer to time periods that have already expired. These targets also only cover one-year periods and as such failed to meet the SBTi criterion that targets cover a minimum of five years from announcement.
- Targets for most companies cover most or all their Scope 1+2 emissions. However, Air Liquide discloses only one narrow target, covering logistics operations, which it cites as representing 2.5% of Scope 1 emissions. Praxair's key target includes only hydrogen plants, approximately 35% of its Scope 1+2 emissions, while another Praxair target covers emissions avoided by product use instead of operational emissions, the latter of which was omitted from assessment, based on the SBTi principle that offsets do not count toward science-based targets.

**Figure 42: Emissions reduction targets summary(i)**

| Company | Classification | Absolute, intensity and/ or renewable energy target | Target applies to >70% of Scope 1+2 emissions | Target applies to >70% of Scope 3 emissions | Target > 5 years in length at initiation | Includes a medium term target of < 15 years | Includes a long-term target (>2030) as per recommendation | Formal commitment to set Science-Based Target | Weighted score | Rank |
|---|---|---|---|---|---|---|---|---|---|---|
| AkzoNobel | Speciality | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 100 | 1 |
| LG Chem | Petrochemicals | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ | 63 | 2 |
| Braskem | Petrochemicals | ✓ | ✓ | ✗ | ✓ | ✓ | ✗ | ✗ | 50 | 3 |
| DSM | Speciality | ✓ | ✓ | ✗ | ✓ | ✓ | ✗ | ✗ | 43 | 4 |
| DuPont | Diversified | ✗ | ✓ | ✗ | ✓ | ✓ | ✗ | ✗ | 39 | 5 |
| Evonik | Speciality | ✗ | ✓ | ✗ | ✓ | ✓ | ✗ | ✗ | 39 | 5 |
| Solvay | Speciality | ✗ | ✓ | ✗ | ✓ | ✓ | ✗ | ✗ | 39 | 5 |
| Air Products | Industrial gases | ✗ | ✓ | ✗ | ✓ | ✓ | ✗ | ✗ | 39 | 5 |
| Johnson Matthey | Speciality | ✗ | ✓ | ✗ | ✓ | ✓ | ✗ | ✗ | 37 | 9 |
| Sumitomo | Diversified | ✓ | ✗ | ✗ | ✓ | ✓ | ✗ | ✗ | 37 | 10 |
| PPG | Speciality | ✗ | ✓ | ✗ | ✓ | ✓ | ✗ | ✗ | 37 | 11 |
| Toray | Diversified | ✓ | ✓ | ✗ | ✓ | ✗ | ✗ | ✗ | 36 | 12 |
| Mitsubishi | Diversified | ✗ | ✓ | ✗ | ✓ | ✓ | ✗ | ✗ | 36 | 13 |
| Linde | Industrial gases | ✗ | ✓ | ✗ | ✓ | ✓ | ✗ | ✗ | 35 | 14 |
| Dow | Diversified | ✓ | ✓ | ✗ | ✓ | ✗ | ✗ | ✗ | 34 | 15 |
| BASF | Diversified | ✗ | ✓ | ✗ | ✓ | ✗ | ✗ | ✗ | 33 | 16 |
| Shin-Etsu | Speciality | ✗ | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ | 25 | 17 |
| Praxair | Industrial gases | ✓ | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ | 23 | 18 |
| Formosa | Petrochemicals | ✗ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | 21 | 19 |
| LyondellBasell | Petrochemicals | ✗ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | 19 | 20 |
| Air Liquide | Industrial gases | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | 11 | 21 |
| Umicore | Speciality | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | 4 | 22 |
| **Weighting** | | **15%** | **35%** | | **35%** | | | **15%** | | |

(i) Scored out of 100 where companies with higher scores receive higher rankings
Source: CDP, company reports

# Science-based targets

Science-based target setting approaches for the chemicals industry are relatively underdeveloped compared with several other high-emitting industries. Key to the challenge is the heterogeneity of the chemicals industry, with many diverse products produced as well as processes employed. Unlike other major GHG emitting sectors like the electricity generation industry or the cement industry, for which there is a relatively homogeneous product delivered, or a relatively small range of core products, this is not the case in the chemicals industry. The chemicals industry is large and has many diverse inputs coming from and outputs going to countless other intermediate or end uses throughout the economy.

Carbon reduction scenarios for the chemicals industry published by entities such as the IEA are lacking in granularity at a process and product level compared with what is needed by companies to set a fair and meaningful SBT based on their own unique product mixes. In particular, physical indicators of production levels and projected future emissions levels for given chemical products, needed to achieve a particular scenario, are lacking the granularity needed for a chemicals company to apply to its own operations and target setting process, given that a given company may be producing dozens, hundreds, or even thousands of chemical products. A given chemical company's product is also often an input to another chemicals company, or a company in another industry. A given chemical company's product also may use diverse and potentially already emissions-intensive inputs produced by other companies. This represents a highly complex and interdependent value chain.

In contrast, only a handful of basic chemical products are transparently identified and tracked in the IEA's industry-specific scenarios published with the latest edition of Energy Technology Perspectives. These do not encompass a comprehensive share of the activities of many chemicals companies, and may not be applicable to a given company's location in the value chain.

**Figure 43: Science Based Target initiative[31]**

**Validating targets as consistent with a 2 degree pathway**

**Eligibility criteria:**

- **Boundary:** The target must cover company-wide Scope 1 and Scope 2 emissions and all relevant GHGs as required in the GHG Protocol Corporate Standard.
- **Timeframe:** The target must cover a minimum of 5 years and a maximum of 15 years from the date of announcement of the target.
- **Level of ambition:** At a minimum, the target will be consistent with the level of decarbonization required to keep global temperature increase to 2°C compared to pre-industrial temperatures, though we encourage companies to pursue greater efforts towards a 1.5° trajectory.
- **Scope 3:** An ambitious and measurable Scope 3 target with a clear time-frame is required when Scope 3 emissions cover a significant portion (greater than 40% of total Scope 1, 2 and 3 emissions) of a company's overall emissions. The target boundary must include the majority of value chain emissions as defined by the GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard (e.g. top 3 categories, or 2/3 of total Scope 3 emissions).
- **Reporting:** Disclose GHG emissions inventory on an annual basis.

**Additional guidance:**

- Companies are encouraged to also develop long-term goals (e.g. 2050).
- Companies are encouraged to express their targets on an absolute AND intensity basis.
- To ensure consistent tracking of performance over time, the SBT should be recalculated, as needed, to reflect significant changes that would compromise its relevance and consistency. A target recalculation should be triggered by significant changes in growth projections and other assumptions used with SBT-setting methodologies and significant changes to your business or data and emissions factors used in your inventory process; the latter will also require recalculation of the base year inventory. Companies should check the validity of their target projections annually.
- Companies should complete a Scope 3 screening before setting their GHG emission reduction targets.

31. See sciencebasedtargets.org for more details

## Emissions data verification

- LG Chem ranks first with both moderate Scope 1 and Scope 2 data assurance – greater assurance than all other companies assessed bar LyondellBasell who have reasonable assurance for both Scopes 1 and 2.
- PPG is the only company not to externally verify its emissions and subsequently ranks last.
- Notably, five of the diversified chemicals rank in the bottom seven for emissions verification with limited assurances on both Scope 1 and 2 emissions as well as less than 100% of Scope 1 and 2 emissions verified for Sumitomo, Dow and Toray.
- Sixteen of the twenty-two companies have third party verification or assurance in place for their Scope 3 emissions. Formosa, LyondellBasell, Solvay and Toray have no third-party verification or assurance of Scope 3 emissions but PPG and Umicore do not even provide any Scope 3 data, the only companies not to do so.

**Figure 44: Emissions data verification**

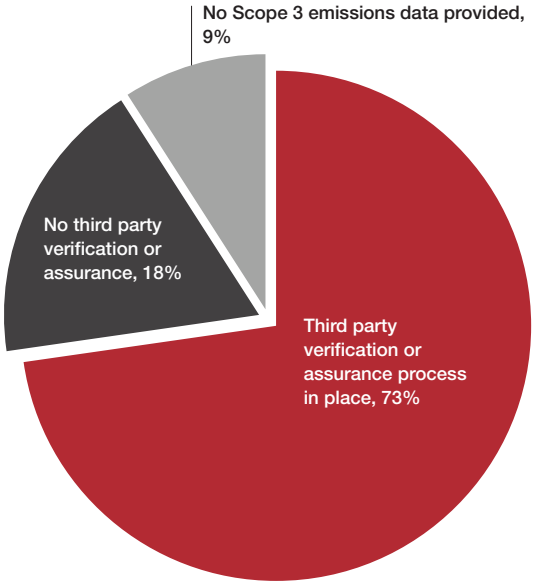



**Figure 45: Emissions data verification**

| Company | Classification | Rank | Total score | Scope 1 assurance type | Proportion of Scope 1 verified | Uncertainty Scope 1 verified | Scope 2 assurance type | Proportion of Scope 2 verified | Uncertainty Scope 2 verified |
|---|---|---|---|---|---|---|---|---|---|
| LyondellBasell | Petrochemicals | 1 | 16.7 | Reasonable | 100% | 5-10% | Reasonable | 100% | 2-5% |
| LG Chem | Petrochemicals | 2 | 15.4 | Moderate | 100% | 2-5% | Moderate | 100% | <2% |
| Air Liquide | Industrial gases | 3 | 13.7 | Limited | 100% | <2% | Limited | 100% | <2% |
| AkzoNobel | Speciality | 3 | 13.7 | Limited | 100% | <2% | Limited | 100% | <2% |
| Shin-Etsu | Speciality | 3 | 13.7 | Limited | 100% | <2% | Limited | 100% | <2% |
| Solvay | Speciality | 3 | 13.7 | Limited | 100% | <2% | Limited | 100% | <2% |
| Air Products | Industrial gases | 7 | 13.5 | Limited | 100% | <2% | Limited | 100% | 2-5% |
| DSM | Speciality | 7 | 13.5 | Limited | 100% | 2-5% | Limited | 100% | <2% |
| Evonik | Speciality | 7 | 13.5 | Limited | 100% | <2% | Limited | 100% | 2-5% |
| Formosa | Petrochemicals | 10 | 13.3 | Third party verification underway | - | 2-5% | Reasonable | 100% | 2-5% |
| BASF | Diversified | 11 | 13.3 | Limited | 100% | 2-5% | Limited | 100% | 2-5% |
| Braskem | Petrochemicals | 11 | 13.3 | Limited | 100% | 2-5% | Limited | 100% | 2-5% |
| Johnson Matthey | Speciality | 11 | 13.3 | Limited | 100% | 2-5% | Limited | 100% | 2-5% |
| Linde | Industrial gases | 11 | 13.3 | Limited | 100% | 2-5% | Limited | 100% | 2-5% |
| Praxair | Industrial gases | 11 | 13.3 | Limited | 100% | 2-5% | Limited | 100% | 2-5% |
| Sumitomo | Diversified | 16 | 13.2 | Limited | 96% | <2% | Limited | 96% | <2% |
| Mitsubishi | Diversified | 17 | 12.6 | Limited | 100% | 5-10% | Limited | 100% | 5-10% |
| Umicore | Speciality | 17 | 12.6 | Limited | 100% | - | Limited | 100% | - |
| DuPont | Diversified | 19 | 12.3 | Limited | 100% | 2-5% | Limited | 100% | 10-20% |
| Dow | Diversified | 20 | 5.6 | Limited | 70% | 5-10% | Limited | 40% | 10-20% |
| Toray | Diversified | 21 | 4.1 | Limited | 45% | <2% | Limited | 18% | <2% |
| PPG | Speciality | 22 | 0.0 | No third party verification | - | 2-5% | No third party verification | - | 2-5% |

Source: CDP

## Value chain emission transparency and supplier engagement

Chemicals companies have substantial and diverse supply chains. Based on data disclosed to CDP and CDP estimates of non-disclosing companies, two-thirds of GHG emissions from chemicals companies assessed in this report are Scope 3 or outside of the direct company boundary and direct scope of control.

Given the magnitude of Scope 3 emissions for the industry, a lack of disclosure could indicate a shortfall of management attention to value chain emissions and their potential impacts and costs. Lack of attention to value chain emissions could be a forward-looking indicator of lack of attention to managing risks or seizing opportunities related to climate friendly products by regulators and customers.

- Companies typically reported the largest Scope 3 emissions in the categories ‘use of sold products’, ‘purchased goods and services’, and ‘end of life treatment of sold products’. These three categories represent over 80% of reported Scope 3 emissions for the companies evaluated. However, five companies fail to report on purchased goods and services, 12 fail to report for use of sold products, and 11 fail to report end of life treatment categories of Scope 3 emissions.

- Companies typically reported the largest Scope 3 emissions in the categories ‘use of sold products’, ‘purchased goods and services’, and ‘end of life treatment of sold products’. These three categories represent over 80% of reported Scope 3 emissions for the companies evaluated. However, five companies fail to report on purchased goods and services, 12 fail to report for use of sold products, and 11 fail to report end of life treatment categories of Scope 3 emissions.

- The majority of companies assessed report transparently on Scope 3 emissions inventories, representing their upstream and downstream value chain outside of their own direct operations. Braskem, Shin-Etsu and Toray have among the highest levels of transparency.

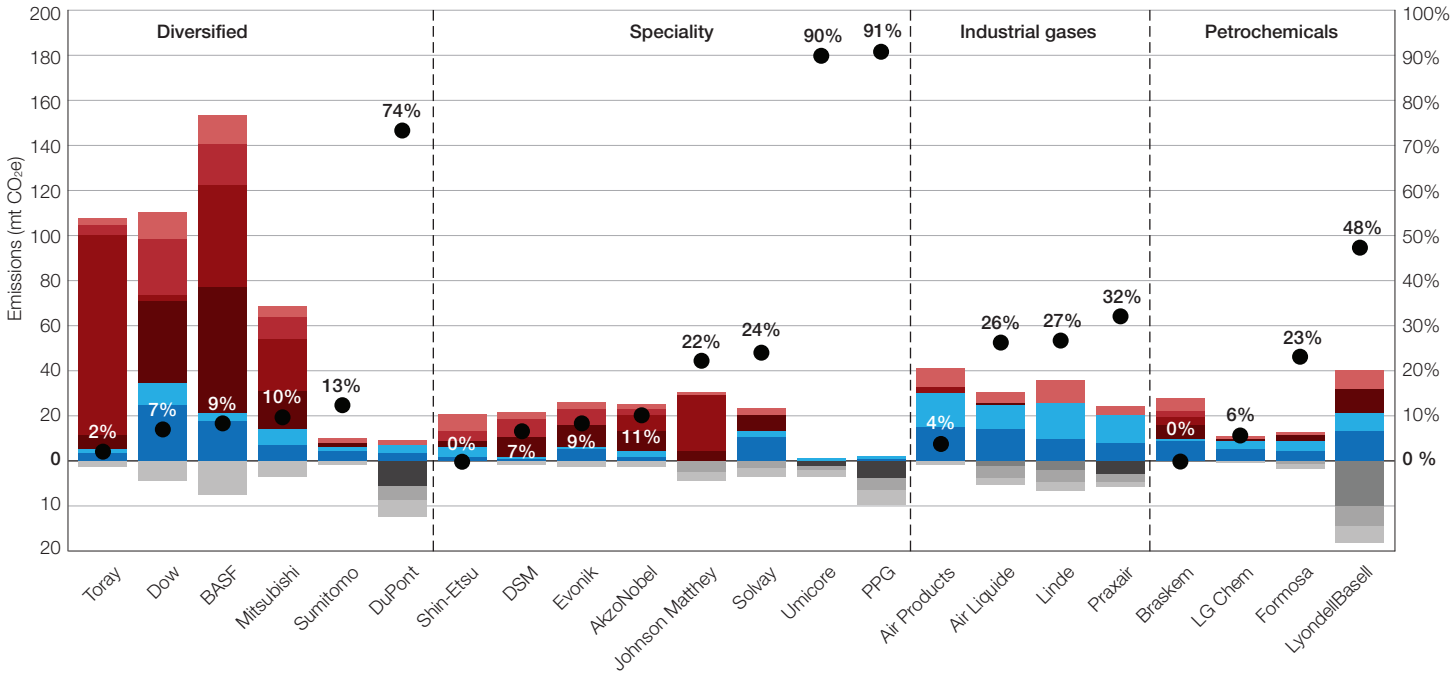
- Of the diversified chemicals, DuPont is a clear laggard in emission value chain transparency, with as much as 74% of value chain emissions undisclosed – Sumitomo, who have the second worst emissions value chain transparency of the diversifieds, only have 13% of emissions unaccounted for. DuPont notes it has undertaken preliminary Scope 3 screening but believes uncertainty in calculating these emissions is too high for reporting of many emissions categories at this time.

