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Are global chemical companies innovating for a low-carbon future?

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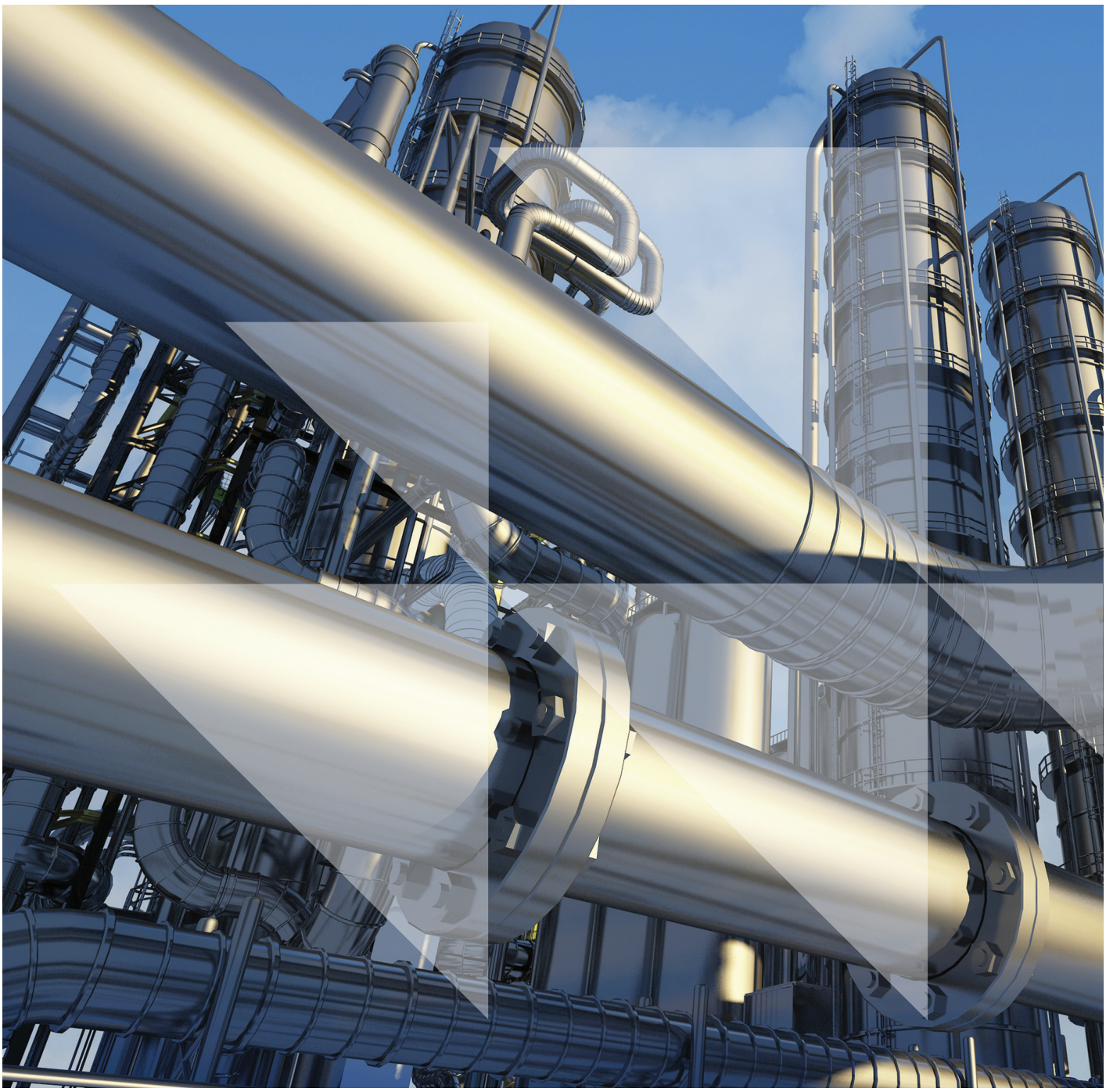

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Contents

Linking emissions-related metrics to earnings for global chemicals	3
Process and energy efficiency	8
Product innovation	22
Supply chain optimization	26
Carbon exposure	30
Carbon regulation readiness	36
Water risk	39
Appendix	45

The CDP Quarterly Sector Research series provides investors with the best and most tailored environmental data in the market. Each quarter CDP's team of analysts takes a detailed look at one high-emitting sector. The first report, No room for passengers: are auto manufacturers reducing emissions quickly enough?, was published in February 2015 and the second, Flicking the switch: Are electric utilities prepared for a low carbon future?, was published in May 2015. Further sectors include: metals and mining, oil and gas and consumer goods.

For more information see

https://www.cdp.net/en-US/Pages/events/2015/sector-research-for-investors.aspx

Linking emissions-related metrics to earnings for global chemical companies

- We launch our Super-League Table for global chemicals, ranking the companies based on a number of emissions-related metrics which in aggregate could have a material impact on company performance.
- Leaders are: DuPont, DSM and AkzoNobel.
- Laggards are: Ashland, Solvay and Eastman.

Overview

This report is the third in a series of quarterly reports covering six high-emitting sectors (transport, electric utilities, materials, metal & mining, oil & gas, and consumer goods). In February, we published our first report in the series, covering the global auto manufacturers and launching our new Super-League Table (SLT) approach. Since then we published a second report, on the European electric utilities, in May. The CDP Super-League Table ranks companies in an industry grouping on a number of environmental metrics relevant to that industry, which in aggregate could have a material impact on company earnings and therefore investment decisions.

In this report, we launch a Super-League Table for global chemical companies. We rank 18 of the largest (by market cap) and highest-emitting chemical companies[1], based on a number of different emissions-related metrics. When taken in aggregate, we believe these metrics could have a material impact on a company's earnings.

Scope of report: key areas

There are six key areas in our SLT:

- **Process and energy efficiency:** against the backdrop of global energy security, rising energy prices and resource scarcity, leaders in process and energy efficiency will gain a competitive advantage and potentially enhance earnings. Using emissions-reduction data as a proxy for process and energy efficiency, we assess both historic trends and future targets for the companies in our study to give investors a sense of the leaders and laggards.
- **Product innovation:** companies provide varying levels of detail on green or eco-products and LCA (Life Cycle Assessment) to CDP and in public information sources; some qualitative, some quantitative and with significant inconsistencies and differing levels of quality. We try to make sense of this information and differentiate between the companies in our study.
- **Supply chain optimization:** we assess companies' supply chain management, analyzing how they engage with their suppliers and customers on environmental topics and how they manage their supply chain emissions.
- **Carbon exposure:** we assess the carbon emissions exposure of the chemical companies in our study and the impact on earnings under different carbon price scenarios.
- **Carbon regulation readiness:** we adopt InfluenceMap's[2] proprietary analysis to assess readiness for a shift towards a low carbon regulatory framework. We believe that truly supportive firms are the most likely to benefit should the regulatory regime change quickly in their favour. InfluenceMap analyses the behavior of the chemical companies regarding the key regulatory items affecting their business.
- **Water risk:** worsening water security may constrain the growth of water-intensive chemical companies both directly and indirectly via the supply chain. We assess the companies' exposure to water risk and how they react to mitigate these risks.