- Two companies, PPG and Umicore, fail to report on any categories of Scope 3 emissions. Those companies rank last on our assessment of value chain transparency and supplier engagement and are considerable laggards within the speciality chemicals subsector. PPG notes that its products include an enormous range of raw materials, making calculation of Scope 3 emissions challenging, and that it has focused on life cycle assessments and environmental product declarations for specific products where such analyses are in demand by customers.

- We also assess what proportion of their supply chain a company engages with on greenhouse gas and climate change issues. DSM ranks highest on this metric, reporting to CDP that it engages with 96% of its suppliers by spend on these issues. Formosa, Linde, Braskem and Evonik also rank highly, engaging with 75% or more of suppliers by spend.

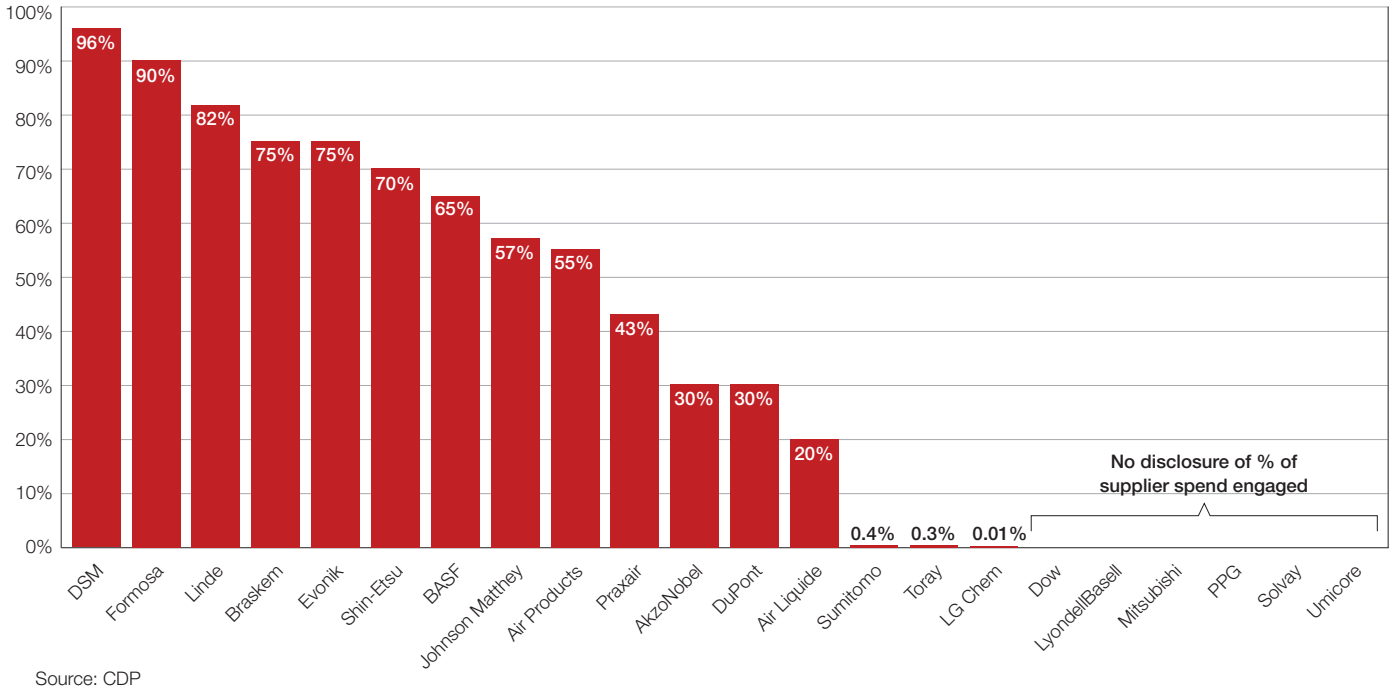
- Six companies report to CDP that they do not engage with any suppliers on greenhouse gases and climate change issues, or do not report an estimated percentage of suppliers engaged to CDP – Dow, LyondellBasell, Mitsubishi, PPG, Solvay and Umicore.

## Figure 46: Transparency of value chain emissions




(i) Estimate value
Source: CDP, company reports

## Figure 47: Supplier engagement




Source: CDP

## Climate-related remuneration

- Overall, the best performing company is DSM. The company links 30% of its annual bonus program and 50% of executive long-term incentives to sustainability performance indicators such as energy efficiency and greenhouse gas emissions reduction targets.
- AkzoNobel also performed strongly, linking 30% of LTI grants to a relative sustainability performance (tested against the RobecoSAM Dow Jones Sustainability Index benchmark) and also provides above average disclosure of the specific targets and vesting schedule, as well as historical performance against the hurdle
- Solvay links up to 20% of the CEO's annual bonus to the company's sustainable development performance criterion and is introducing a link between its GHG emissions target and LTI grants. Praxair links 13.5% of executive bonuses to non-financial KPIs, which include specified climate-change components. Praxair also provides above-average disclosure of performance against non-financial KPIs.
- Evonik ranks bottom with no apparent evidence in the company's CDP questionnaire reply or remuneration report linking climate-related performance to remuneration practices at executive or company-wide levels.
- More broadly, only three out of the 22 companies covered reported to include climate-risk related performance requirements in their LTI programs.
- PPG had a 2016 shareholder resolution filed relating to the incorporation of sustainability metrics into executive compensation (withdrawn with company to address the issue).

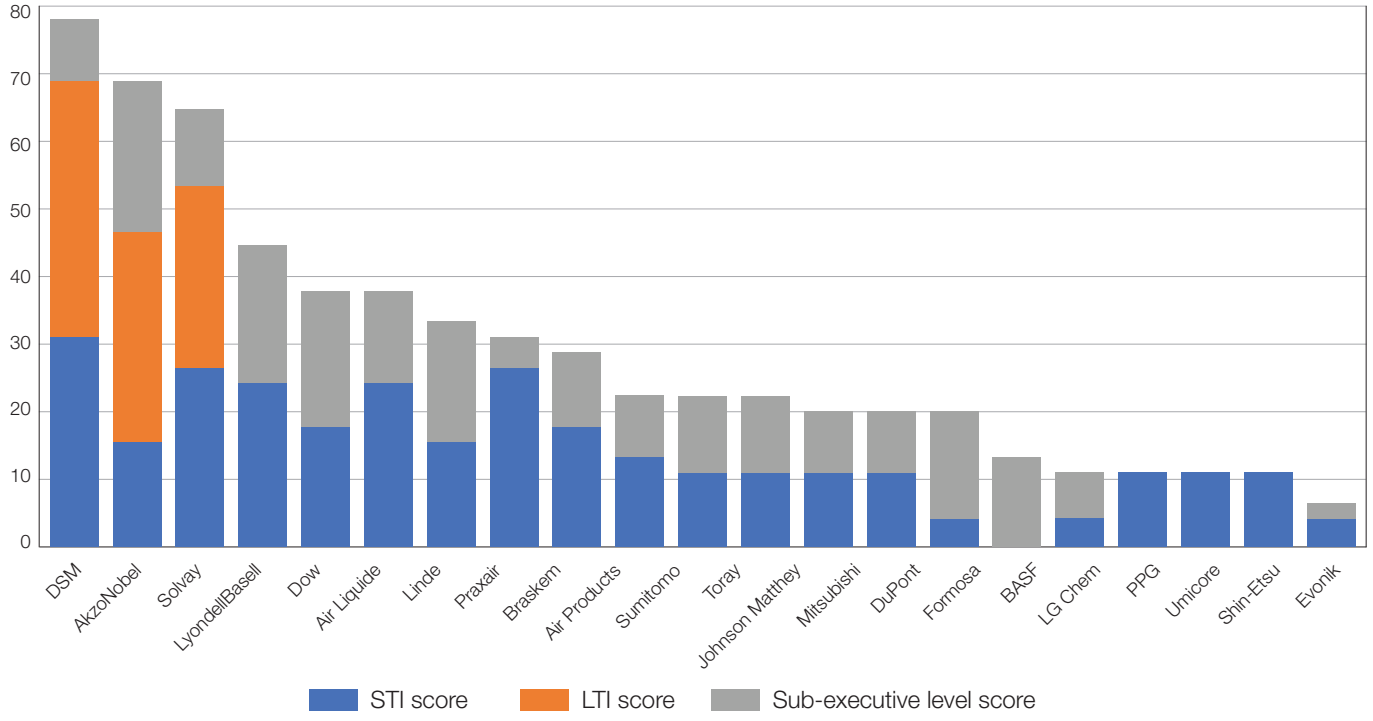
## Board level climate responsibility and expertise

- Nine out of the 22 companies reported having a board-level committee responsible for climate-risk.
- 14 out of the 22 companies report to having some form of an executive-level committee responsible for climate-risk. There were 4 companies reporting to have both board and executive level committees, who were considered to be the strongest performers.
- The two best performing companies were Dow and Johnson Matthey. Both have evidence of climate competent directors and above average quality of disclosure about their climate-related committees (including climate-risk specificity, membership and climate responsibilities). The two worst performing companies were Umicore and Solvay, who provided no indication of climate-responsible committees at either board or executive levels.
- Out of the 22 companies, 19 reported either a board level or executive level standalone committee with climate change responsibility (best performing companies reported separate committees at both levels).

## Use of an internal carbon price

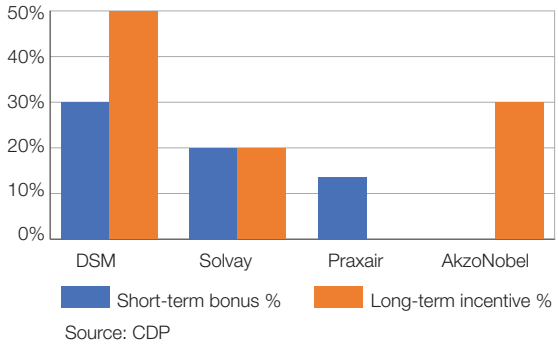
- Four companies disclose the internal carbon prices they apply to their operations. AkzoNobel applies the highest disclosed price of €50-135 and ranks first for applying the most conservative internal carbon price applied to future investment decisions and mergers and acquisitions. Solvay ranks second, and DSM third, based on significant disclosed internal carbon prices, both of which also include a range of prices based on defined criteria. LG Chem ranks fourth with a significant carbon price but no range of scenarios applied.
- Companies ranked in the following seven places indicate they apply an internal carbon price but do not disclose its magnitude. BASF and DuPont rank higher than the other five based on evidence of applying multiple price scenarios.
- The remaining half of the companies assessed do not apply an internal carbon price, ten of the eleven of which do not anticipate setting one within two years.

**Figure 48: Climate-related remuneration scorecard[i]**



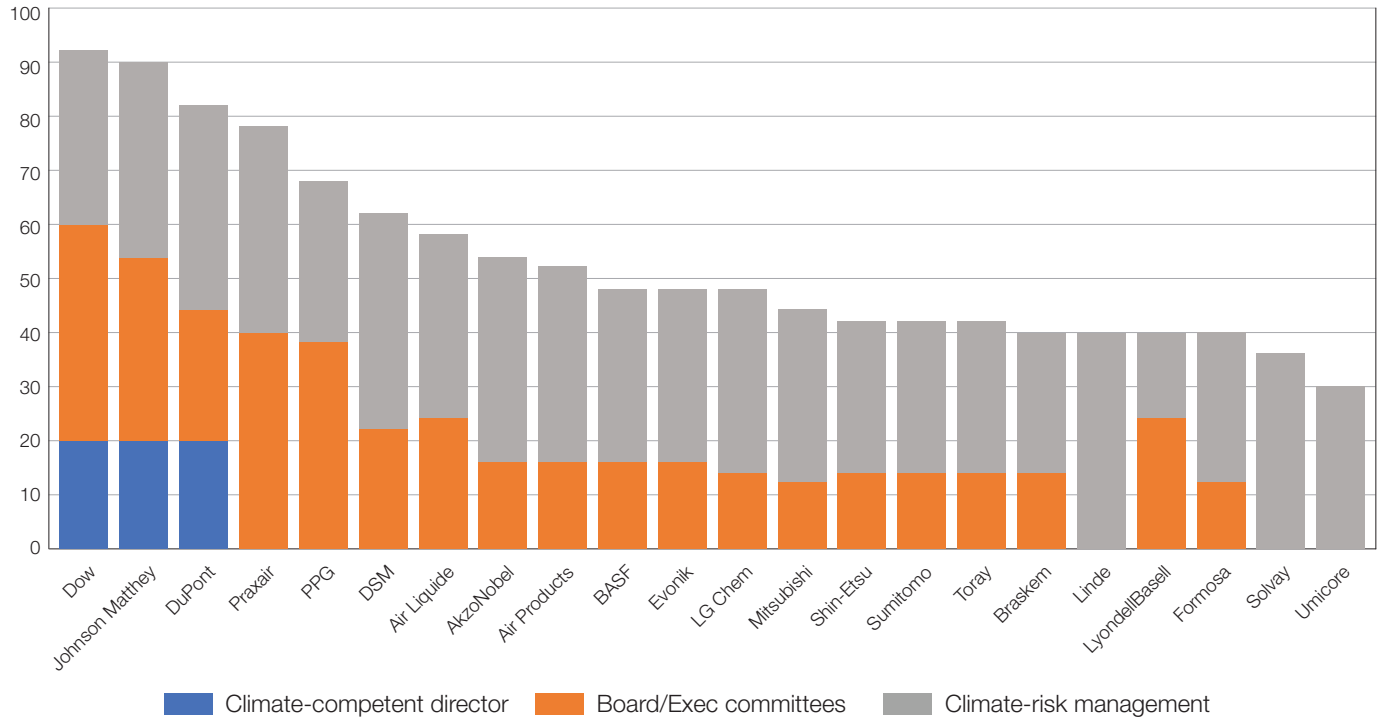

(i) Scored out of 100 where companies with higher scores receive higher rankings
Source: CDP, company reports