1. Selected from diversified, specialty and commodity chemicals (and not fertilizers or industrial gases).
2. A UK-based not-for-profit whose remit is to map, analyze and score the extent to which corporations are influencing climate policy and legislation. http://www.influencemap.org/

Condensed summary of the Super-League Table (SLT) for chemical companies

SLT rank	Companies	Country	Market cap YTD 2015 (US$m)	Overall SLT Score	Process and energy efficiency grade	Product innovation grade	Supply chain optimization grade	Carbon exposure grade	Carbon regulation readiness grade	Water risk grade	CDP perfomance band (2014)
1	DuPont	USA	65,523	6.12	A	A	D	B	A	B	B
2	DSM	Netherlands	10,223	6.87	A	A	B	D	A	B	C
3	AkzoNobel	Netherlands	18,380	6.88	C	C	A	C	A	A	B
4	Sumitomo Chemical	Japan	8,582	7.40	B	C	B	C	B	E	B
5	BASF	Germany	86,043	7.45	B	A	C	B	E	A	B
6	Bayer	Germany	120,252	7.76	C	C	A	A	E	A	A
7	Mitsubishi Chemical	Japan	8,777	8.32	B	C	D	D	C	B	B
8	Asahi Kasei	Japan	13,149	8.72	C	B	B	B	D	E	B
9	Dow Chemical	USA	56,932	8.89	A	B	D	E	D	C	B
10	PPG	USA	31,206	9.76	C	D	E	A	C	D	D
11	LG Chem	South Korea	14,427	9.84	D	D	C	E	C	B	A
12	Shin-Etsu	Japan	27,799	9.85	E	E	A	C	C	B	B
13	Toray	Japan	13,625	10.05	D	B	A	D	E	E	B
14	Evonik	Germany	16,353	10.52	C	E	C	D	D	N/A	B
15	Nitto Denko	Japan	11,838	10.63	D	E	E	A	C	D	C
16	Eastman	USA	11,132	11.08	E	D	D	C	B	E	E
17	Solvay	Belgium	11,908	11.37	E	C	C	E	D	C	B
18	Ashland	USA	8,599	13.30	E	E	D	B	B	N/A	D
Weighting for each area (i)					**40%**	**15%**	**10%**	**10%**	**10%**	**10%**	**5%**

(i) the weightings are adjusted for Evonik and Ashland, as they were not sent our CDP water questionnaire.

Source: CDP

Non-responders to CDP

Company	Country	Market cap YTD 2015 (US$m)	Business activities
LyondellBasell Industries	Netherlands	41,889	Production of chemicals and plastics: mainly olefins and polyolefins. Also, refinery: production of gasoline and diesel fuel
Nan Ya Plastics	Taiwan	17,239	Production of electronic materials, petrochemicals, plastic products, polyester fiber and utility products
Formosa Plastics	Taiwan	15,382	Production of olefins, polyolefins, vinyl, specialty polyvinyl chloride, chlor-alkali, and oil & gas
Formosa Chemicals & Fibre	Taiwan	13,217	Production of petrochemicals products, plastic products, textile and fibre products
Petronas Chemicals	Malaysia	11,912	Production of olefins, glycols & derivatives, polymers, aromatics and MTBE, methanol, ammonia and fertilizers
Westlake Chemical	USA	8,881	Production of basic chemicals, vinyls, polymers and fabricated building products
Celanese Corporation	USA	8,871	Production of advanced engineered materials, consumer specialties, industrial specialties, acetyl intermediates

Source: CDP, company data

Scope of report: company selection

We selected the group of companies for our study as follows:

- Started with the 80 chemical companies that responded to CDP's 2015 climate change questionnaire;
- Added Bayer (often classified as pharmaceuticals);
- Ranked the companies by market cap and selected the top 30 companies (this equated to companies with a market cap greater than US$8bn);
- Ranked the 30 companies by emissions (scope 1+2)[3] and selected the 20 highest-emitters;
- Removed Ecolab as its activities are much more downstream than the other companies, and we also removed PTT Global Chemicals as approximately half of its revenue is from O&G production.

The remaining 18 companies together represent approximately US$530bn in market cap and account for more than 60% of the combined emissions (scope 1+2[3]) of the 80 companies that responded to CDP. The activities of the 18 companies are fairly diversified: they manufacture both commodity chemicals and high-value chemicals (HVCs), and with varying levels of integration. Their many different products have uses spanning numerous end markets, including electronics, automotive, construction, healthcare and crop-sciences.

Leaders and laggards

The highlights of our analysis are as follows (see condensed SLT on previous page):

- The largest non-responders (by market cap) to CDP's 2015 questionnaire were: LyondellBasell Industries, Nan Ya Plastics, Formosa Plastics, Formosa Chemicals & Fibre, Petronas Chemicals, Westlake Chemical and Celanese Corporation.
- DuPont is ranked first and is a comfortable leader (with an overall SLT score of 6.12). It achieves A and B-grades across all areas except for supply chain optimization where it is awarded a D-grade. We note that DuPont's response to CDP's 2015 questionnaire relates to emissions from 2014 and therefore pre-dates the spin-off of its higher-emitting performance chemicals business in June, which makes its achievement even more impressive.
- Dutch companies DSM and AkzoNobel are ranked second and third. They score three A-grades each. We note that the top three companies are the only three companies that are awarded an A-grade in our new carbon regulation readiness area, emphasizing the point that companies which are truly supportive of low carbon regulation are forward thinkers and positioning themselves as low carbon leaders.
- German companies BASF and Bayer are ranked fifth and sixth. They would have ranked higher but for their poor performance in our carbon regulation readiness area, where they both scored an E. According to InfluenceMap[4], BASF appears to oppose a number of policies relating to climate change in the EU, including the potential reforms to the EU ETS to make it more efficient, and Bayer lacks transparency with its position towards climate change policies. This is surprising given their good performance in the other five key areas.
- There are three Japanese companies in the top half of the table and three in the bottom half. Sumitomo is the leading Japanese company in fourth place and Nitto Denko is the lowest ranking of the Japanese companies, in fifteenth place.
- Nitto Denko ranked in the bottom three on our data transparency metric (in the process and energy efficiency area). It is one of only three companies that do not receive third party verification of their Scope 1 and 2 emissions data. The other two companies are Ashland and PPG. Nitto Denko also ranked bottom three in supply chain optimization. It is one of only three companies that reported to CDP (in 2015) that does not engage with any stakeholders on emissions and strategies The other two companies are Mitsubishi Chemical and PPG.
- The five US companies are spread throughout the table, with DuPont in first place, Dow Chemical mid-table (in ninth place) and Ashland in last place. It is noticeable that all five US companies performed poorly in our supply chain optimization area. They received D and E-grades.
- Eastman and Solvay join Ashland in the bottom three of the table. They all receive at least two E-grades, including in our most important area of process and energy efficiency. Ashland is the worst performer on future emissions reduction targets, which does not bode well for its commitment to future efficiency savings. Solvay is ranked bottom on emissions-reduction performance over the last ten years.

3. Scope 1 emissions are those directly controlled by the company, both process and power-related, and Scope 2 emissions are indirect emissions from purchased power.
4. The results for the carbon regulation readiness area are based on InfluenceMap's proprietary analysis

Impact of carbon exposure on EBIT

- In our carbon exposure chapter, we consider potential future carbon cost exposure based on the companies' total global emissions. We consider three scenarios: (1) YTD weighted average carbon price for existing carbon schemes of US$7.75 per tonne; (2) a carbon price of US$20 per tonne; (3) a carbon price of US$30 per tonne.