**Figure 48a: Senior management climate-related remuneration**



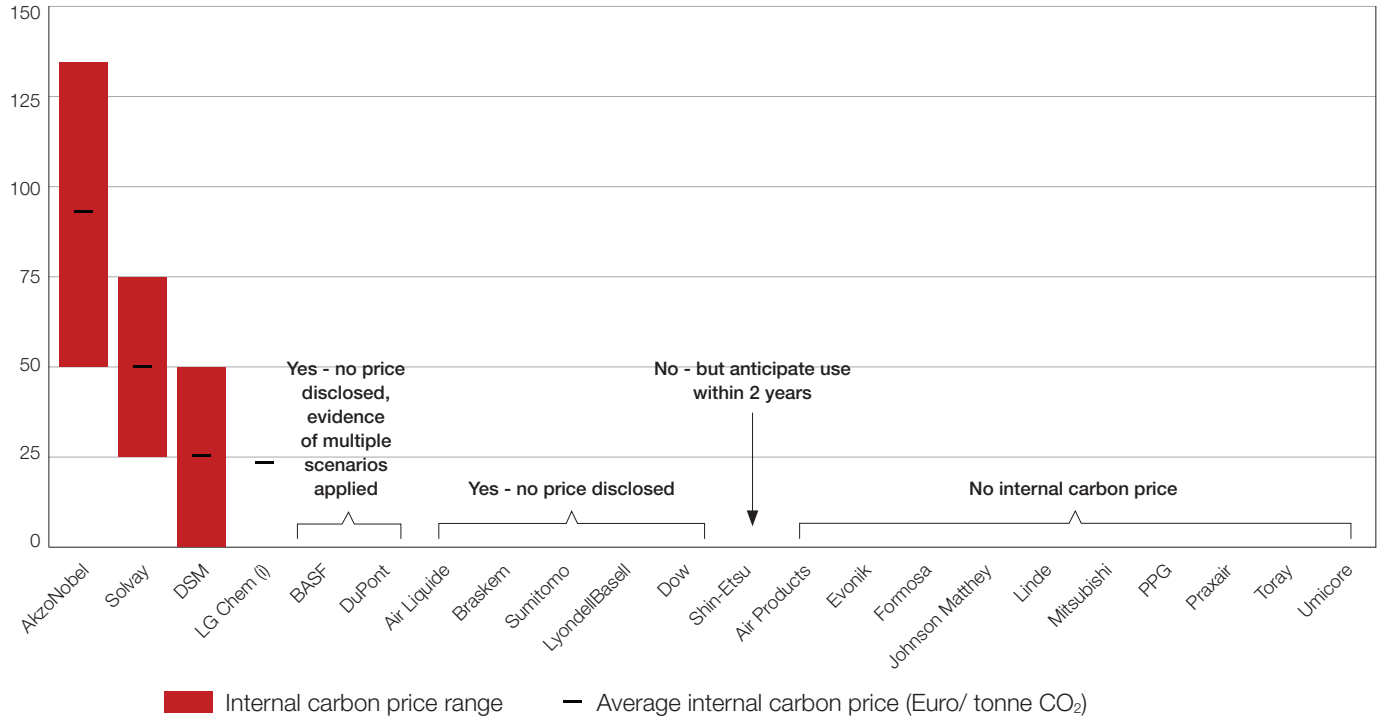

Source: CDP

**Figure 49: Overall board & executive climate responsibility(i)**




(i) Scored out of 100 where companies with higher scores receive higher rankings
Source: CDP, company reports

**Figure 50: Use of an internal carbon price**




(i) LG Chem: KRW 30,000 carbon price converted to EUR at 2016 average exchange rate

Source: CDP, company reports

# Low carbon scenarios for the chemicals industry

The International Energy Agency publishes scenario data specific to a number of high GHG emitting industries in its annual Energy Technology Perspectives publication, representing one of the most widely watched and credible sources of granular industry-by-industry scenarios of the low carbon transition. The IEA projects that production of key chemicals[32] will continue to rise considerably over time, by over 50% by 2030 from 2014 levels. Longer term, demand would rise by 96% by 2060 in the Reference Technology Scenario (RTS, consistent with Nationally Determined Contributions pledged under the Paris Agreement and 2.7°C of warming by 2100), or 75% in either the 2°C Scenario (2DS) or Beyond 2°C Scenario (B2DS).

The IEA projects that chemical industry emissions would also continue to rise in the medium term. However, to achieve the ambition of well below 2°C of warming agreed to in the Paris Agreement by over 190 countries, those emissions would have to peak around 2025. To meet a level consistent with 1.75°C of warming, based on the IEA's B2DS scenario which is the closest representation of the Paris Agreement ambition to pursue efforts to limit warming to 1.5°C, chemical sector emissions would have to fall by 4% by 2030, and 70% by 2060. To achieve a 50% chance of limiting warming to 2°C, chemical industry emissions would grow 32% higher by 2025, before declining and falling below 2014 levels prior to 2050.

**FIgure 51: Chemical industry GHG emissions**

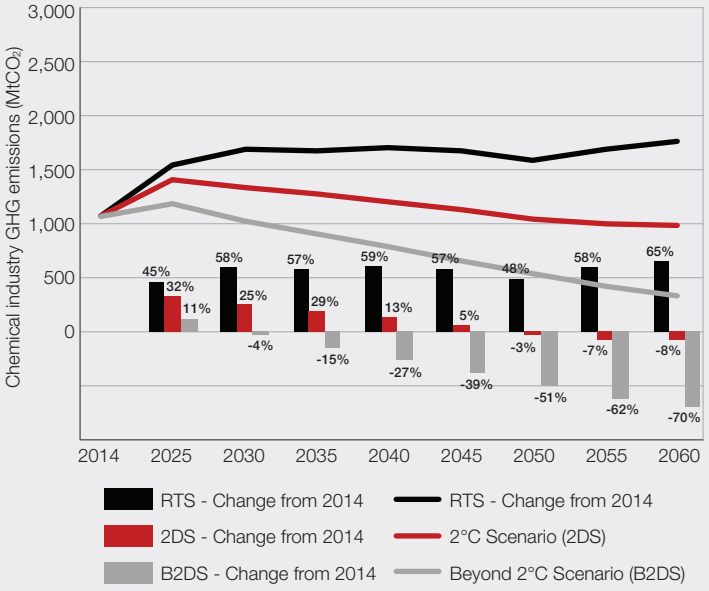
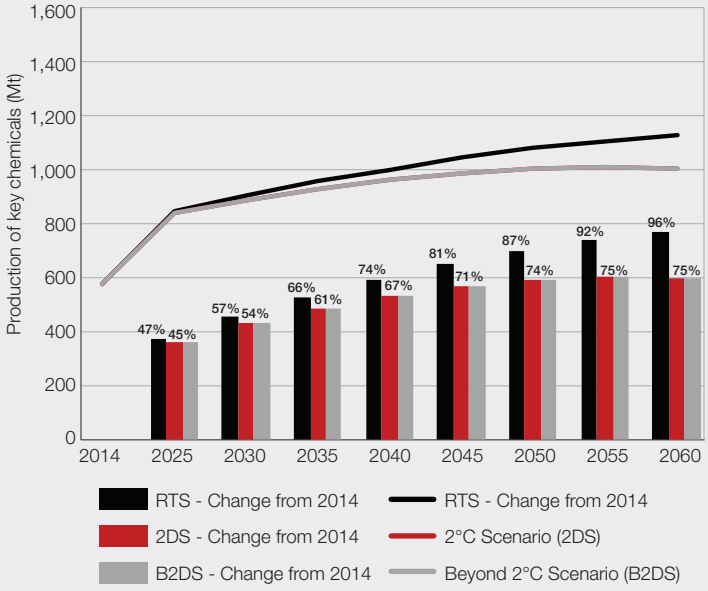
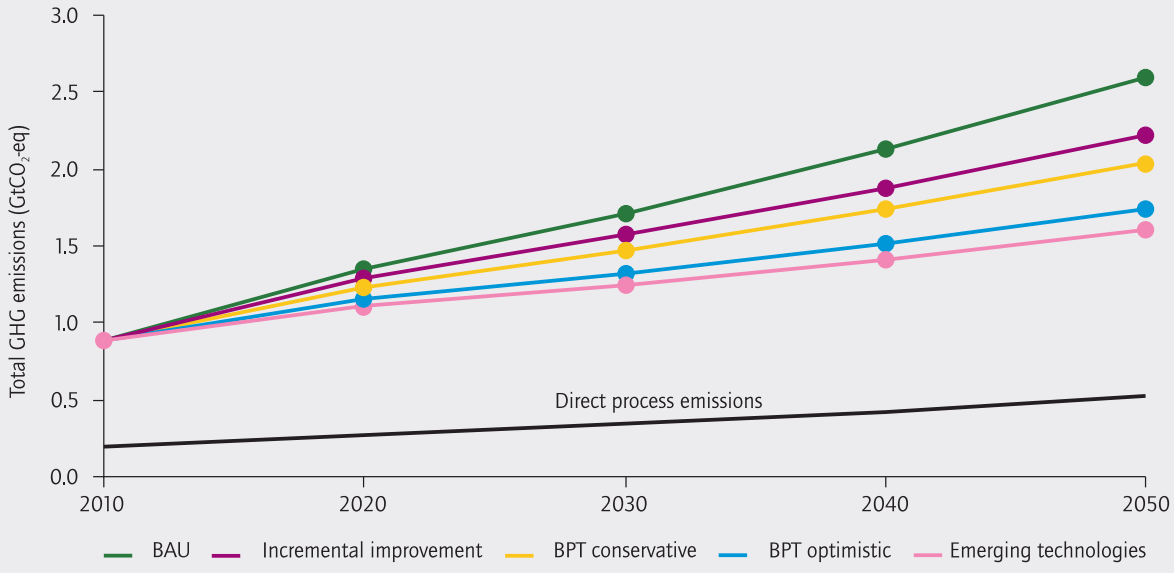



**Figure 52: Production of key chemicals**




The combination of growing demand for chemicals, together with the need for emissions abatement indicated by these scenarios, imply that significant operational energy and GHG efficiencies will need to be made, and new technologies need to be developed, proven, and brought into widespread usage, in order to meet growing demand while emitting less GHG per unit of production.

**Figure 53: GHG impact of improvement options for the top 18 chemical products to 2050**

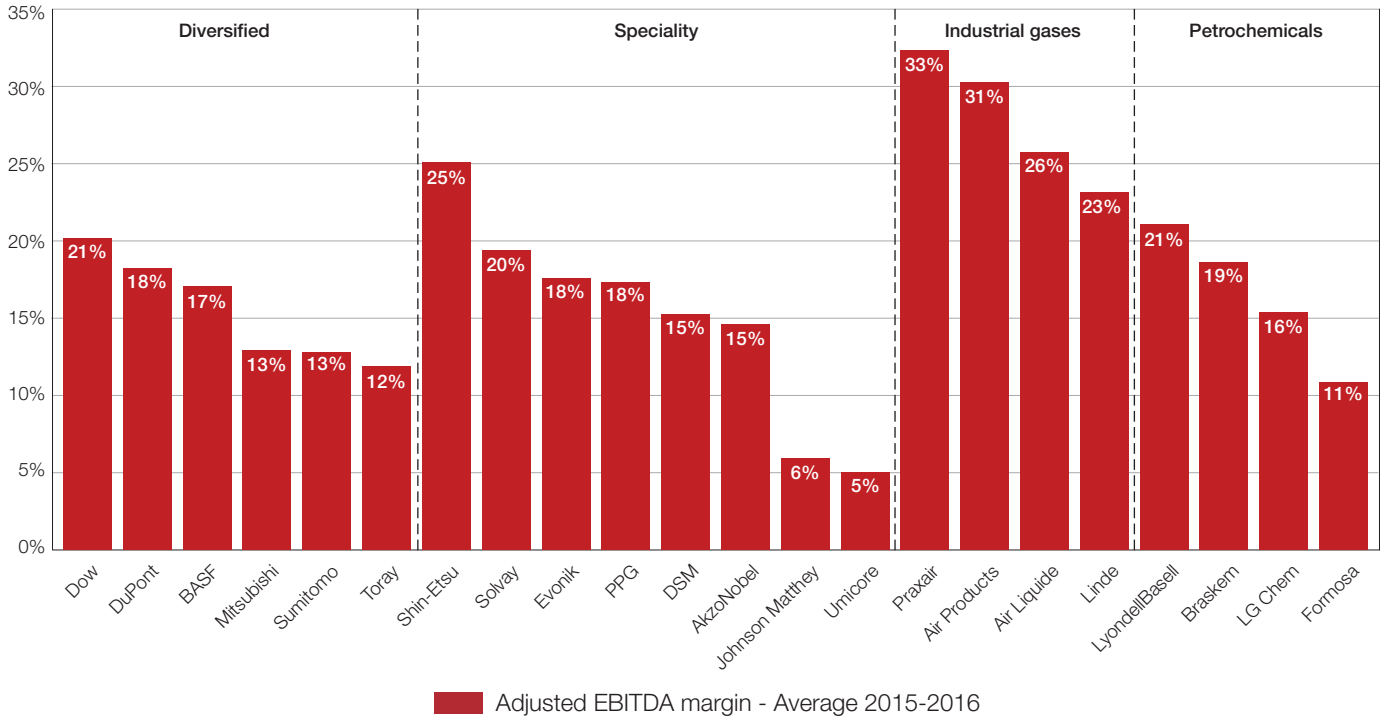



Source: Low carbon energy and feedstock for the European Chemical Industry (Dechema, 2017)

32. Ammonia, methanol, and high value chemicals

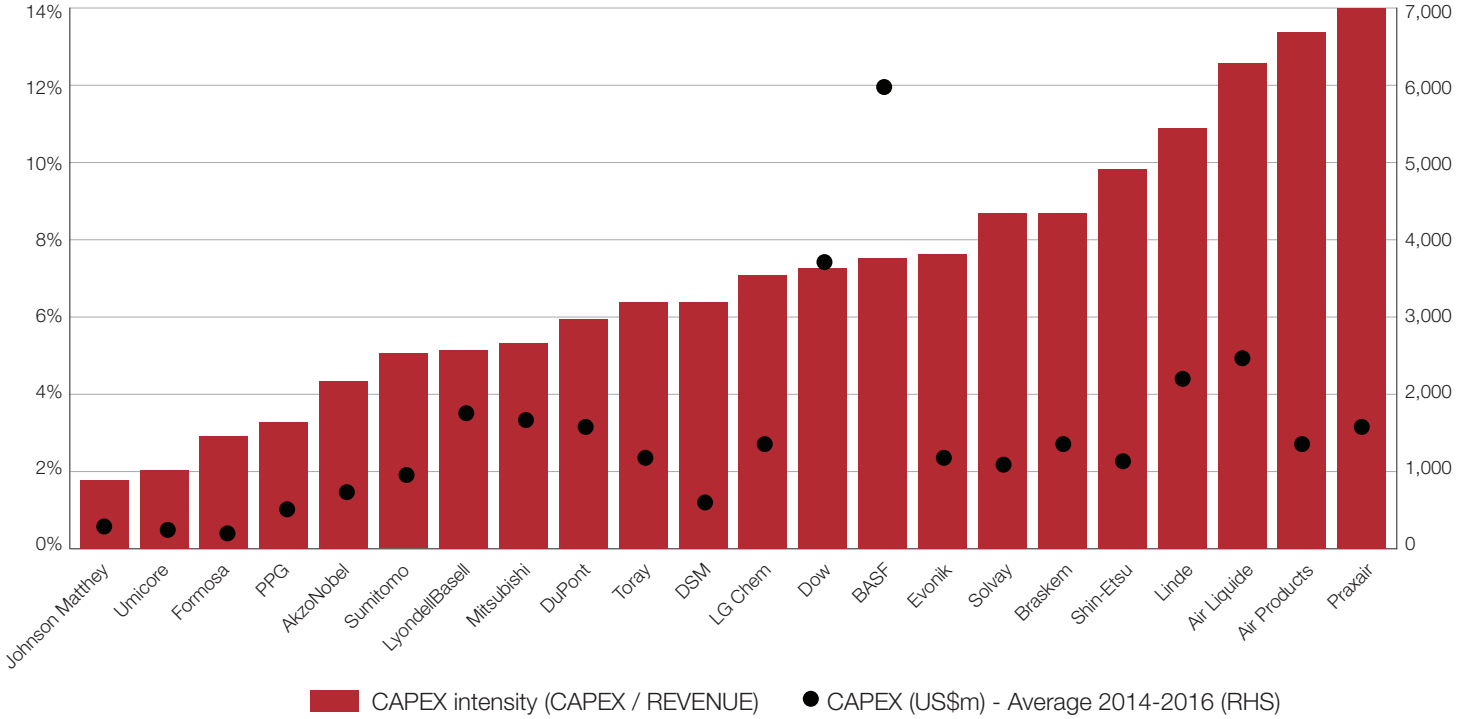
# Supplementary figures

**Figure 54: EBITDA margins (2015 – 2016)**

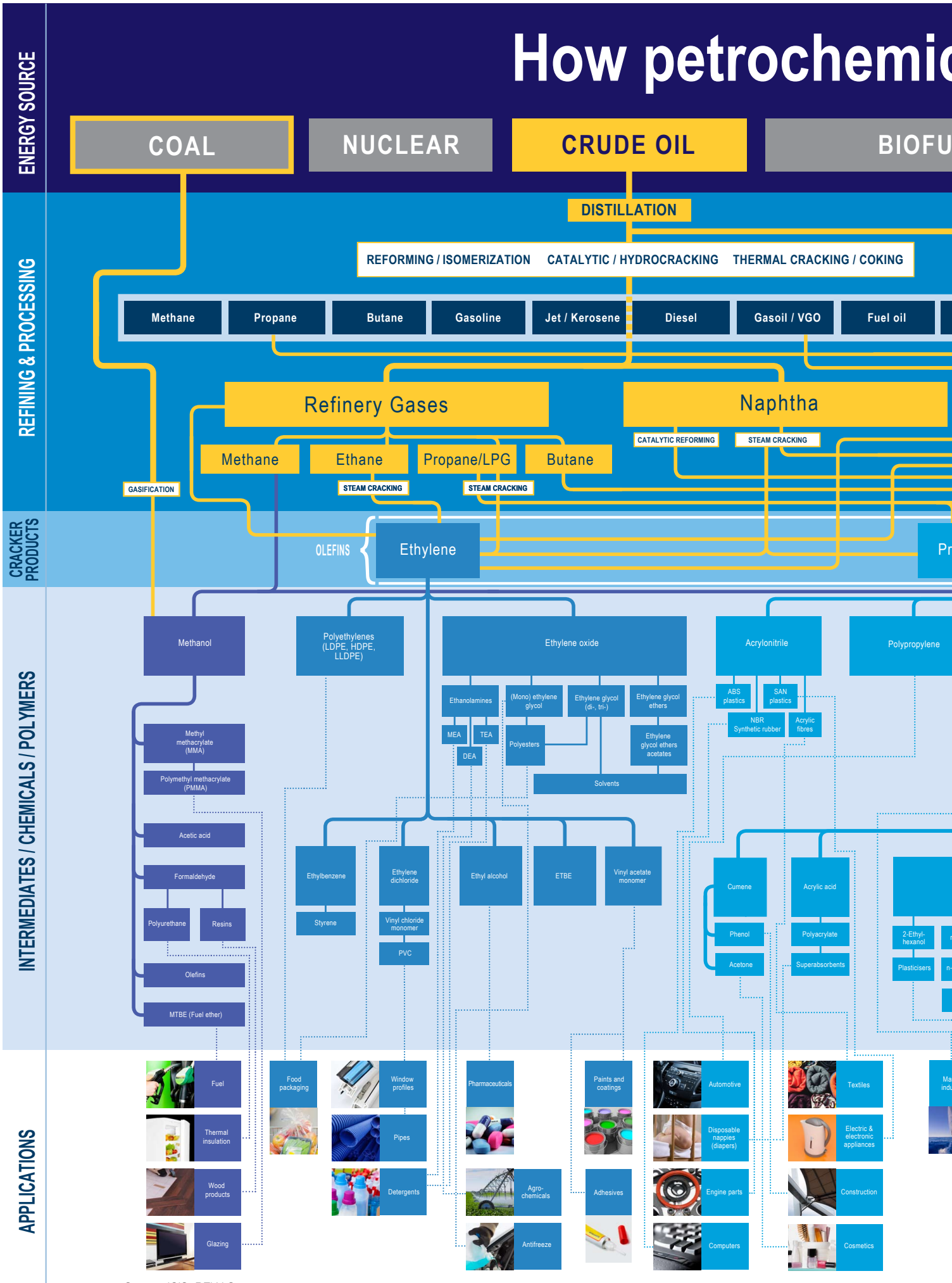



Source: Bloomberg, company reports

**Figure 55: CAPEX intensity (2014 – 2016)**




Source: CDP, company reports




Source: ICIS, RELX Group

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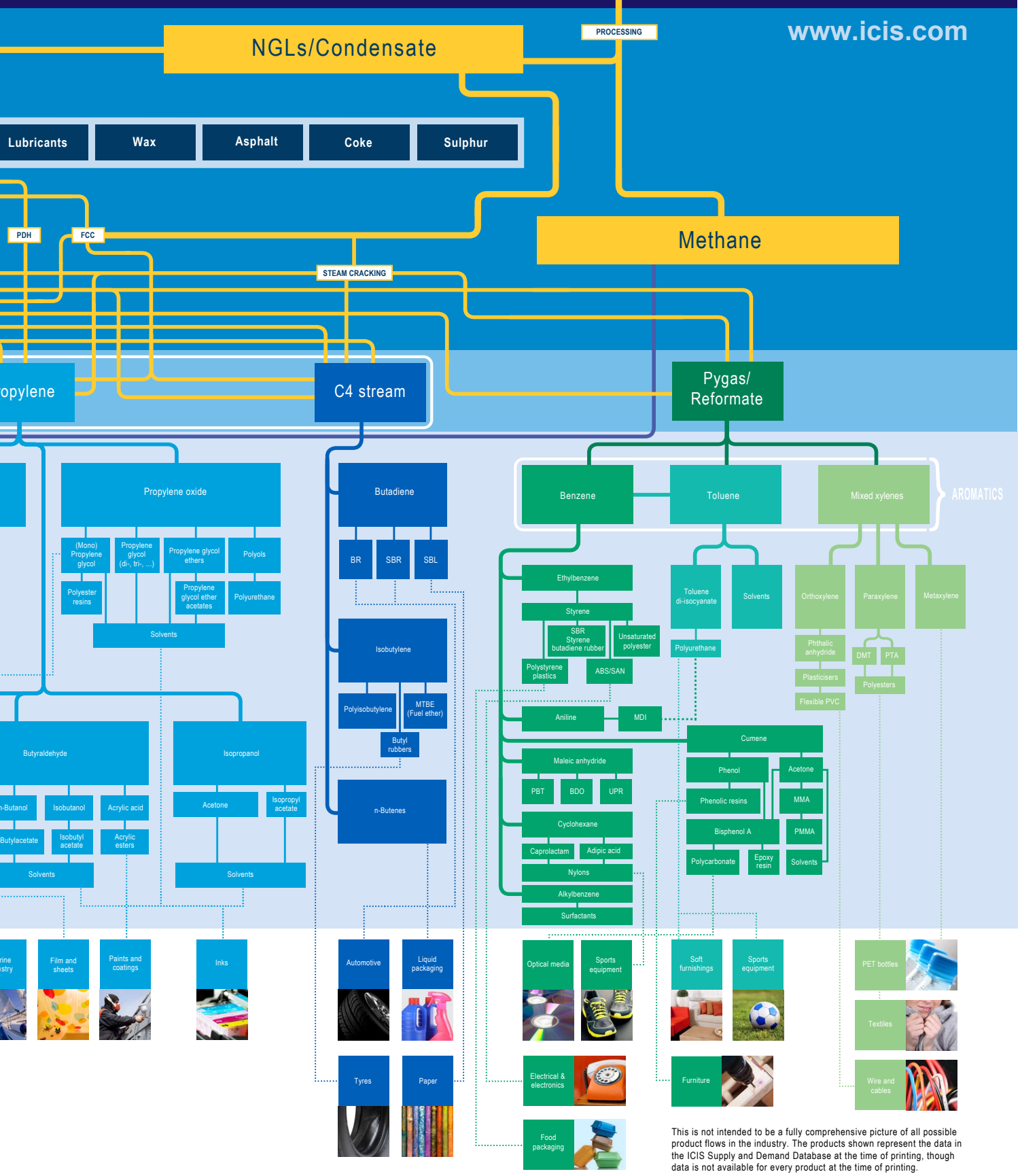



This is not intended to be a fully comprehensive picture of all possible product flows in the industry. The products shown represent the data in the ICIS Supply and Demand Database at the time of printing, though data is not available for every product at the time of printing.

## Company performance overview

| | | | | Transition risks | | | | Physical risks | | | | | Transition opportunities | | | | | | Climate governance and strategy | | | | | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| League Table Rank | Company | Classification | Country | Transition risks rank | Emissions intensity | Energy intensity | Scope 3 emissions exposure | Physical risks rank | Water withdrawal intensity | Water consumption intensity | COD intensity | Water governance | Transition opportunities rank | Production innovation | Process innovation | Low carbon revenue | R&D | Energy mix | Climate governance and strategy rank | Emissions reduction targets | Emissions verification | Transparency of value chain emissions | Climate-related remuneration | Board level expertise | Use of internal carbon price | CDP score | Green | Amber | Red |
| 1 | AkzoNobel | Speciality | Netherlands | 7 | 4 | 10 | 11 | 2 | 10 | 2 | 4 | 2 | 1 | 8 | 1 | 2 | 6 | 1 | 2 | 1 | 2 | 11 | 2 | 8 | 1 | 1 | 13 | 6 | 0 |
| 2 | DSM | Speciality | Netherlands | 6 | 2 | 6 | 18 | 5 | 7 | 8 | 17 | 5 | 5 | 13 | 7 | 1 | 1 | 16 | 1 | 4 | 6 | 3 | 1 | 6 | 3 | 1 | 8 | 10 | 1 |
| 3 | Johnson Matthey | Speciality | UK | 5 | 3 | 4 | 21 | 3 | 1 | 1 | 8 | 10 | 4 | 3 | 9 | 7 | 15 | 5 | 7 | 9 | 10 | 12 | 13 | 2 | 13 | 6 | 7 | 10 | 2 |
| 4 | DuPont | Diversified | USA | 4 | 7 | 6 | 4 | 9 | 11 | 4 | 22 | 9 | 8 | 2 | 21 | 14 | 7 | 6 | 8 | 5 | 18 | 19 | 13 | 3 | 5 | 6 | 4 | 11 | 4 |
| 5 | BASF | Diversified | Germany | 9 | 5 | 8 | 18 | 4 | 13 | 3 | 11 | 1 | 3 | 1 | 4 | 16 | 5 | 15 | 14 | 16 | 10 | 7 | 17 | 10 | 5 | 6 | 5 | 11 | 3 |
| 6 | Sumitomo Chemical | Diversified | Japan | 2 | 11 | 1 | 2 | 13 | 16 | 17 | 1 | 12 | 15 | 22 | 14 | 11 | 2 | 8 | 11 | 10 | 16 | 15 | 10 | 14 | 7 | 6 | 4 | 13 | 2 |
| 7 | PPG | Speciality | USA | 1 | 1 | 1 | 8 | 15 | 3 | 17 | 12 | 19 | 16 | 17 | 10 | 8 | 12 | 14 | 21 | 11 | 22 | 22 | 17 | 5 | 13 | 19 | 4 | 7 | 8 |
| 8 | Evonik | Speciality | Germany | 10 | 9 | 9 | 15 | 12 | 19 | 11 | 18 | 7 | 6 | 12 | 3 | 3 | 3 | 20 | 9 | 5 | 6 | 5 | 22 | 10 | 13 | 6 | 4 | 10 | 5 |
| 9 | Braskem | Petrochemicals | Brazil | 11 | 10 | 13 | 5 | 1 | 1 | 7 | 19 | 3 | 17 | 9 | 17 | 15 | 22 | 4 | 3 | 3 | 10 | 1 | 9 | 17 | 7 | 1 | 6 | 8 | 5 |
| 10 | LG Chem | Petrochemicals | South Korea | 13 | 16 | 16 | 1 | 6 | 6 | 6 | 8 | 8 | 10 | 6 | 19 | 12 | 8 | 12 | 4 | 2 | 1 | 8 | 17 | 10 | 4 | 1 | 7 | 10 | 2 |
| 11 | Air Liquide | Industrial gases | France | 15 | 17 | 17 | 3 | 20 | 21 | 9 | 2 | 17 | 2 | 5 | 5 | 3 | 14 | 3 | 13 | 21 | 2 | 16 | 5 | 7 | 7 | 13 | 6 | 9 | 4 |
| 12 | Toray | Diversified | Japan | 8 | 8 | 3 | 22 | 16 | 5 | 17 | 10 | 20 | 20 | 20 | 22 | 10 | 3 | 10 | 12 | 12 | 21 | 6 | 10 | 14 | 13 | 6 | 2 | 10 | 7 |
| 13 | Mitsubishi Chemical | Diversified | Japan | 14 | 12 | 11 | 16 | 7 | 15 | 5 | 4 | 6 | 11 | 4 | 13 | 17 | 11 | 19 | 18 | 13 | 17 | 14 | 13 | 13 | 13 | 13 | 3 | 13 | 3 |
| 14 | Shin-Etsu | Speciality | Japan | 12 | 13 | 12 | 9 | 14 | 9 | 17 | 20 | 13 | 14 | 15 | 11 | 17 | 8 | 11 | 17 | 17 | 2 | 2 | 21 | 14 | 12 | 13 | 2 | 11 | 6 |
| 15 | Umicore | Speciality | Belgium | 3 | 6 | 5 | 5 | 17 | 4 | 17 | 12 | 21 | 19 | 14 | 8 | 17 | 18 | 17 | 22 | 22 | 20 | 21 | 17 | 22 | 13 | 20 | 1 | 7 | 11 |
| 16 | Praxair | Industrial gases | USA | 17 | 21 | 14 | 9 | 11 | 14 | 13 | 7 | 11 | 7 | 11 | 6 | 13 | 19 | 2 | 15 | 18 | 10 | 17 | 8 | 4 | 13 | 1 | 3 | 11 | 5 |
| 17 | Solvay | Speciality | Belgium | 16 | 15 | 15 | 12 | 19 | 17 | 13 | 21 | 14 | 18 | 7 | 15 | 9 | 15 | 21 | 6 | 5 | 6 | 18 | 3 | 21 | 2 | 13 | 2 | 12 | 5 |
| 18 | Linde | Industrial gases | Germany | 18 | 19 | 18 | 7 | 8 | 18 | 10 | 6 | 4 | 9 | 19 | 2 | 17 | 13 | 9 | 16 | 14 | 10 | 13 | 7 | 17 | 13 | 13 | 3 | 10 | 6 |
| 19 | Air Products | Industrial gases | USA | 21 | 22 | 21 | 14 | 10 | 7 | 15 | 3 | 15 | 11 | 10 | 12 | 6 | 17 | 13 | 5 | 5 | 6 | 4 | 10 | 9 | 13 | 6 | 2 | 14 | 3 |
| 20 | Dow | Diversified | USA | 19 | 14 | 19 | 17 | 21 | 20 | 16 | 12 | 16 | 11 | 16 | 18 | 3 | 8 | 7 | 10 | 15 | 19 | 10 | 5 | 1 | 10 | 13 | 2 | 11 | 6 |
| 21 | LyondellBasell | Petrochemicals | USA | 20 | 18 | 20 | 18 | 22 | 21 | 17 | 12 | 21 | 21 | 18 | 20 | 17 | 21 | 18 | 19 | 20 | 5 | 20 | 4 | 17 | 10 | 20 | 0 | 6 | 13 |
| 22 | Formosa Plastics | Petrochemicals | Taiwan | 22 | 20 | 22 | 12 | 18 | 12 | 12 | 12 | 18 | 22 | 21 | 16 | 17 | 20 | 22 | 20 | 19 | 15 | 9 | 16 | 17 | 13 | 20 | 0 | 6 | 13 |
| **Weighting:** | | **Metric** | | | **40%** | **40%** | **20%** | | **35%** | **15%** | **15%** | **35%** | | **20%** | **20%** | **10%** | **25%** | **25%** | | **25%** | **10%** | **20%** | **20%** | **10%** | **10%** | **5%** | | | |
| | | **Area** | | **35%** | | | | **10%** | | | | | **35%** | | | | | | **20%** | | | | | | | | | | |

Source: CDP

This heat map is designed to help investors pinpoint priority areas for engagement.

**Green** = good performance

**Amber** = monitor performance, possible concern

**Red** = area of concern, engage with company

We have not assigned a uniform number of green, amber and red across the metrics according to rank. Instead, we have reviewed the results of each metric in detail and assigned the above colours according to the underlying values for each metric.