- In our scenario (3), Solvay has 34% of EBIT at risk, while Dow Chemical, LG Chem and Mitsubishi Chemical all have more than 20% of EBIT at risk. We note that scenarios (2) and (3) are for illustrative purposes as they assume zero carbon costs are passed on to customers. That said, several companies, including Ashland and Dow Chemical, admit that they are not always able to pass on carbon costs as it is dependent on market conditions.

Linking our findings to investment choices

We recognise that investment decisions are based on a multitude of different factors and that some of these factors can be misaligned with emissions reduction efforts.

Our SLT rankings are not intended as definitive winners and losers for investment purposes, more as a proxy for business-readiness in an industry where a significantly higher carbon price is required to meet stringent long term emissions-reduction targets.

We would flag that companies towards the bottom of our SLT are possibly higher risk investments from a sustainability perspective than those towards the top.

A summary of key areas, associated metrics and relative weighting within the Super-League Table

Key area in SLT	Link to company earnings	Metric	Metric weighting within each key area	Key area weighting for overall SLT score
Process and energy efficiency	Improvement in energy and raw material efficiency can lead to cost savings and thus enhanced earnings.	i) Emissions performance over 2005-2014 ii) Emissions reduction targets iii) Data transparency	30% 50% 20%	40%
Product innovation	Potentially high market growth in areas where carbon emissions reduction regulations are in place; first movers will benefit, laggards may miss out.	i) Green product leadership ii) Life cycle assessment (LCA) leadership iii) R&D intensity	35% 35% 30%	15%
Supply chain optimization	A sustainable supply chain may help companies manage reputational risk, reduce costs, improve quality and ultimately lead to competitive advantage.	i) Supply chain engagement ii) Supply chain strategy iii) Manufacturing emissions intensity	25% 25% 50%	10%
Carbon exposure	Cost exposure to meeting regulatory requirements on carbon emissions.	i) Current exposure to emissions trading systems ii) Total emissions exposure	50% 50%	10%
Carbon regulation readiness	Companies that are truly supportive of low-carbon regulations are more likely to gain a competitive advantage should the regulatory regime change quickly in their favour.	i) Organizational score ii) Relationship score	60% 40%	10%
Water	Potential physical risks may constrain the growth of the chemical business.	i) Water risk and opportunity ii) Supply chain management iii) Policy & regulatory compliance iv) Water withdrawal Intensity	50% 20% 20% 10%	10%
CDP performance band	A good annual CDP score is a proxy for a generally well-run company. Well-run companies are better placed to succeed in a changing marketplace.	i) CDP annual performance band	100%	5%

Source: CDP

Methodology

We score each chemical company based on a number of different metrics which are first ranked and then weighted within each key area (see table on page 6 for metric weightings within each key area) to give a weighted rank for each area. We then grade each area from A to E based on these weighted ranks. We calculate the overall SLT score by weighting the weighted ranks for each key area (see table on page 6 for metric weightings for overall SLT score).

Each of the key areas has a separate chapter within this report and the precise methodology for how we rank and grade each metric is outlined in the relevant chapter.

In addition to the six key areas, we also include CDP's climate performance band for 2014 in the SLT. It scores the 1,749 companies that respond to CDP's investor-backed climate change questionnaire based on their climate change readiness. A high score can imply a well-run business with a forward looking management team, not just focused on the short term.

For further study

Interesting areas for further investigation include:

- Advanced modelling of carbon pricing scenarios, including real options analysis, which would consider companies passing on carbon costs and altering their product mixes as certain products become less economic.
- An assessment of hazardous waste for the companies, although we would require a consistent global data set to enable us to calculate meaningful metrics. During our initial investigations, such a data set does not appear readily available.
- An assessment of the economics of the numerous 'green' products that companies are offering, including analysis of end-market growth under different scenarios (related to product economics, pricing and also tightening regulation).

Process and energy efficiency

- DuPont is a clear leader and Dow Chemical is ranked third. They have strong emissions targets and are performing well against them, boding well for enhanced future efficiency savings.
- The smaller US manufacturers Eastman and Ashland are ranked in the bottom three. They both perform poorly across all areas.
- Despite being the most transparent company, Shin-Etsu is ranked second from bottom due to poor performance on both emissions reduction and targets.

Overview

The industrial segment is the largest contributor of anthropogenic greenhouse gas (GHG) emissions, accounting for more than 32% of global GHGs[5]. The chemical industry contributes about 15% of global industrial GHG emissions. Carbon dioxide (CO_2) accounts for 76% of GHGs emitted by the chemical industry, and HFC (hydroflurocarbon) and N_2O (nitrous oxide) contribute 14% and 9% respectively. Most of these emissions are caused by the production of a small number of chemicals. The production of just five chemicals accounts for 75% of CO_2 emissions (18 account for 95%), and just four chemicals account for almost all of the HFC and N_2O. A significant number of the companies in our study have exposure to a large number of these processes. They are all investing in R&D to reduce process emissions, energy consumption and/or find eco-friendly alternatives.

In this chapter, we assess process and energy efficiency trends of the chemicals companies as measured by emissions intensity. More efficient or less emission-intensive alternatives are available for many processes required to make products in the chemical and petrochemical sector. Improvements in efficiency can be achieved by increased process integration, waste heat recovery and utilization, the use of efficient electrical equipment, and the implementation of captive cogeneration units. Also, substantial opportunities exist (up to 50 percent emissions reduction) in using less material. Leaders in efficiency will enjoy a reduced cost base and thus enhanced earnings. We identify five metrics across three different areas:

Emissions performance

We analyze historic trends in the companies' own manufacturing (Scope 1+2) emissions intensity over the last ten years. We believe this can be considered as a proxy for process and energy efficiency performance. Scope 1+2 emissions are those emissions directly controlled by the company, both process and power-related (Scope 1) combined with emissions from purchased power (Scope 2).

We use emissions intensity-related metrics rather than absolute emissions, as we do not want to penalise companies that grow faster than others. We use both value-added (gross profit) and revenue as normalization factors.

Metric 1) Reduction in Scope 1+2 emissions intensity

This metric identifies the companies that have reduced their emissions intensity by the most over the last ten years. Since cumulative carbon emissions matter from a global warming perspective (and increasingly so from a cost perspective), instead of using a compound annual growth rate (CAGR) calculation, which only looks at the first and last year's data, we apply a proprietary function that takes account of the emissions intensity profile over each of the years 2005-14. In addition, our function adjusts for anomalies and doesn't penalise companies with unrepresentative emissions data at the start and end of the period. It should identify the true leaders and true laggards (subject to the limitations set out in the methodology section).

Metric 2) Scope 1+2 emissions intensity

This metric identifies those companies with the lowest emissions intensity, and therefore lower carbon risk exposure. We appreciate that it is difficult to compare a diverse set of chemical companies with varying degrees of integrated manufacturing and differing product mixes; however, we include this metric in acknowledgement of the fact that companies with a lower emission intensity may find it more difficult to reduce emissions than those companies which are reducing their emissions from a higher base. We assign a 20% weighting to this metric, versus an 80% weighting to metric 1) above.