# Appendix II: Company summaries

## Formosa Plastics

**Country:** Taiwan

Market cap (LTM Q2 2017): 19.0 bn

2016 emissions: 9.0 mt $CO_2$ (Scope 1+2)

Company classification by revenue (%)

Diversified | Speciality | Industrial gases | Petrochemicals

| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| 1301 TT | 22 | E | D | E | D |

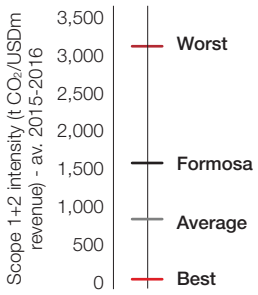
### Company strengths

- Ranks better in Scope 3 emissions and physical risks than any other category evaluated but comes bottom or close to the bottom for most metrics.

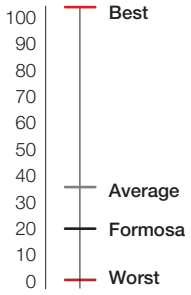
### Company weaknesses

- Rank worst of petrochemicals for managing transition risks and second worst overall with highest current emission intensity relative to value add of all companies.
- Deemed least prepared of all companies for capitalizing on transition opportunities, coming second last of all companies for product innovation.
- Highest coal use by over a factor of two (72% of operations).

**Emissions intensity**



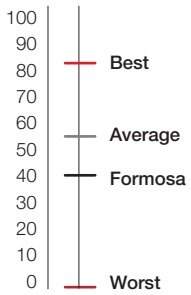

**Emissions target score**



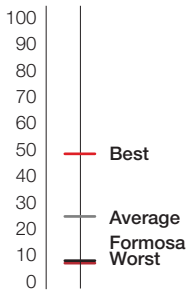

**Emissions by region**

Insufficient data available for Formosa Plastics to split emissions by region.

**Water governance score**




**Product innovation score**




## LyondellBasell

**Country:** USA

Market cap (LTM Q2 2017): 35.3 bn

2016 emissions: 21.7 mt $CO_2$ (Scope 1+2)

Company classification by revenue (%)

Diversified | Speciality | Industrial gases | Petrochemicals

| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| LYB US | 21 | E | E | E | D |

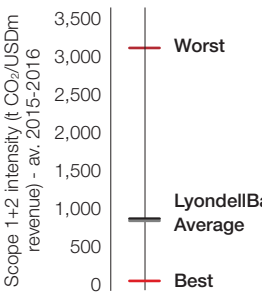
### Company strengths

- Rank second of the petrochemicals for data assurance and fifth overall.
- Highest ranked of the petrochemicals for climate related remuneration and fourth overall.

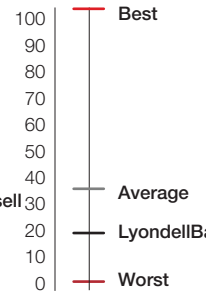
### Company weaknesses

- Third worst overall for energy intensity with some of the highest growth and current intensity figures of all companies.
- Only company not to answer CDP water questionnaire.
- Ranked second from bottom of all chemical companies for transition opportunities.
- Rank last of the petrochems and third last overall for board level climate expertise and responsibility.

**Emissions intensity**

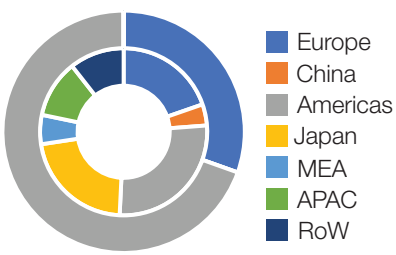



**Emissions target score**

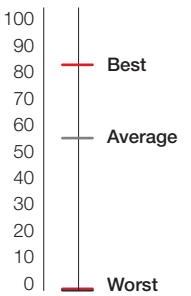



**Emissions by region**

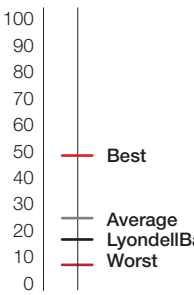
**Outer circle:** LyondellBasell
**Inner circle:** average for 22 companies




**Water governance score**




**Product innovation score**



## Dow[(i)]

**Country:** USA

(i) Dow and DuPont completed merger to form DowDuPont on 1st Sep 2017.

**Market cap (LTM Q2 2017): 68.0 bn**

**2016 emissions: 35.4 mt $CO_2$ (Scope 1+2)**

Company classification by revenue (%)

Diversified | Speciality | Industrial gases | Petrochemicals

| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| DOW US | 20 | D | D | C | C |

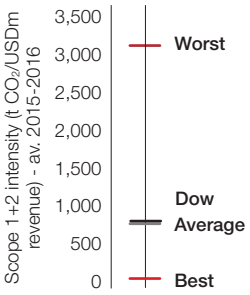
# Company strengths

- Highest ranked diversified chemical for low carbon revenue at 40% of total revenue with R&D spend of 3% of sales.
- Highest ranked diversified chemical for climate related remuneration.
- Rank first overall for board level climate expertise and climate responsibility.

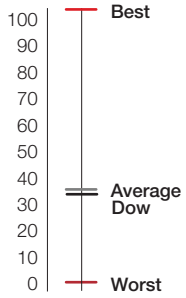
# Company weaknesses

- Worst performing diversified chemical for managing transition risks, highlighted by its performance for emissions intensity where it has the highest current level of the diversified chemicals.
- Worst performing diversified for energy intensity metric, with current energy intensities roughly three times higher than next worse diversified peers.
- Highest current water withdrawal and water consumption intensities of all companies.

**Emissions intensity**

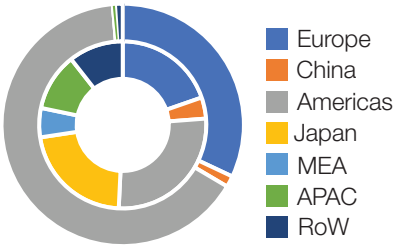



**Emissions target score**

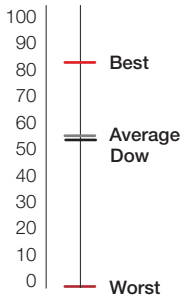



**Emissions by region**

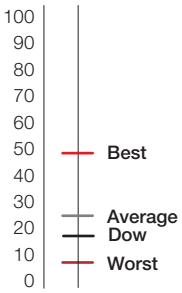
**Outer circle:** Dow
**Inner circle:** average for 22 companies




**Water governance score**




**Product innovation score**




## Air Products

**Country:** USA

**Market cap (LTM Q2 2017): 31.2 bn**

**2016 emissions: 30.2 mt $CO_2$ (Scope 1+2)**

Company classification by revenue (%)

Diversified | Speciality | Industrial gases | Petrochemicals

| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| APD US | 19 | E | C | C | B |

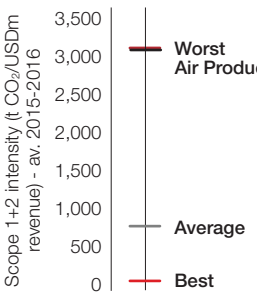
# Company strengths

- Highest ranked of the industrial gases for emissions targets and transparency for value chain emissions analysis.
- Rank third for COD intensity with very low current intensity levels.

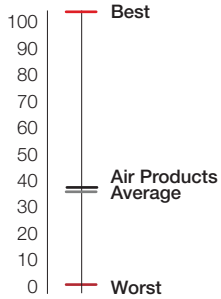
# Company weaknesses

- Worst ranked of all companies for emissions intensity metric, with the highest current intensity relative to revenue and second highest relative to gross profit.
- Ranked second worst of all companies for energy intensity metric, with second highest current energy intensities of all companies.
- Highest Scope 3 emission intensities of the industrial gases.

**Emissions intensity**

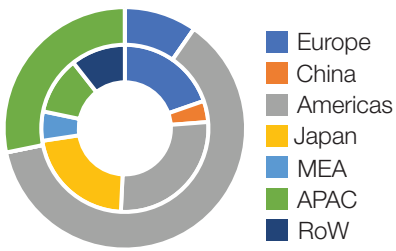



**Emissions target score**

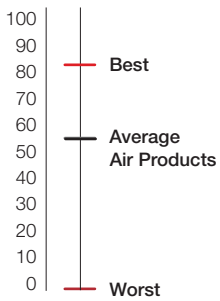



**Emissions by region**

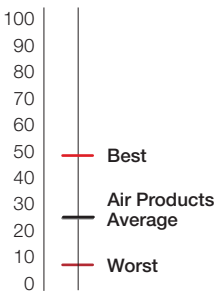
**Outer circle:** Air Products
**Inner circle:** average for 22 companies




**Water governance score**




**Product innovation score**



# Linde

**Country:** Germany

Market cap (LTM Q2 2017): 33.4 bn

2016 emissions: 25.8 mt $CO_2$ (Scope 1+2)

Company classification by revenue (%)

Diversified | Speciality | Industrial gases | Petrochemicals

| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| LIN GR | 18 | D | B | C | C |

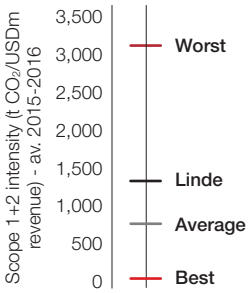
## Company strengths

- Ranks first of the industrial gases and second overall for process innovation
- Rank fourth for water governance and policies with the highest score for water policy.

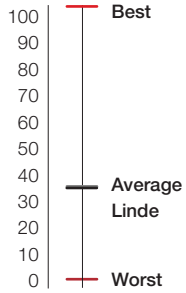
## Company weaknesses

- Ranked fourth worst overall for emissions intensity metric, despite being second best industrial gas, such is the sub-sector's expected poor performance for this section.
- Ranked last of the industrial gases for product innovation and fourth last overall.
- Lowest ranked of the industrial gases for board level expertise and climate responsibility.

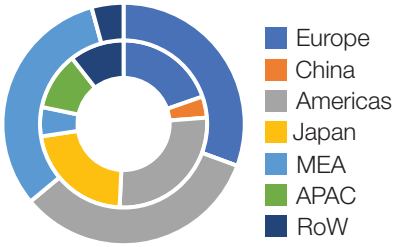
### Emissions intensity



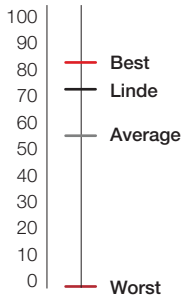

### Emissions target score



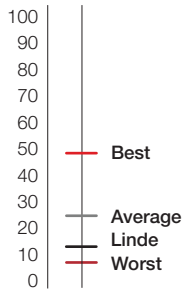

### Emissions by region




### Water governance score




### Product innovation score




# Solvay

**Country:** Belgium

Market cap (LTM Q2 2017): 13.8 bn

2016 emissions: 13.2 mt $CO_2$ (Scope 1+2)

Company classification by revenue (%)

Diversified | Speciality | Industrial gases | Petrochemicals

| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| SOLB BB | 17 | C | D | D | B |

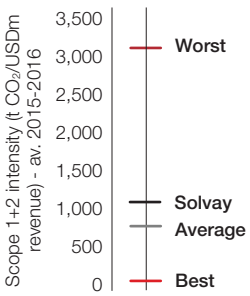
## Company strengths

- Rank third of the speciality chemicals and overall for climate related remuneration.
- Second highest internal carbon price of the speciality chemicals and all 22 chemical companies.

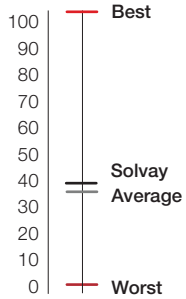
## Company weaknesses

- Despite the steepest cuts in emissions and energy intensities of the speciality chemicals, current emission intensities are still considerably higher than all other speciality peers.
- Second highest coal use of all companies explains a poor performance in the renewable energy metric.
- Second lowest ranked of the specialities and overall for board level expertise and executive level climate responsibility.

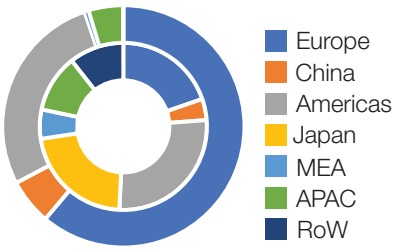
### Emissions intensity



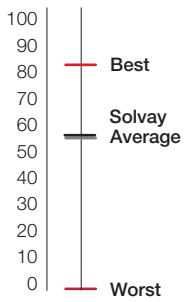

### Emissions target score



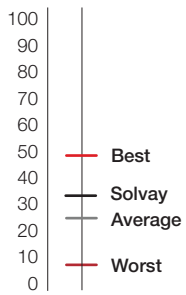

### Emissions by region




### Water governance score




### Product innovation score

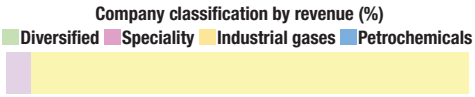


# Praxair

**Country:** USA

Market cap (LTM Q2 2017): 36.0 bn

2016 emissions: 21.2 mt $CO_2$ (Scope 1+2)




| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| PX US | 16 | D | C | B | C |

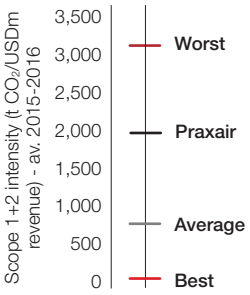
## Company strengths

- Second highest ranked overall and top industrial gas for renewable energy metric, with second highest use of renewable energy (27%) of all companies.
- Highest ranked of the industrial gases and fourth highest ranked overall for board level climate expertise and executive climate responsibility score.

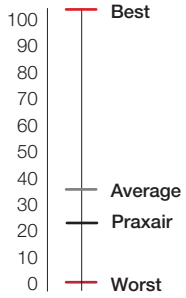
## Company weaknesses

- Ranked 21st for emissions intensity metric with particularly high current emissions intensity.
- Lowest R&D ranking of the industrial gases with 5th lowest R&D to net sales ratio of the 22 chemical companies.

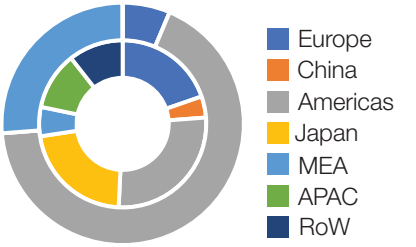
**Emissions intensity**



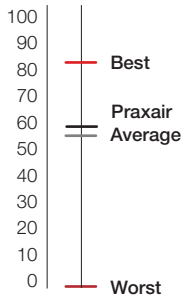

**Emissions target score**



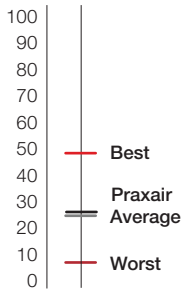

**Emissions by region**




**Water governance score**




**Product innovation score**




# Umicore

**Country:** Belgium

Market cap (LTM Q2 2017): 7.2 bn

2016 emissions: 0.7 mt $CO_2$ (Scope 1+2)


| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| UMI BB | 15 | B | D | D | E |

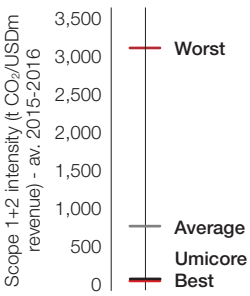
## Company strengths

- Despite the highest growth in emissions and energy intensities relative to speciality peers, current levels are still impressively low compared to all 22 chemical companies.
- Lowest Scope 3 emissions intensities of the speciality chemicals.
- Second lowest current water withdrawal intensities.

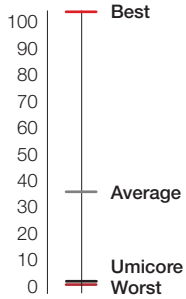
## Company weaknesses

- Umicore score poorly for water governance through substantial lack of water disclosure with low disclosure overall for the company.
- Rank bottom of the climate governance and strategy section of all companies.
- Rank last of all companies for emission targets and board level climate expertise.