5. Based on IPCC data for 2010. We have apportioned emissions due to power generation, i.e. 43% of emissions from power generated in 2010 was due to industry. We have excluded GHG emission sinks.

Summary of the highest emitting chemical processes

Chemical	GHG Type	Share of chemical GHG emissions	Number of major production processes	Number of SLT companies exposed (i)	Production processes	Key end uses
Ammonia	CO_2	27%	1	8	Synthesis (Haber-Bosch process).	Fertiliser production.
Ethylene	CO_2	11%	1	11	Steam cracking (can use various fuel feedstocks).	Polyethylene production.
Methanol	CO_2	7%	1	9	Catalytic synthesis process (feedstock natural gas into a synthesis gas stream).	Pharma, fuel blending, plastics, paint, olefins, DME (viii).
Propylene	CO_2	6%	3	10	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	4	Direct oxidation (from ethylene).	Detergents, thickeners, solvents, plastics, and various organic chemicals such as ethylene glycol.
BTX (ii)	CO_2	2%	2	8	Produced from two main feedstocks: (i) Reformates from catalytic reforming in refineries; (ii) steam cracker pyrolysis gasoline.	Chemical feedstock.
Polyethylene	CO_2	2%	1	6	Polymerization of ethylene.	Primary use in packaging.
Propylene oxide	CO_2	1%	2	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	2	Propylene ammoxidation: Feedstocks and air are reacted in a fluidized bed in the presence of a catalyst.	Textiles.
Nitric acid (iii)	N_2O (v)	7%	1	10	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 (iii)	N_2O		1	4	Manufactured from a cyclohexanone/ cyclohexanol (vii) 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	5	Beckmann rearrangement: Oxidation of cyclohexane (C6H12) followed by a catalytic rearrangement.	Nylon-6 (used to produce, for example, textiles).
HCFC-22 (iv)	HFC-23 (vi)	14%	1	1	Reaction of chloroform (CHCl3) and hydrogen fluoride (HF) in the presence of antimony pentachloride (SbCl5) catalyst.	As a refrigerant in air-conditioning systems, a blend component in foam blowing feedstock for the manufacturing of synthetic polymers (e.g. Teflon).
	Total	**83%**				

(i) At least this number of companies in our study have exposure to these processes
(ii) Benzene, toluene and xylene
(iii) 7% is for nitric acid and adipic acid combined
(iv) Chlorodifluoromethane
(v) Nitrous oxide
(vi) Fluoroform
(vii) Cyclohexanone, (CH2)5CO, and Cyclohexanol, (CH2)5CHOH
(viii) Dimethoxyethane

Source: CDP, IPCC

Future targets

We assess companies' emissions-reduction targets using two forward-looking metrics. We believe they can be used as a proxy for a company's intentions towards future process and energy efficiency measures. Significant proprietary analysis has gone into assessing the quality of each company's target and the performance of each company versus its target. All 18 companies, except Ashland, sets some kind of target: 10 companies set an absolute emissions (Scope 1+2) target; 12 companies set an intensity target (Scope 1+2); and, AkzoNobel sets a Scope 1+2+3 intensity targets. This includes seven companies that set both an absolute and an intensity target.

Metric 3) Quality of target

We assess whether the companies' targets are better or worse than science-based targets. We adopt a similar approach to that established by the Science Based Targets collaboration in which CDP is a partner[6]. For companies with more than one target, we assess both and adopt the stronger of the two targets for our rankings on this metric.

Metric 4) Performance against target

We assess the companies' performance against their targets. Our proprietary modelling enables us to assess the profile of the companies' historic emissions annually versus their respective targets. This method highlights those companies whose emissions profile consistently outperforms what is required to meet their target. The benefits of this are two-fold: first, from a global warming perspective keeping emissions low on an annual basis is crucial, rather than, for instance, a company simply having low emissions in the final year of its target (but much higher over the remaining years of its, say, 10 year target); second, companies which consistently outperform on emissions reductions are those that consistently benefit from a process and energy perspective, hence cost savings and enhanced earnings. For our rankings on this metrics, we adopt the results of the stronger metric selected by metric 3).

Data transparency

We undertake a qualitative review of the quality, transparency and level of sophistication of the companies' responses to CDP on Scope 1+2 emissions. Investors require transparency as it reduces uncertainty.

Metric 5) Transparency on emissions

We form a scorecard that assesses the companies' emissions accounting procedures. The scorecard includes: method of consolidation for emissions (the reporting boundary), level of third party verification and assurance, scope of verification and any exclusions relative to the reporting boundary.

6. Science Based Targets is a joint collaboration between CDP, the United Nations Global Compact, World Resources Institute and WWF. This initiative adopts a scientific approach to help companies establish meaningful and ambitious carbon emissions reduction targets that are in line with the emissions scenarios suggested by the Intergovernmental Panel on Climate Change (IPCC)'s latest report in order to decarbonize the economy. The methodology was published in May 2015 in the report: "Sectoral Decarbonization Approach".

Process and efficiency saving for high-emitting chemicals

Chemical (i)	Examples of existing and future major alternative eco-friendly processes (ii)	Measures reported by companies
Ammonia	◥ Fuel switching: natural gas based ammonia production results in 36% emissions reduction compared to naphtha, 47% compared to fuel oil and 58% compared to coal. ◥ Deployment of CCS on emissions from steam natural gas reforming process currently used to make ammonia. ◥ Nuclear high-temperature steam electrolysis. ◥ Solid state ammonia synthesis using electricity.	◥ AkzoNobel reported the installation of an ammonia recovery unit at one of their production sites, reducing their carbon footprint by 37%.
Ethylene	◥ Methanol-to-Olefins (iii) route, a process that yields ethylene and propylene, allows for using biomass instead of fossil resources as feedstock. ◥ The following measures reduce CO_2 emitted during the manufacturing process: cogeneration using furnace exhaust; improved furnace and cracking tube materials; state-of-the-art steam cracking of naphtha; integrated gas turbines with cracking furnace to generate additional electricity or drive compressors; catalytic cracking to replace the current steam cracking process.	◥ Dow Chemical reports to CDP the implementation of energy efficiency improvements of US olefins crackers. ◥ DuPont reports the installation of more efficient natural gas burners in the ethylene furnaces at its Sabine facility.
Methanol	◥ Methanol derived from biomass is a greener option but has not commercially taken off yet.	-
Propylene	◥ Propylene is produced in its majority as a by-product of ethylene steam cracking production. Some of the emission reduction measures mentioned above, would also have positive emission reduction benefits in propylene production.	◥ Mitsubishi Chemical, together with JGC Corporation, developed a catalyst to produce propylene with high yield and low energy consumption.
Propylene oxide	◥ Hydrogen peroxide-based propylene oxide (HPPO) is a GHG reducing technology.	◥ HPPO was first made commerically viable in 2009 and pioneered by BASF and Dow Chemical. ◥ Sumitomo Chemical has also pioneered a cumene PO-only process which reduces water waste and unneeded by-products.
Ethylene oxide	◥ No major emission reduction technologies identified, besides the measure reported by BASF.	◥ BASF increased the energy efficiency of their ethylene oxide facility in Ludwigshafen (Germany) by optimizing the plant control systems.
Nitric acid	◥ Catalytic reduction of N_2O inside the ammonia burner of nitric acid plants. ◥ Catalytic destruction of N_2O in the tail gas of nitric acid Plants.	◥ BASF reports catalytic reduction of N_2O at its nitric acid plants in Ludwigshafen (Germany) and Puławy (Poland). It also reports using catalysts to break down N_2O at its nitric acid plants in Shanghai (China). ◥ Bayer reported the catalytic reduction of N_2O inside the ammonia burner and catalytic N_2O destruction in the tail gas of the Bayer Nitric Acid Plant in Cologne (Germany). ◥ Solvay reports an N_2O emission reduction project in their nitric acid plant Paulinia (Brazil).
Adipic acid	◥ Thermal decomposition of N_2O. ◥ Catalytic decomposition of N_2O.	◥ BASF reports the catalytic decomposition of residual N_2O from the adipic acid plant in Ludwigshafen (Germany). ◥ Solvay reports the reduction of N_2O emissions from exhaust gases in their adipic acid plant in Chalampe (Germany), and the thermal destruction of N_2O in its adipic acid plant in Paulinia (Brazil). ◥ Asahi Kasei reports the improved operation of equipment for the thermal decomposition of N_2O.
Caprolactam	◥ N_2O destruction in the tail gas of caprolactam production plants.	◥ DSM reports tertiary N_2O abatement measures in their caprolactam plant in Nanjing (China), with expected annual N_2O reduction of 169 $ktCO_2e$ up to 2021. This is about 9% of their current N_2O emissions. ◥ Sumitomo Chemical reports that it was able to reduce its CO_2e emissions by 16,000 tonnes annually through equipment modifications to maximize thermal recovery efficiency at their caprolactam production plant at the Ehime Works (Japan).
HCFC-22	◥ Incineration of HFC-23 has been one of the measures adopted by the industry.	◥ DuPont reports that measures have been taken to: (1) improve the HFC-23 emissions intensity in the production of HCFC-22; (2) increase HFC-23 capture efficiency; and (3) implement manufacturing equipment reliability controls. Annual savings from these measures are estimated at 500,000 tCO_2e per year – about 9% of current HFC emissions.

(i) as far as we are aware the companies in our study are not currently undertaking emissions reduction activities for the following chemicals: BTX, Polyethylene and Acrylonitrile.
(ii) some of these technology options are still at an early stage of development.
(iii) Olefins are a class of chemicals that includes ethylene, propylene and 1,3-butadiene.

Source: CDP, company data, IEA, UK Government

Process and efficiency grade summary

Company	Emissions performance	Furture targets	Data transparency	Overall weighted rank	Process and efficiency rank	Process and efficiency grade
DuPont	6	1	6	5.1	1	A
DSM	2	6	7	6.6	2	A
Dow Chemical	8	2	9	6.6	3	A
Sumitomo Chemical	5	4	8	6.8	4	B
BASF	3	11	3	7.0	5	B
Mitsubishi Chemical	7	2	12	7.1	6	B
Bayer	4	16	4	8.7	7	C
AkzoNobel	12	9	4	8.8	8	C
PPG	1	11	16	9.2	9	C
Evonik	14	11	2	9.3	10	C
Asahi Kasei	9	5	15	9.7	11	C
LG Chem	11	10	10	10.2	12	D
Toray	10	11	14	10.8	13	D
Nitto Denko	13	6	16	10.9	14	D
Solvay	17	6	13	11.7	15	E
Eastman	17	11	11	12.3	16	E
Shin-Etsu	16	17	1	12.4	17	E
Ashland	15	18	16	15.8	18	E
Weighting	**30%**	**50%**	**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

- The US giants perform very well. DuPont is a clear leader and Dow Chemical is ranked third. They both have strong emissions targets and are performing well against them, boding well for enhanced efficiency savings over the coming years.
- DSM is ranked second. It is a top two performer on historic emissions reduction and also on quality of its target. This strong performance could be related to its management board having bonuses linked to emissions reduction and energy efficiency.
- German manufacturers BASF and Bayer rank in the top half (fifth and seventh respectively). They are top four performers on emissions reduction and also on data transparency, but are both let down by weaker than average targets. In particular, Bayer is marked down for quality of target, as the scope of its 'strongest' target is just 18% of Scope 1+2 emissions.
- AkzoNobel ranks mid-table. It is one of the most transparent companies, however its emissions reduction over the last ten years is below average, although overall AkzoNobel has one of the lowest emissions intensities, ranking fifth on metric 2) behind Bayer, Ashland and Nitto Denko. In addition, we acknowledge that AkzoNobel is the only company that sets a target that includes the emissions of its supply chain and products' emission footprints (Scope 3 emissions). We commend AkzoNobel for this, however, are unable to assess this target against science-based targets as it is outside the scope of our methodology[7].
- Despite being the most transparent company, Shin-Etsu's poor performance on both emissions reduction and targets dragged its overall position down. It is ranked second from bottom.
- The US manufacturers Ashland and Eastman are ranked bottom and third from bottom. They both perform poorly across all three areas, despite Ashland being ranked fourth on metric 2.

7. The only Scope 3 emissions currently addressed by the SDA are fleet emissions for the auto manufacturers.

Emissions performance

- Dutch companies PPG and DSM are ranked in the top two places. They are clear leaders on metric 1), occupying the top two positions using both normalization factors. It is particularly impressive that PPG also ranks joint first for metric 2), as it implies it is reducing emissions by the most, despite already being the joint lowest emitter.

- German companies BASF and Bayer are ranked third and fourth. Bayer is ranked third for metric 2), assisted by 50% of revenue coming from pharmaceutics and consumer health. BASF was an early-mover in emission reductions, dating back to the mid-1990s when it started using eco-efficiency analysis to help identify areas of potential economic and environmental improvements for products and processes.

- Dow has one of the highest emissions intensities (metric 2), however it ranked top half overall due to a good performance on metric 1): it reduced its normalized emissions by 5% pa (on average) over the last ten years.

- Solvay is rock bottom. It has by far the highest emissions intensity, and unfortunately its normalized emissions have increased over the last ten years (on a per annum basis).

- Shin-Etsu and Ashland are poor performers; they are the only two companies, other than Solvay, which have increased normalized emissions (on a per annum basis) over recent years.

- Eastman is ranked second from bottom overall. It was the only company that has insufficient historic emissions data for us to calculate its emissions reduction since 2005. We rank it purely based on its performance in metric 2.

Emissions performance summary

Company	Reduction in emissions intensity 2005-2014	Emissions intensity 2012-14	Weighted rank	Overall rank
PPG	1.5	2.0	1.6	1
DSM	1.5	10.0	3.2	2
BASF	3.0	7.0	3.8	3
Bayer	5.5	2.5	4.9	4
Sumitomo Chemical	6.0	5.5	5.9	5
DuPont	7.0	12.5	8.1	6
Mitsubishi Chemical	8.0	10.0	8.4	7
Dow Chemical	6.5	16.5	8.5	8
Asahi Kasei	9.0	8.0	8.8	9
Toray	9.0	10.5	9.3	10
LG Chem	10.0	14.5	10.9	11
AkzoNobel	12.5	5.0	11.0	12
Nitto Denko	14.0	2.0	11.6	13
Evonik	11.5	14.5	12.1	14
Ashland	16.0	4.0	13.6	15
Shin-Etsu	16.5	12.5	15.7	16
Eastman (i)		16.0	16.0	17
Solvay	15.5	18.0	16.0	17
Weighting	**80%**	**20%**		

(i) Eastman is the only company not to have emissions data prior to 2010.