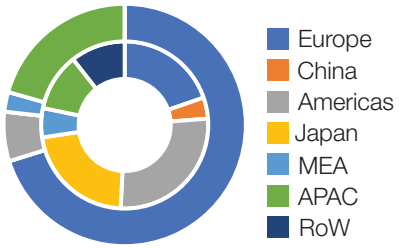
**Emissions intensity**



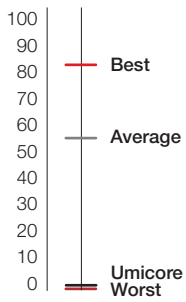

**Emissions target score**



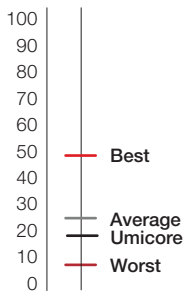

**Emissions by region**




**Water governance score**




**Product innovation score**

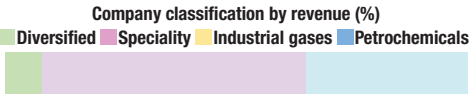


# Shin-Etsu

**Country:** Japan

**Market cap (LTM Q2 2017): 37.7 bn**

**2016 emissions: 6.2 mt $CO_2$ (Scope 1+2)**




| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| 4063 JP | 14 | C | C | C | D |

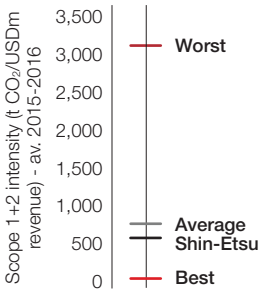
## Company strengths

- Second steepest cuts to energy intensities since 2012 of specialities.
- Highest ranked speciality chemical and second highest ranked chemical company overall for transparency in Scope 3 emissions reporting.

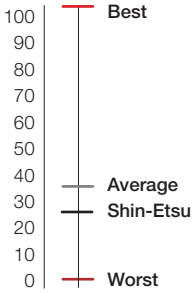
## Company weaknesses

- One of only two speciality chemicals to increase their emissions intensities since 2009 with second highest current level.
- Second worst ranked for both product and process innovation of the speciality chemicals.
- Second lowest ranked of the specialties and overall for climate related remuneration.

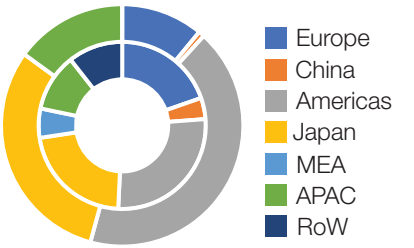
### Emissions intensity



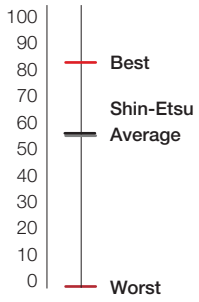

### Emissions target score



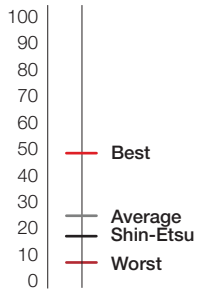

### Emissions by region




### Water governance score




### Product innovation score




# Mitsubishi Chemical

**Country:** Japan

**Market cap (LTM Q2 2017): 12.0 bn**

**2016 emissions: 14.5 mt $CO_2$ (Scope 1+2)**


| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| 4188 JP | 13 | C | B | C | D |

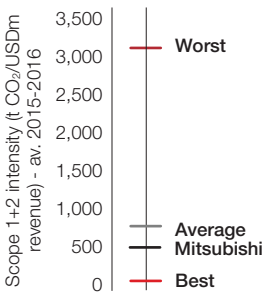
## Company strengths

- Strong performance in water governance, especially for water data verification and water policies.
- Fourth best overall for product innovation but only third best diversified against a strong performance for innovative production for this sub-group but does not report on low carbon revenues.

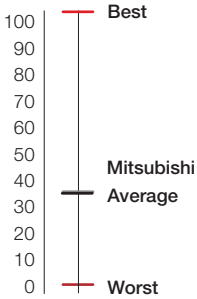
## Company weaknesses

- Second worst prepared for the transition risks of diversified chemicals with highest growth in energy intensity of diversifieds 2012-2016.
- Lowest ranked of the diversified chemicals for climate governance and strategy with poor performance for renewable energy and internal carbon price metrics.

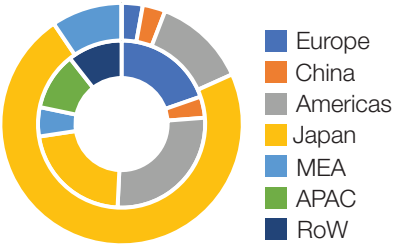
### Emissions intensity



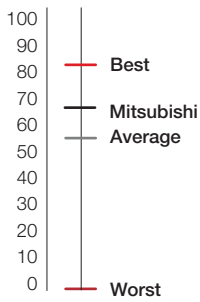

### Emissions target score



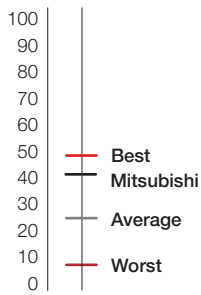

### Emissions by region




### Water governance score




### Product innovation score



# Toray

**Country:** Japan

Market cap (LTM Q2 2017): 14.3 bn

2016 emissions: 5.6 mt $CO_2$ (Scope 1+2)

Company classification by revenue (%)


| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| 3402 JP | 12 | B | D | D | C |

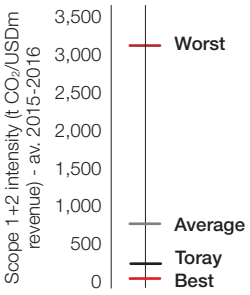
## Company strengths

- Second best placed of diversified chemicals for managing transition risks.
- Second best energy intensity rank of diversified chemicals and third overall, with both steep declines since 2012 and low current levels.

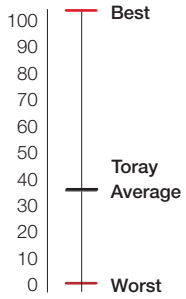
## Company weaknesses

- Worst Scope 3 emissions intensity score of all companies, with considerably highest Scope 3 intensity relative to revenue of all 22 companies.
- Poor water governance displayed, particularly relating to water data verification and water risk assessment.
- Worst ranked diversified chemical for transition opportunities and 20th overall, coming third bottom for product innovation and last for process innovation of all companies.

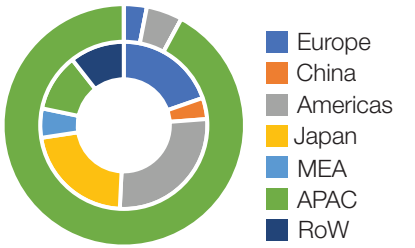
### Emissions intensity



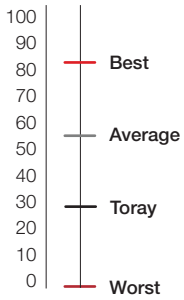

### Emissions target score



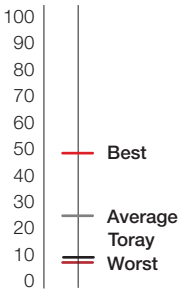

### Emissions by region




### Water governance score




### Product innovation score




# Air Liquide

**Country:** France

Market cap (LTM Q2 2017): 46.0 bn

2016 emissions: 25.2 mt $CO_2$ (Scope 1+2)

Company classification by revenue (%)


| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| AI FP | 11 | C | D | B | C |

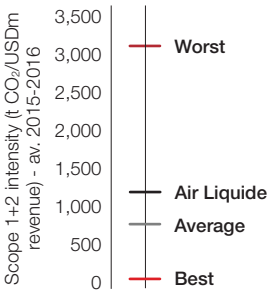
## Company strengths

- Highest low carbon revenue of the industrial gases and third highest overall at 40%.
- A renewable energy target of 50% by 2020 sees Air Liquide come second of the industrial gases and third overall for the renewable energy metric.
- Best ranked industrial gas for Scope 3 emissions intensity, ranking third overall

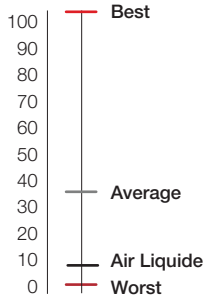
## Company weaknesses

- Score poorly for water governance and policies mainly due to lack of water data verification.
- Worst ranked of all industrial gases and second worst overall for emissions targets.

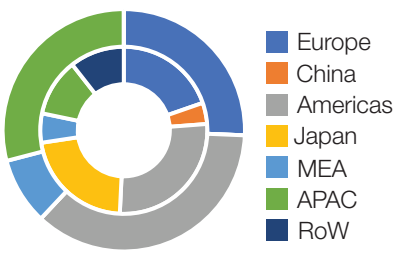
### Emissions intensity



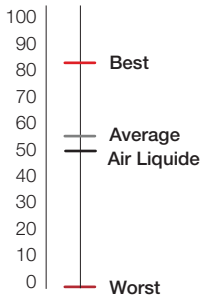

### Emissions target score



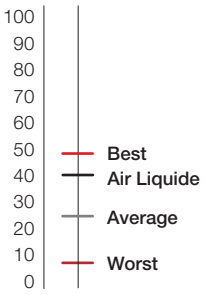

### Emissions by region




### Water governance score




### Product innovation score



# LG Chem

**Country:** South Korea

**Market cap (LTM Q2 2017): 18.6 bn**

**2016 emissions: 9.1 mt $CO_2$ (Scope 1+2)**

**Company classification by revenue (%)**

Diversified | Speciality | Industrial gases | Petrochemicals

| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| 051910 KS | 10 | C | B | C | B |

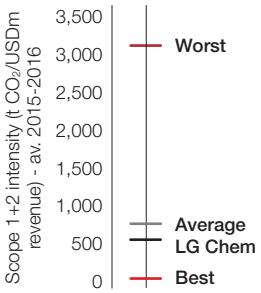
## Company strengths

- Highest ranked petrochemical sub-group for product innovation and low carbon revenue which is 15% of total revenue.
- Ranks first of the petrochemicals and second overall for emissions targets with a long-term target out to 2030.
- Lowest Scope 3 emissions intensities of all companies.

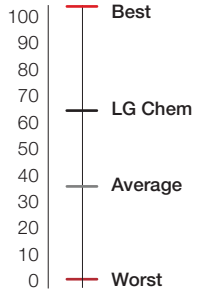
## Company weaknesses

- Third highest energy intensity growth of all companies relative to revenue – 7.7% growth since 2012.
- Lowest ranked of the petrochemicals for climate related remuneration analysis.

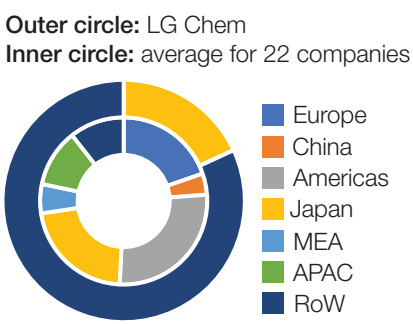
### Emissions intensity



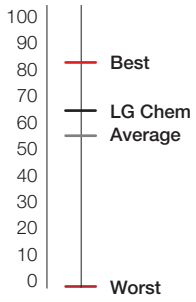

### Emissions target score



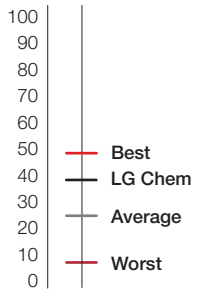

### Emissions by region




### Water governance score




### Product innovation score




# Braskem

**Country:** Brazil

**Market cap (LTM Q2 2017): 8.3 bn**

**2016 emissions: 10.2 mt $CO_2$ (Scope 1+2)**

**Company classification by revenue (%)**

Diversified | Speciality | Industrial gases | Petrochemicals



| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| BRKM5 BZ | 9 | C | A | D | B |

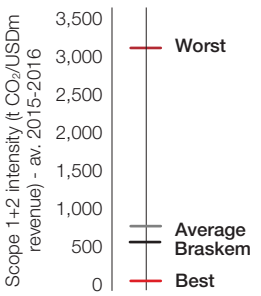
## Company strengths

- Steepest energy and emissions intensity cuts of all companies since 2009 and scores third for emission reduction targets.
- Only petrochemical company in the group to use any bio-feedstocks to produce “green” plastics although current production is low at 5.3% against fossil fuel feedstock.
- Braskem have the best water withdrawal intensity score due to their very steep intensity declines.

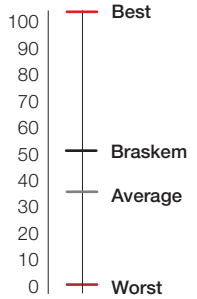
## Company weaknesses

- Lowest R&D to net sales ratio of all companies.

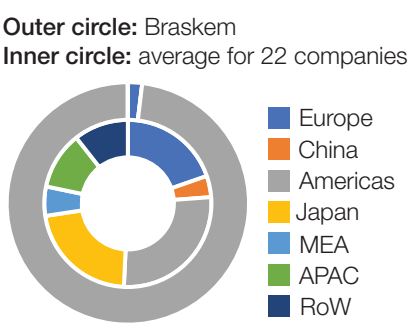
### Emissions intensity



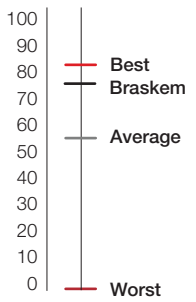

### Emissions target score



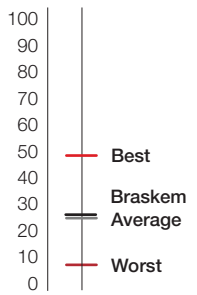

### Emissions by region




### Water governance score




### Product innovation score



# Evonik

**Country:** Germany

Market cap (LTM Q2 2017): 15.2 bn

2016 emissions: 6.4 mt $CO_2$ (Scope 1+2)

Company classification by revenue (%)


| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| EVK GR | 8 | C | C | B | C |

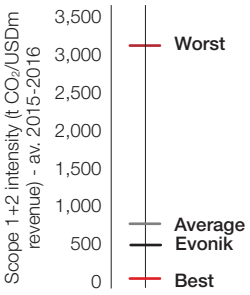
## Company strengths

- Second best specialty chemical company and third best overall for process innovation.
- Joint third highest low carbon revenue of all companies at 40%.

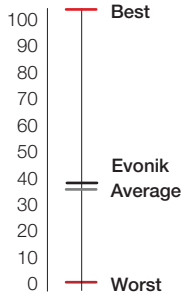
## Company weaknesses

- 19th placed for water withdrawal intensity.
- Third worst for renewable energy metric of all companies with third highest coal use of the 22.
- Lowest ranked of all companies for climate related remuneration.

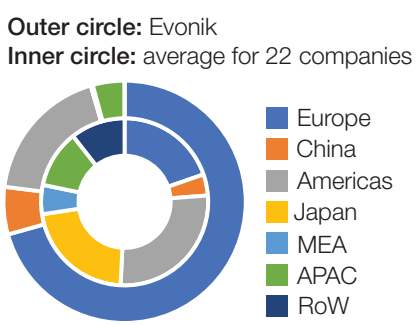
### Emissions intensity



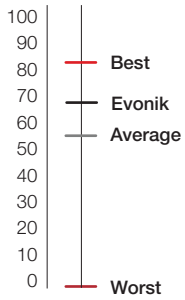

### Emissions target score



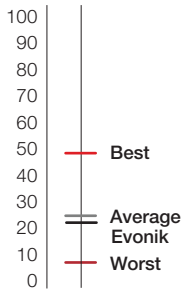

### Emissions by region




### Water governance score




### Product innovation score




# PPG

**Country:** USA

Market cap (LTM Q2 2017): 27.1 bn

2016 emissions: 1.8 mt $CO_2$ (Scope 1+2)

Company classification by revenue (%)


| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| PPG US | 7 | A | C | C | D |

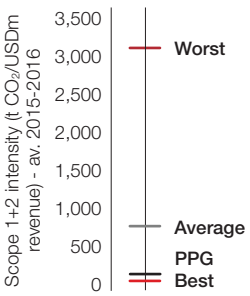
## Company strengths

- Rank first for emissions intensity metric with steep cuts over the last 8 years and low current intensities.
- Rank first for energy intensity, again with large cuts allowing for low current intensities.
- Rank third for water withdrawal intensity with third lowest current intensities.