Source: CDP data

Metric 1) Reduction in emissions intensity over the period 2005-2014 (t CO_2 per normalization factor)

Company	Normalized by value-add (US$m)	Rank	Normalized by revenue (US$m)	Rank	Weighted rank	Overall rank
DSM	-13.1%	2	-14.2%	1	1.5	1
PPG	-13.5%	1	-12.3%	2	1.5	1
BASF	-9.4%	3	-9.2%	3	3.0	3
Bayer	-5.3%	7	-4.4%	4	5.5	4
Sumitomo Chemical	-5.8%	6	-4.2%	6	6.0	5
Dow Chemical	-4.7%	8	-4.4%	5	6.5	6
DuPont	-6.0%	4	-2.1%	10	7.0	7
Mitsubishi Chemical	-5.9%	5	-1.5%	11	8.0	8
Asahi Kasei	-3.7%	9	-3.0%	9	9.0	9
Toray	-3.2%	10	-3.1%	8	9.0	9
LG Chem	-0.8%	13	-3.5%	7	10.0	11
Evonik	-3.1%	11	-1.4%	12	11.5	12
AkzoNobel	-0.9%	12	-1.4%	13	12.5	13
Nitto Denko	0.0%	14	-0.1%	14	14.0	14
Solvay	6.5%	16	0.3%	15	15.5	15
Ashland	2.5%	15	7.5%	17	16.0	16
Shin-Etsu	11.0%	17	6.9%	16	16.5	17
Eastman (i)						
Weighting		**50%**		**50%**		

(i) We do not rank Eastman on this metric.

Source: CDP data, company data

Metric 2) Emissions intensity averaged over 2012-2014 (t CO_2 per normalization factor)

Company	Normalized by value-add (US$m)	Rank	Normalized by revenue (US$m)	Rank	Weighted rank	Overall rank
Nitto Denko	371	3	105	1	2.0	1
PPG	319	2	137	2	2.0	1
Bayer	303	1	157	4	2.5	3
Ashland	541	5	144	3	4.0	4
AkzoNobel	528	4	205	6	5.0	5
Sumitomo Chemical	733	6	200	5	5.5	6
BASF	911	7	232	7	7.0	7
Asahi Kasei	913	8	246	8	8.0	8
DSM	1,341	9	343	11	10.0	9
Mitsubishi Chemical	1,390	10	292	10	10.0	9
Toray	1,411	12	271	9	10.5	11
DuPont	1,403	11	518	14	12.5	12
Shin-Etsu	1,527	13	382	12	12.5	12
Evonik	1,859	14	522	15	14.5	14
LG Chem	2,849	16	407	13	14.5	14
Eastman	2,694	15	743	17	16.0	16
Dow Chemical	3,721	17	618	16	16.5	17
Solvay	4,385	18	1,063	18	18.0	18
Weighting		**50%**		**50%**		

Source: CDP data, company data

Future targets

- Pleasingly, 14 of the 18 companies have a target which is aligned with or better than science-based targets. Ashland is the only company not to set a target at all.

- In metric 3), we penalise companies that have a smaller scope of emissions for their target. This impacted Bayer, which has by far the smallest scope of any of the targets at only 18%.

- We commend DSM for having two strong targets. Its absolute target beats science-based targets by 16% and its intensity target beats by 24% (see methodology section for definition of % beat and % miss). However, we adopted the absolute target in our rankings for metric 3) and metric 4), as we could not assess its intensity target due to insufficient data[8].

- Eastman, Evonik and PPG have the weakest targets. They are the only three targets that are not aligned with or better than science-based targets. It is especially disappointing that PPG has such a weak target, given its top position in emissions performance (metrics 1) and 2)).

Target summary

Companies	Quality of target	Performance against target	Weighted rank	Overall rank
DuPont	4	2	3.0	1
Dow Chemical	8	1	4.5	2
Mitsubishi Chemical	6	3	4.5	2
Sumitomo Chemical	7	7	7.0	4
Asahi Kasei	3	13	8.0	5
DSM	2	15	8.5	6
Nitto Denko	1	16	8.5	6
Solvay	5	12	8.5	6
AkzoNobel	9	10	9.5	9
LG Chem	11	9	10.0	10
BASF	13	8	10.5	11
Eastman	15	6	10.5	11
Evonik	16	5	10.5	11
PPG	17	4	10.5	11
Toray	10	11	10.5	11
Bayer	12	14	13.0	16
Shin-Etsu	14	16	15.0	17
Ashland	18	16	17.0	18
Weighting	**50%**	**50%**		

Source: CDP

8. DSM adopts what it calls 'Volume Related Revenue' as a normalization factor. It defines VRR as 'revenue corrected for the effects of the selling price and exchange rates' but provides no historic data on this quantity.

Metric 3) Quality of target

Company	Absolute target % beat/(miss) science-based target	Intensity target % beat/(miss) science-based target	Select strongest target for each company	Strongest target % beat/(miss) science-based target	Scope of strongest target	Adjusted result	Rank
Nitto Denko		19%	Intensity	19%	100%	19%	1
DSM (i)	16%	24%	Absolute	16%	100%	16%	2
Asahi Kasei	18%		Absolute	18%	70%	13%	3
DuPont	12%		Absolute	12%	98%	12%	4
Solvay	11%		Absolute	11%	100%	11%	5
Mitsubishi Chemical	14%		Absolute	14%	80%	11%	6
Sumitomo Chemical	9%	-9%	Absolute	9%	70%	6%	7
Dow Chemical	5%	-7%	Absolute	5%	100%	5%	8
AkzoNobel	5%		Absolute	5%	100%	5%	9
Toray	7%	-11%	Absolute	7%	67%	5%	10
LG Chem (iii)	6%	-6%	Absolute	6%	77%	5%	11
Bayer	10%	-7%	Absolute	10%	18%	2%	12
BASF		0%	Intensity	0%	93%	0%	13
Shin-Etsu		0%	Intensity	0%	100%	0%	14
Eastman (ii)		-3%	Intensity	-3%	95%	-3%	15
Evonik		-6%	Intensity	-6%	100%	-6%	16
PPG		-6%	Intensity	-6%	100%	-6%	17
Ashland							18

(i) We could not assess DSM's performance against its intensity target due to lack of transparent data therefore selected its absolute target instead.
(ii) Eastman report in its response to CDP's 2015 climate change questionnaire that their target is for 100% of manufacturing sites (and therefore not for the entire business). As such, we adopt Eastman's scope of target reported in their response to CDP's 2014 questionnaire (of 95%).
(iii) LG Chem report that their scope is 100%; however, we have adjusted it to 77% as their target is for the petrochemical business only.

Source: CDP

Metric 4) Performance against target

Company	Absolute target % beat/ (miss) company's target	Intensity target % beat/ (miss) company target	Select strongest target for each company (i)	Strongest target % beat/ (miss) company's target	Rank
Dow Chemical	19.6%	-18.0%	Absolute	19.6%	1
DuPont	9.9%		Absolute	9.9%	2
Mitsubishi Chemical	6.6%		Absolute	6.6%	3
PPG		6.0%	Intensity	6.0%	4
Evonik		3.4%	Intensity	3.4%	5
Eastman		3.3%	Intensity	3.3%	6
Sumitomo Chemical	3.3%	7.3%	Absolute	3.3%	7
BASF		2.7%	Intensity	2.7%	8
LG Chem	2.5%	-15.9%	Absolute	2.5%	9
AkzoNobel	1.4%		Absolute	1.4%	10
Toray	1.1%	33.6%	Absolute	1.1%	11
Solvay	-2.8%		Absolute	-2.8%	12
Asahi Kasei	-3.8%		Absolute	-3.8%	13
Bayer	-7.6%	9.5%	Absolute	-7.6%	14
DSM (ii)	-10.9%		Absolute	-10.9%	15
Ashland					16
Nitto Denko (ii)					16
Shin-Etsu (ii)					16

(i) We adopt the strongest target metric selected in the metric 3) ranking process.
(ii) DSM, Nitto Denko and Shin-Etsu did not provide sufficient information for us to fully assess their intensity targets.

Source: CDP

Transparency on emissions

- Shin-Etsu is a clear leader. It is the only company to receive a high level of assurance from a third party on 100% of its Scope 1 and Scope 2 emissions.
- Evonik and BASF are ranked second and third, clearly ahead of fourth place. They both adopt operational control as their reporting boundary, which is the most comprehensive emissions reporting methodology (see methodology section below), and receive verification for 100% of their Scope 1 and Scope 2 emissions.
- AkzoNobel, Bayer, DuPont and DSM are ranked fourth to seventh on nearly the same points. They all receive verification for 100% of their Scope 1 and Scope 2 emissions.
- Ashland, Nitto Denko and PPG are ranked bottom as they do not receive third party verification on their Scope 1 and Scope 2 emissions data.

Methodology and limitations

GHG emissions analysis for diversified chemicals companies is complex and not without significant pitfalls. These include: data availability, consistency in GHG reporting methodology over time (for a given company), consistency in GHG reporting methodology between different companies, compounded by significant acquisitions and divestments within the peer group over the last decade or so. In addition, differing business models makes comparison between the companies difficult, especially with respect to differences in level of power purchased versus generated internally and also varying degrees of backward integration. This is why we focus mostly on the reduction of emissions intensity within the companies themselves.

The chemical industry experiences high long-term growth rates linked to global GDP but with notable variation between the companies and over time; thus we have opted to consider only intensity-related metrics, as this reflects efficiency improvements (normalized for growth). We use both value-added (revenue less cost of goods sold) and revenue as a normalization factors. Value-added is perhaps a closer representation of production output as it is less sensitive to raw material price movements.

Metric 5) Data transparency summary

Company	Rank	Total score (iii)	Boundaries (i)	Scope 1 verification	Scope 1 assurance type (ii)	Proportion of scope 1 verified (ii)	Uncertainty scope 1 verified	Scope 2 verification	Scope 2 assurance type (ii)	Proportion of scope 2 verified (ii)	Uncertainty Scope 2 verified
Shin-Etsu	1	14.7	ES	Complete	High	100%	2%	Complete	High	100%	2%
Evonik	2	13.7	OC	Complete	Limited	100%	2%	Complete	Limited	100%	2%
BASF	3	13.3	OC	Complete	Limited	100%	5%	Complete	Limited	100%	5%
AkzoNobel	4	10.3	FC	Complete	Limited	100%	2%	Complete	Limited	100%	2%
Bayer	4	10.3	FC	Complete	Limited	100%	2%	Complete	Limited	100%	2%
DuPont	6	10.1	OC	Underway	Limited	100%	2%	Underway	Limited	100%	5%
DSM	7	10.0	FC	Complete	Limited	100%	5%	Complete	Limited	100%	5%
Sumitomo Chemical	8	8.7	OC	Underway	Limited	93%	2%	Underway	Limited	85%	2%
Dow Chemical	9	7.7	OC	Complete	Limited	90%	10%	Complete	Limited	50%	20%
LG Chem	10	7.7	OC	Complete	DNKY	96%	5%	Complete	DNKY	70%	2%
Eastman	11	6.6	FC	Complete	Reasonable	100%	2%	Complete	NR	NR	5%
Mitsubishi Chemical	12	5.3	OC	Underway	Limited	84%	10%	Underway	Limited	46%	10%
Solvay	13	5.1	FC	Complete	Moderate	85%	2%	Complete	Limited	19%	2%
Toray	14	4.6	OC	Complete	Limited	59%	2%	Complete	Limited	27%	2%
Asahi Kasei	15	4.3	FC	Underway	DNKY	97%	5%	Underway	DNKY	75%	2%
Ashland	16	0.0	OC	None	NR	NR	2%	None	NR	NR	2%
Nitto Denko	16	0.0	FC	None	NR	NR	10%	None	NR	NR	10%
PPG	16	0.0	FC	None	NR	NR	5%	None	NR	NR	5%

(i) FC = Financial Control, OC = Operational Control, ES = Equity Share.
(ii) NR = No Response, DNKY = Do Not Know Yet
(iii) Refer to methodology section for steps used to calculate the total score.

Source: CDP

The overall process and energy efficiency rank and grade are determined as follows:

- We combine the weighted-rank of the three areas using the following weightings: (i) Emissions performance 30%; (ii) Future targets 50%; and (iii) Data transparency 20%. This determines the overall weighted rank for process and energy efficiency, from which we award the process and energy efficiency grade.

- The process and energy efficiency grade is awarded according to the each of the three areas rank.

- In determining the separate weighted-ranks for each of the three areas we apply the following weightings and methodologies to each metric within those areas:

Emissions performance

The emissions performance rank is determined by combining the weighted-ranks of metric 1) and metric 2) in a ratio of 80:20.

Data collation:
We apply the following steps to ensure the data is as consistent and credible as possible for our intensity calculations:

- Collate emissions, revenue and value-added data for each year.

- Replace this with restated emissions data, where available (for instance, after an acquisition or divestment), but subject to equivalent restated revenue and value-added data being available.

- In the absence of restated normalization factors (i.e. revenue and value-added) over the entire period of restatement, we are unable to calculate the restated emissions intensity and thus reflect the most accurate position of the companies' emissions reductions (as per by GHG Protocol). That said, as we are calculating emissions intensity (and not absolute emissions), this limitation is mitigated somewhat (so long as any acquisitions or divestments are not significantly different in emissions intensity).

- We urge companies to provide better transparency on emissions data as follows: firstly, make data for any restated emissions publicly available (we require the emissions data to go at least as far back as the base year for the company target); secondly, ensure that relevant normalization factors including (at least) revenue, value-added and production are also available for all the restated years.

Metric 1): Reduction in emission intensity from 2005-14

- We collate emissions and financial data for the ten year period 2005-14 from CDP's database and company sources.

- We calculate the emissions intensity over the period for each company, using two different normalization factors, revenue and value-added.

For each normalization factor we apply the following steps:

- We use our proprietary function to assess the companies' emissions performances for each of the following periods: 2005-14, 2006-14, 2007-14, 2008-14 and 2009-14.

- Our function takes account of the full emissions profile of each of the five periods, i.e. all 10 years' worth of data for 2005-14, all nine years' worth of data for 2006-14, and so on.