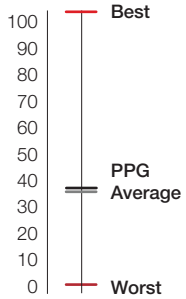
## Company weaknesses

- Rank nineteenth for water governance and policies, particularly falling down on its water risk assessment.
- Lowest ranking of all companies for emissions data assurance and value chain emissions analysis.

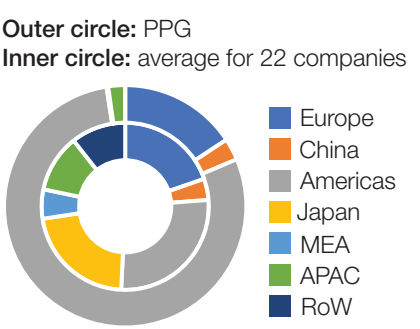
### Emissions intensity



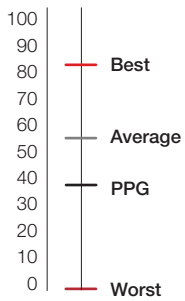

### Emissions target score



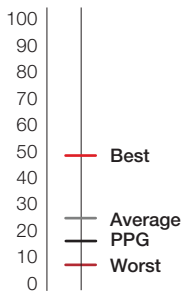

### Emissions by region




### Water governance score




### Product innovation score



# Sumitomo Chemical

**Country:** Japan

**Market cap (LTM Q2 2017): 9.2 bn**

**2016 emissions: 6.5 mt $CO_2$ (Scope 1+2)**


| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| 4005 JP | 6 | B | C | C | C |

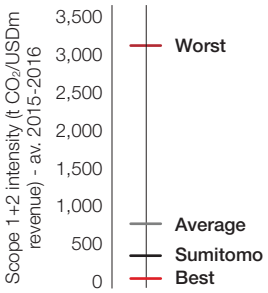
## Company strengths

- Top for R&D metric of all companies with highest R&D to net sales ratio of all companies at 7.2% of sales.
- Lowest Scope 3 intensities of the specialities and second lowest overall.
- Rank first for COD intensity of all companies with steepest decline in intensity over last five years.

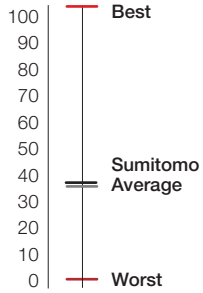
## Company weaknesses

- Highest growth in emissions intensity since 2009 of all diversifieds.
- Ranked last of all companies for product innovation.

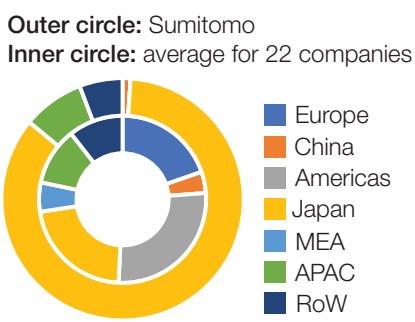
### Emissions intensity



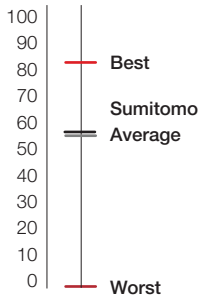

### Emissions target score



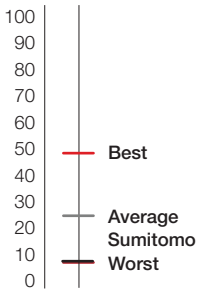

### Emissions by region




### Water governance score




### Product innovation score




# BASF

**Country:** Germany

**Market cap (LTM Q2 2017): 88.3 bn**

**2016 emissions: 20.8 mt $CO_2$ (Scope 1+2)**


| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| BAS GR | 5 | C | B | B | C |

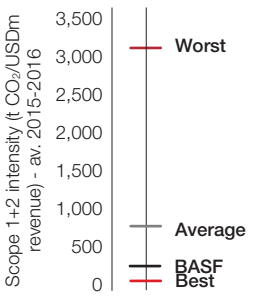
## Company strengths

- Steepest decline in emissions intensity relative to revenue of diversified chemicals and third overall.
- BASF rank first for water governance and policies, scoring the highest marks for water disclosure, water data verification and water risk assessment.
- Highest ranked diversified chemicals company for transition opportunities, ranking third overall, with the highest ranking for product innovation and highest ranking in sub-group for process innovation.

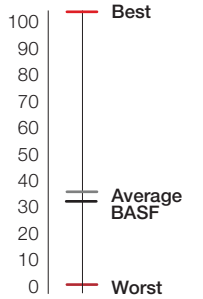
## Company weaknesses

- Lowest ranked of the diversified chemicals for emissions targets.
- Lowest ranked of the diversified chemicals for remuneration metric.

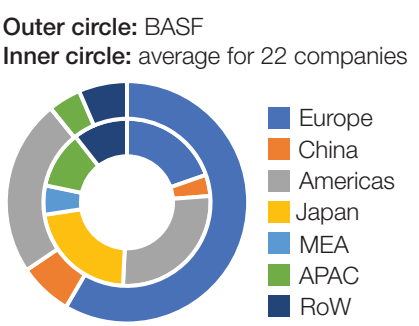
### Emissions intensity



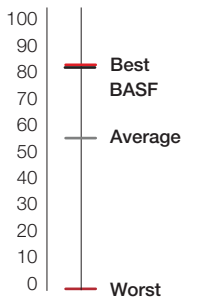

### Emissions target score



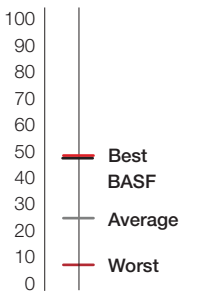

### Emissions by region




### Water governance score




### Product innovation score



## DuPont[(i)]

**Country:** USA

(i) Dow and DuPont completed merger to form DowDuPont on 1st Sep 2017.

**Market cap (LTM Q2 2017): 64.4 bn**

**2016 emissions: 6.3 mt $CO_2$ (Scope 1+2)**

Company classification by revenue (%)

Diversified | Speciality | Industrial gases | Petrochemicals

| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| DD US | 4 | B | C | B | C |

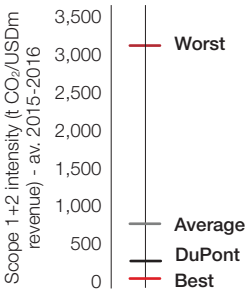
# Company strengths

- Best performing diversified chemical for transition risk with lowest current emissions intensity level of diversifieds.
- Rank second highest overall for product innovation.
- Performs strongly on governance as highest ranked diversified company for renewable energy metric and emission targets with board level expertise and climate responsibility high, third highest ranking overall.

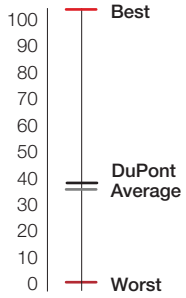
# Company weaknesses

- Steepest growth in water withdrawal intensity of all chemicals from 2012-2016.
- Rank last for COD intensity with highest current intensity relative to revenue.
- Rank second lowest overall for process innovation.

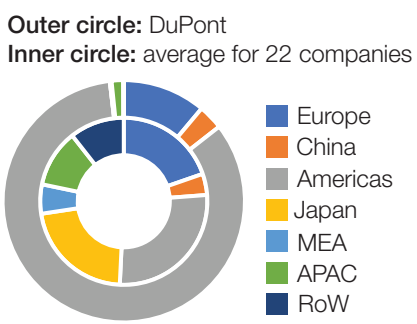
### Emissions intensity



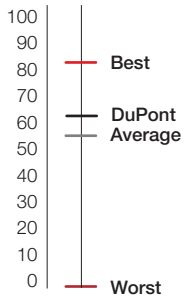

### Emissions target score



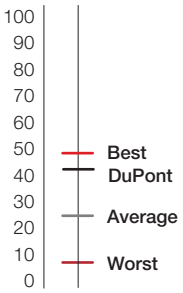

### Emissions by region




### Water governance score




### Product innovation score




## Johnson Matthey

**Country:** UK

**Market cap (LTM Q2 2017): 7.4 bn**

**2016 emissions: 0.5 mt $CO_2$ (Scope 1+2)**

Company classification by revenue (%)

Diversified | Speciality | Industrial gases | Petrochemicals



| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| JMAT LN | 3 | B | A | B | C |

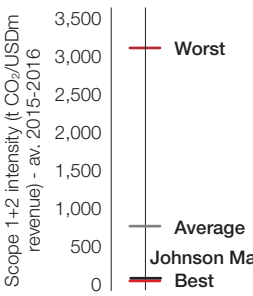
# Company strengths

- Third highest overall for product innovation and highest ranked of all speciality sub-group.
- Lowest emission and energy intensity level relative to revenue of all companies with ambitious targets for further cuts within a sub-group where energy costs are low at below 5% of operating costs.
- Top ranked overall for water withdrawal and water consumption intensity with smallest current intensity.
- Second overall and first of the speciality chemicals for board level climate expertise and board responsibility.

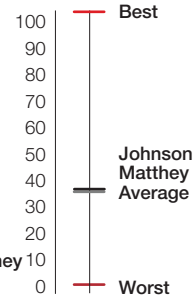
# Company weaknesses

- Ranks worst of the speciality chemicals and second worst overall for Scope 3 emissions intensity.
- Lowest R&D spend of the sub-group at 1.5% of sales against 4.2% of sales for the leader DSM in this group.

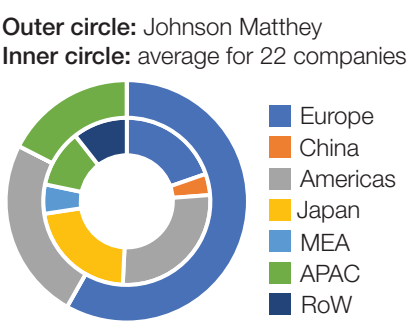
### Emissions intensity



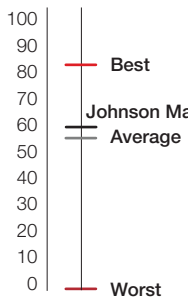

### Emissions target score



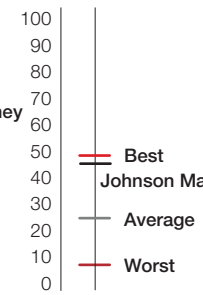

### Emissions by region




### Water governance score




### Product innovation score



# DSM

**Country:** Netherlands

**Market cap (LTM Q2 2017): 12.8 bn**

**2016 emissions: 1.5 mt $CO_2$ (Scope 1+2)**

Company classification by revenue (%)


| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| DSM NA | 2 | B | B | B | A |

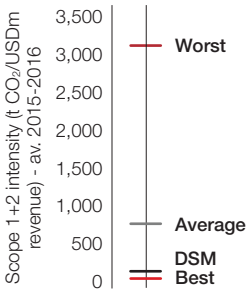
## Company strengths

- Rank second overall for emissions intensity with steep cuts since 2009 and low current intensities.
- Highest ranked of all companies for climate related remuneration and highest low carbon revenue of all companies with 59%.
- Highest ranked company for R&D metric with 90% of R&D in low carbon products.

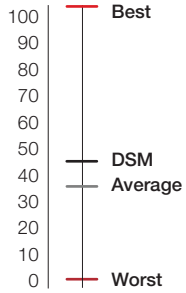
## Company weaknesses

- High Scope 3 emissions intensity with intensity relative to revenue second highest of all 22 companies.

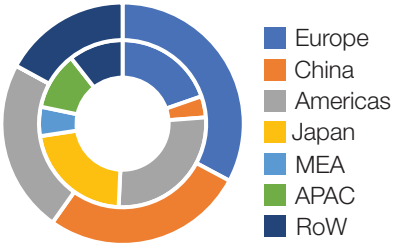
### Emissions intensity



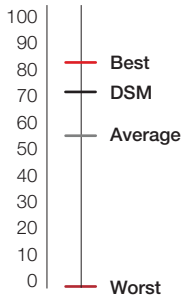

### Emissions target score



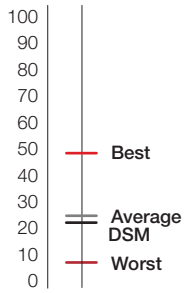

### Emissions by region




### Water governance score




### Product innovation score




# AkzoNobel

**Country:** Netherlands

**Market cap (LTM Q2 2017): 20.7 bn**

**2016 emissions: 3.7 mt $CO_2$ (Scope 1+2)**

Company classification by revenue (%)


| Ticker | League Table rank | Managing transition risks | Managing physical risks | Transition opportunities | Climate governance & strategy |
|---|---|---|---|---|---|
| AKZA NA | 1 | B | A | A | A |

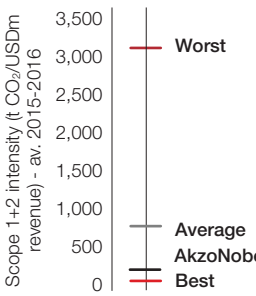
## Company strengths

- The only company to have a decarbonization target by 2050.
- Highest ranked company overall for transition opportunities, scoring highest for process innovation and second for low carbon revenues at 48% of sales.
- One of only two companies to commit to RE100 and highest internal carbon price of all companies, up to €135 a tonne.

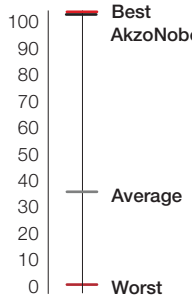
## Company weaknesses

- Despite ranking 7th overall for transition risk, ranks 5th of the speciality chemicals in this category such is the strong performance of the speciality chemicals for transition risks.
- Ranks lowly on estimated Scope 3 emissions and is in the bottom half for all companies.

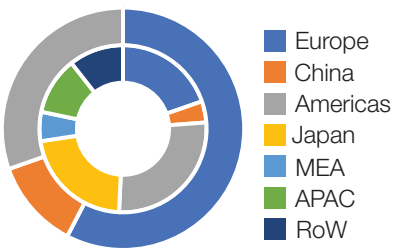
### Emissions intensity



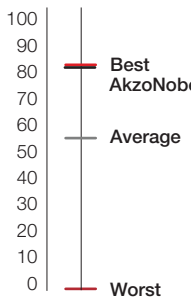

### Emissions target score



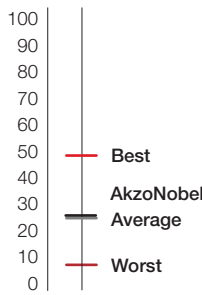

### Emissions by region




### Water governance score




### Product innovation score



# Appendix III: Methodology and limitations

## Methodology

### Transition risks

The overall transition risk rank and grades are determined as follows:

- We combine the weighted ranks of the three metrics using the following weightings: metric 1) 40%, metric 2) 40% and metric 3) 20%. This determines the overall weighted rank for transition risks.

**Metric 1) Emissions intensity**

Current emissions intensity

- We collate emissions figures for each company for 2009 to 2016 at a company level using data from the CDP questionnaire and company sources.
- We calculate emissions intensity over the period using two different normalization factors, revenue and gross profit. Revenue and gross profit figures are converted from local currencies to US$ using the average monthly foreign exchange rate for the eight-year period. The US$ exchange rate is pegged at this level for all years to avoid distortion in intensity due to foreign exchange movements.
- We divide company emissions by revenue and gross profit for the corresponding year to produce two emissions intensity figures. We take the average of 2015 and 2016 as the company current emissions intensity.
- We combine the ranks for each normalization factor at a ratio of 50:50. This determines the weighted rank for this metric. Companies with a lower emissions intensity of revenue and gross profit are ranked higher.

Change in emissions intensity

- Using the company emissions intensities described above we calculate the continuous compound growth rate over the period 2009-2016.
- Companies that have reduced their emissions intensity quicker are ranked higher.

The weighted rank for the metric is calculated by applying a 75% weight to the intensity level and a 25% weight to the emissions intensity trend from 2009-2016.

**Metric 2) Energy intensity**

Current energy intensity

- We collate total energy consumption figures for each company from 2012 to 2016 at a company level using data from the CDP questionnaire and company sources.
- We divide energy consumption figures by the two normalization factors stated above. Revenue and gross profit figures are converted from local currencies to US$ using the average monthly foreign exchange rate for the five-year period. The US$ exchange rate is pegged at this level.
- We take an average of 2015 and 2016 as the company current energy intensity.
- We combine the ranks for each normalization factor at a ratio of 50:50. This determines the weighted rank for this metric. Companies with a lower energy intensity of revenue and gross profit are ranked higher.

Change in energy intensity

- Using the company energy intensities described above we calculate the continuous compound growth rate over the period 2012-2016.

The weighted rank for the metric is calculated by applying a 75% weight to the intensity level and a 25% weight to the energy intensity trend from 2012-2016.

**Metric 3) Scope 3 emissions intensity**

- We estimate 2016 company Scope 3 emissions intensity by revenue and gross profit, combining company disclosed Scope 3 data from the CDP questionnaire, company sources and data from CDP's Full GHG Emissions Dataset, which provides modelled Scope 3 data.
- Where companies have not reported on all Scope 3 categories, relevant data-points for the chemicals industry are filled using the modelled data.
- We combine the ranks for each normalization factor at a ratio of 50:50. This determines the weighted rank for this metric. Companies with lower Scope 3 intensities rank higher. Absolute Scope 3 emissions are also displayed but not ranked.

### Limitations

- Using revenue and gross profit as denominators is not as robust as normalizing by production data. This is because revenue and gross profit are monetary indicators and can be influenced by numerous non-operational factors such as currency fluctuations, changing energy/oil prices and M&As.
- Scope 3 data was modelled and as such there could be large error margins.

### Physical risks: Water resilience

The overall physical risk rank and grades are determined as follows:

- We combine the weighted ranks of the four metrics using the following weightings: metric 1) 35%, metric 2) 15%, metric 3) 15% and metric 4) 35%.

**Metric 1) Water withdrawal intensity**

Current water withdrawal intensity

- We collate water withdrawal figures for each company from 2012 to 2016 at a company level using data from the CDP water questionnaire and company sources.

- We divide company water withdrawal by both revenue and gross profit to produce two withdrawal intensity figures.
- We take the average of 2015 and 2016 as the company current withdrawal intensity.
- Companies with a lower withdrawal intensity are ranked higher.

Change in water withdrawal intensity
- Using the company water withdrawal intensities described above, we calculate the continuous compound growth rate over the period 2012-2016.
- Companies that have reduced their water withdrawal intensity quicker are ranked higher.

The weighted rank for the metric is calculated by applying a 37.5% weight to current revenue based withdrawal intensity, a 37.5% weight to current gross profit based withdrawal intensity, 12.5% to the revenue based CAGR and 12.5% to the gross profit based CAGR.

**Metric 2) Water consumption intensity**
Current water consumption intensity
- We collate water consumption figures for each company from 2013 to 2016 at a company level using data from the CDP water questionnaire and company sources.
- We divide company water consumption by both revenue and gross profit to produce two consumption intensity figures.
- We take the average of 2015 and 2016 as the company current consumption intensity.
- Companies with a lower consumption intensity are ranked higher.

Change in water consumption intensity
- Using the company water consumption intensities described above, we calculate the continuous compound growth rate over the period 2013-2016.
- Companies that have reduced their water consumption intensity quicker are ranked higher.

The weighted rank for the metric is calculated by applying a 37.5% weight to current revenue based consumption intensity, a 37.5% weight to current gross profit based consumption intensity, 12.5% to the revenue based CAGR and 12.5% to the gross profit based CAGR.

**Metric 3) Chemical oxygen demand (COD) intensity**
Current COD intensity
- We collate COD figures for each company from 2012 to 2016 at a company level using data from company sources.
- We divide company COD by both revenue and gross profit to produce two COD intensity figures.
- We take the average of 2015 and 2016 as the company current COD intensity.
- Companies with a lower consumption intensity are ranked higher.

Change in COD intensity
- Using the company COD intensities described above, we calculate the continuous compound growth rate over the period 2012-2016.
- Companies that reduced their COD intensity quicker are ranked higher.

The weighted rank for the metric is calculated by applying a 37.5% weight to current revenue based COD intensity, a 37.5% weight to current gross profit based COD intensity, 12.5% to the revenue based CAGR and 12.5% to the gross profit based CAGR.

**Metric 4) Water governance and policy**
We use the following approach to score companies according to their water governance.
- Metrics are taken from the 2017 CDP water questionnaire. Where a company has not disclosed to CDP we look for equivalent data points from company sources.
- We use the following metrics and weighting: disclosure to the CDP water program (5%), water withdrawal, discharge and consumption data verification (25%), water supply chain engagement (5%) the identification of a risk assessment, with scale, frequency, timeframe, contextual and stakeholder issues considered (30%), water governance (5%), water policy factors considered (15%) and water related targets and goals (15%).
- Companies are ranked by their weighted average points total, with a higher score indicating better water governance. The scorecard is out of 100.

## Limitations

- There are numerous data points missing which undermines the ability to compare companies.
- Differing understandings of the definitions of water withdrawal and water consumption can lead to misleading and incorrect reporting of such figures.
- Analysis does not capture water stress analysis, a key metric for assessing drought, storm and other related physical risk issues for chemical companies.

## Transition opportunities

The overall transition opportunities rank and grades are determined as follows:

- We combine the weighted ranks of the five-metrics using the following metrics: metric 1) 20%, metric 2) 20%, metric 3) 10%, metric 4) 25%, metric 5) 25%.

**Metric 1) Product innovation**

- We collate information on products judged to be favorable in contributing to a low carbon transition and rank companies using a scorecard approach.
- Products are categorized into the following subsectors: bio-based production, efficiency improvement applications, renewable energy applications, battery/energy storage applications, hydrogen applications and pollution reduction applications.
- Products within each subsector are scored relative to other products within the subsector, based on their potential contribution in directly or indirectly decarbonizing the chemicals industry or other industries.
- The subsectors are weighted as follows: bio-based production – 20%, efficiency improvements – 20%, renewable energy – 25%, battery/energy storage – 15%, hydrogen – 10%, with a total score out of 100.
- Companies with higher scores are ranked higher.

**Metric 2) Process innovation**

- We collate information of innovative company processes that go beyond business as usual practices or maintenance of plants as well as information regarding emissions and energy reducing initiatives and rank companies using a scorecard approach.
- Processes are categorized into the following subsectors: GHG capture or use, process efficiency and technological optimization, renewable energy and low carbon feedstocks, recycling materials and reduction/use of emitted waste, emissions/energy reducing initiatives and digitization.
- Processes within each subsector are scored relative to other processes within the subsector, based on their potential benefit in reducing emissions within the chemical industry's direct operations or within the supply chains.
- The subsectors are weighted as follows: GHG capture or use – 15%, process efficiency – 20%, renewable energy and low carbon feedstocks – 25%, recycling materials – 25 %, emissions/energy reducing initiatives – 10%, digitization – 5%, with a total score out of 100.
- Companies with higher scores are ranked higher.

**Metric 3) Low carbon revenue**

- Low carbon revenue was assessed based on CC3.2a C5 in the CDP questionnaire where companies are asked to disclose the % revenue from low carbon product/s in the reporting year.
- Additional figures were also taken from Bloomberg and company reports.
- Companies with higher percentages were ranked higher.

**Metric 4) Research and Development (R&D)**

- We collate financial data and R&D expenses from company reports and data from CC3.2a C6 in the CDP questionnaire where companies are asked to disclose the % R&D in low carbon product/s in the reporting year.
- We rank companies on their average R&D expense to sales ratio over the period 2014-2016 and on the range of % R&D spend in low carbon products.
- The weighted rank for the metric is calculated by applying a 50% to the R&D expenses to sales ratio and a 50% weight to the % R&D spend in low carbon products.

**Metric 5) Renewable energy**

- Companies are ranked on their energy consumption fuel mix, renewable energy targets and whether they are a member of the RE100 initiative.
- We collate data on total energy consumption, split by fuel type and renewable targets from company reports and data reported to CDP (CC11 and CC3.1e).
- For fuel mix, companies are ranked positively based on the total percentage of energy consumption from renewable sources and negatively for the total percentage of energy from coal / coke.
- Renewable energy targets are linearly extrapolated to an equivalent target for 2020 to allow for comparison.
- The weighted rank for the metric is calculated by applying a 30% weight to share from renewable energy, 30% weight to share from coal / coke, 30% weight to renewable energy targets and 10% weight to being a member of the RE100 initiative.

## Limitations

- The product and process innovation scorecards were subjectively assessed such was their qualitative nature.
- A lack of reporting of both low carbon revenue and low carbon R&D undermines the ability to compare companies.

## Climate governance and strategy

The overall governance and strategy rank and grade is determined as follows:

- We combine the weighted ranks of the seven-metrics using the following metrics: metric 1) 25%, metric 2) 10%, metric 3) 20%, metric 4) 20%, metric 5) 10%, metric 6) 10%, metric 7) 5%.

**Metric 1) Emission reduction targets**
Assessment of company targets was undertaken through a criteria-based assessment against requirements set by the Science Based Targets Initiative (SBTi) to validate company targets as consistent with achieving below 2 degrees of warming.

This differs to methods used in other recent CDP sector research reports, which sought to apply quantitative elements of the Sectoral Decarbonization Approach. Science-based target setting approaches for the chemicals industry are relatively underdeveloped compared with other high emitting industries, with the SBTi yet to develop a formal methodology.

We undertook a criteria based scorecard approach, assessing companies' emission reduction targets based on general requirements and recommendations cited by the SBTi. The following variables were assessed:

- Multidimensional target: Companies were scored higher for meeting the recommendation to set reduction targets in both absolute and intensity terms.
- Scope and coverage: Companies were scored based on the % coverage of their Scope 1 and 2 target and % coverage of Scope 3 emissions. The target must cover at least 70% of emissions per Scope.
- Target length. Companies must demonstrate that the target runs at least 5 years at initiation, the target that runs for at most 15 years and there is an additional long-term target ending beyond 2030.
- Companies were also scored based on their public commitment to the SBT initiative.
- The weighted rank for the metric is calculated by applying a 15% weight to multidimensional aspect of the target, 35% to the Scope and coverage of the target, 35% weight to the target length and 15% to the commitment to the SBTi. This metric is scored out of 100.

**Metric 2) Emissions data verification**
We use the following approach to score companies according to their Scope 1+2 emissions data transparency:

- The start point in the analysis is the proportion of emissions verified by a third party. We score this out of 10. If 100% are verified, this achieves 10 points. Then, points are awarded according to the proportion verified, i.e. a company with 86% of emissions verification is awarded 8.6 points.
- We then adjust the score (max 10) according to the uncertainty of the Scope verified. If the uncertainty is 5%, we deduct 0.5 points, if the uncertainty is 2%, we deduct 0.2 points, and so on.
- We multiply the remaining score according to the level of assurance as follows: high assurance = 100%; reasonable = 90%; moderate = 80%; limited = 70%; don't know yet = 50%; none = 0%.
- We then multiply the remaining score (still max 10) according to the status of the verification: complete = 100%; underway = 75%; none = 0%.
- We rank companies according to final score, with higher scores ranking higher.

**Metric 3) Value chain emission transparency and supplier engagement**
Value chain transparency

- We collate Scope 3 emissions disclosures for each company using CDP2017 CC14.1, which lists Scope 3 in 17 categories, 15 in line with the GHG Protocol plus options for two additional 'other' categories', one for upstream and one for downstream.
- We identify which of the 15 GHG Protocol categories are disclosed by each company, and cross reference any gaps in disclosure with CDP's Clean and Complete Dataset, which estimates emissions for any categories identified to be substantial but undisclosed.
- Estimates are undertaken by specialist CDP analysts, based on expected emissions profiles of each company's disclosed business segments. We create a second matrix of Scope 3 emissions that incorporates both disclosures and CDP estimates.
- Scope 1+2+3 emissions are calculated in two ways - (1) a version that sums only disclosed values, and (2) a version that sums both disclosed and CDP estimated values. The ratio (1)/(2) is calculated, representing the approximate percentage of total value chain emissions that are transparently disclosed by companies. We rank companies from the highest to lowest ratio.

Supplier engagement

- We collate supplier engagement data from CDP2017 CC14.4b which asks for the proportion of the company's total spend the suppliers they engage with represents.

The weighted rank for this metric is calculated by applying a 65% weighting to the value chain transparency aspect and a 35% weighting for the supplier engagement aspect.

**Metric 4) Climate-related remuneration:**

- We assessed companies based on publicly available remuneration reports and responses to the CDP climate change questionnaire CC1.2 and CC1.2a.
- The focus was on senior executive remuneration (for short-term and long-term variable incentive programs) as well as company-wide remuneration practices (at a monetary level only excluding competitions and awards).
- At the senior executive level, we considered the quality of disclosure surrounding metric targets, historical performance against targets, climate-risk specificity of targets and overall proportion of variable incentives tied to climate performance.
- At a company-wide level we considered the overall quality of disclosure and practices.
- The weighted rank for this metric is calculated by applying a 39% rank to executive short-term remuneration, a 39% rank to executive long-term remuneration and a 22% rank to company-wide remuneration initiatives. This metric is scored out of 100.

**Metric 5) Board level climate responsibility and expertise:**

- We assessed companies based on publicly available company reports and responses to the CDP climate change questionnaire (sections CC1.1 & CC2.2). The focus was on the level of climate expertise amongst board members, the quality of climate-related committees (at both board and executive levels) and the quality of the company's climate-risk management system.
- We developed a scorecard based on the level of climate expertise amongst board members. A 'climate experienced individual' was considered to be someone with direct experience of climate-related issues within business, policy or academia. We ranked companies on the percentage of their board members that were considered to be 'climate experienced individuals'.
- A scorecard was developed to assess the quality of climate-related committees at both board (60% weighting) and executive (40% weighting) levels. Companies that had separate climate-related committees at both board and executive levels received scores for both levels, as it demonstrates a stronger governance commitment to climate related risks and opportunities. Assessment of the quality of committees considered disclosure quality (of members, responsibilities and depth of climate-risk focus) as well as proportion of independent members (for board level committees).
- A scorecard was also developed to assess the quality of companies' climate-risk management systems. Assessment considered frequency of reporting to board, extent of geographical areas considered, extent of climate-risk time horizon considered, quality of disclosure and degree of integration of the system throughout the company.
- The weighted rank for this metric is calculated by applying a 20% rank to the number of climate-experienced directors on the board, a 40% rank to the quality of climate-related committees and a 40% rank to the quality of the company's climate-risk management system. This metric is scored out of 100.

**Metric 6) Use of an internal carbon price:**

- We collect data on the use of internal carbon prices from companies' responses to question CC2.2c-d from the 2017 CDP climate change questionnaire.
- We rank companies according to whether they use an internal carbon price, whether they assess multiple scenarios, whether they disclose the price level(s) used and how high it is - with higher prices favored.

**Metric 7) CDP Score:**

- The 2016 CDP Score (previously also known as CDP Performance Band) provides an aggregate measure of quality of climate-related disclosure and management systems addressing climate risks.
- The CDP score is for the 2016 disclosure cycle as the 2017 disclosure cycle has not yet been scored.

## Limitations

- The breakdown of both the short-term and long-term remuneration schemes (at the executive level) was often not disclosed very clearly or in some cases was not disclosed at all. For instance, for many sustainability metrics it remained unclear to what degree climate performance influenced potential payments. For this reason, we considered climate-risk specificity in ranking metrics as well as the quality of disclosure surrounding targets, historical performance and proportion of total variable incentives. A similar approach was taken to assessing company-wide climate related remuneration initiatives (at a monetary level only).
- Judgement of professional climate experience was based on publicly available biographies and board of directors' profiles. These searches could have inadvertently failed to identify some relevant director backgrounds.
- Scope 3 data was modelled and as such there could be large error margins.

**Notes:**

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