- The function effectively measures the total emissions (or intensity) over a period and calculates the implied constant growth rate per annum required to create the same aggregate emissions (over the same period) starting from the base year for the period.

- The function is therefore independent of end date for the period (i.e. 2014) but dependent on start date. This is why we apply the function to five periods with differing start dates.

- We calculate the implied constant growth rate for each of the five periods.

- We take the median of the results in order to exclude any anomalies (i.e. a material acquisition with a significantly different emissions intensity that occurred in say 2007 for which the emissions have not been restated back to 2005.

- We rank the companies based on the median implied growth rate.

- We apply the above methodology for each of the two normalization factors, revenue and value-added, and combine the ranks in a ratio of 50:50. This determines the weighted rank for this metric.

Metric 2): Emissions intensity (2012-14)

- We collate emissions and financial data for the three year period 2012-14 from CDP's database and company sources.
- We calculate the emissions intensity over the period for each company, using two different normalization factors, revenue and value-added.
- We converted revenue in local currency to US$ using the average daily foreign exchange rate during 2013. We peg the US$ exchange rate at this level for all years to avoid distortion in the intensity metric due to foreign exchange movements.
- For each normalization factor, we calculate the median emissions intensity over each of the three years 2012-14; and rank the companies on this basis.
- We combine the ranks for each normalization factor in a ratio of 50:50. This determines the weighted rank for this metric.

Future targets

The future targets rank is determined by combining the weighted-ranks of metric 3) and metric 4) in a ratio of 50:50.

Metric 3): Quality of target assessment

- We assess whether the companies' targets are stronger or weaker than science-based targets.
- We adopt the methodology of the Sectoral Decarbonization Approach (SDA), published by the Science Based Targets collaboration[9].
- We assess these pathways for both absolute and intensity targets belonging to the company out to 2050, with an associated science-based target. The emissions pathways are based on IEA data.
- We start by modelling future emissions from a 2010 base.
- If we prima facie adopt the SDA's emissions pathways for the chemical industry to model Scope 1 emissions and the SDA's emissions pathway for power generators to model Scope 2 emissions, we would be disfavoring companies that produce a lower degree of their power internally, since the emissions pathway for the power generators is significantly more aggressive than for the chemical industry[10].
- In fact, the chemical companies all generate a portion of their power internally (which varies notably depending on company) and data does not exist to enable stripping out of the emissions relating to this internal power generation from Scope 1.
- As such, we estimate the proportion of the chemical companies' emissions that are from power generation (both purchased and consumed in-house). This data is not readily available; however, we have used data from CDP and other sources to estimate that power consumed[11] by chemical companies accounts for approx. 50-70% of total emissions.
- In order to calculate the Scope 1+2 emissions pathway required for science-based targets (Scope 1+2 emission pathway), we apply the following steps:
  - Start with Scope 1+2 emissions.
  - Assume emissions from power generation are 60% of Scope 1+2 emissions.
  - Forecast the emissions pathway for power generation using the intensity pathway for the power generation sector.
  - The remaining 40% of Scope 1+2 emissions relate to process.
  - Forecast the emissions pathway for this portion using the IEA emissions pathway for the chemical industry.
  - Combine the power generation and process related emissions pathways to get Scope 1+2 emissions pathways for the companies.
- A limitation of this approach is that perhaps chemical companies should not be expected to decarbonize their internal power generation portfolio as quickly as utilities; moreover, any decarbonization would be lumpier due to the relatively small number of discrete power plant assets owned by the chemical companies.
- We now apply slightly different approaches for absolute targets versus intensity targets.

For absolute targets:

- We compare the Scope 1+2 emissions pathways, which are from a 2010 base, with the companies' targets[12].
- In order to compare like with like, we rebase the company targets to 2010 and we assume a constant CAGR over the life of the companies' targets.

9. Science Based Targets is a joint collaboration between CDP, the United Nations Global Compact, World Resources Institute and WWF. This initiative adopts a scientific approach to help companies establish meaningful and ambitious carbon emissions reduction targets that are in line with the emissions scenarios suggested by the Intergovernmental Panel on Climate Change (IPCC)'s latest report in order to decarbonise the economy. The methodology was published in May 2015 in the report: "Sectoral Decarbonisation Approach"
10. The SDA's emissions pathway for the power generators is based on 90% reduction in absolute emissions or 95% reduction in intensity by 2050.
11. Power consumed = internally generated power combined with purchased power.
12. A constraint of the IEA's forecasts

- We calculate the percentage by which the company target beats or misses the level of emissions required by the emissions pathway in 2015. We chose 2015 as a number of the companies' targets expire in this year.

For intensity targets:

- We normalise the Scope 1+2 emissions pathway with value-added in order to calculate the Scope 1+2 emission intensity pathway. We forecast value-added from a 2010 base using the IEA's activity forecast for growth in the chemical industry (basically, long-term global GDP).

- We compare the Scope 1+2 emissions intensity pathways, which are from a 2010 base[13], with the companies' intensity targets.

- In order to compare like with like, we rebase the company targets to 2010; and we assume a constant CAGR over the life of the companies' targets.

- We calculate the percentage by which the company target beats or misses the level of emissions required by the emissions pathway in 2015. We chose 2015 as a number of the companies' targets expire in this year.

Selecting the strongest target:

- Where companies have more than one target, we select the strongest target for inclusion in our rankings for metric 3).

- We recognise that a target which covers 100% of Scope 1+2 emissions is better than one that has a reduced scope. As such, we apply the following adjustment:
  - For targets which are stronger than science-based targets: multiply % beat by % scope
  - For targets which are weaker than science-based targets: multiply % miss by (2-% scope)

- These formulae have the effect of reducing a % beat by up to 100%, or increasing a % miss by up to 100%.

- We rank the adjusted % beat or miss as the results for metric 3)

Metric 4): Performance against target

- In assessing companies' targets, we reward those companies who have created a carbon surplus (or credit) relative to their target pathway (over the entire forecast period), and not just superficially compare the latest reported emissions against the target.

- Moreover, if a company is consistently off track to meet its target over the entire target period, its carbon exposure will be higher than a company that consistently outperforming the level required to meet its target.

- We assess all absolute and intensity targets (subject to sufficient data); however, we select only the results corresponding to the strongest targets for each company (see metric 3)) in order to rank the companies for metric 4).

- For both absolute and intensity targets, we apply the following steps:
  - We assume that the level required to meet the target follows a constant annual growth rate (CAGR) from the base year emissions over the period over the target[14].
  - The CAGR is derived from the base year, target year, base year emissions and % reduction targeted by the company.
  - We compare the actual emissions of each company with level required to meet the target for each year of the forecast period (the annual hurdle).
  - We apply the following formula for each year assessed: annual hurdle less actual emissions = beat (positive value) or miss (negative value) annual hurdle (for the year)
  - We sum the annual beats or misses from the base year to 2014
  - We divide this aggregate value by the aggregate value of the annual hurdle over the same period.
  - This gives the % beat or miss used to determine our metric 4) rankings.

- The % beat or miss is essentially a measure of the carbon surplus (credit) or deficit created by the company relative to its target. We believe that analyzing targets in terms of a carbon surplus of deficit is particularly important in relation to science-based targets, which are based on a global 'carbon budget'.

13. A constraint of the IEA's forecasts
14. We acknowledge that there is not always such a CAGR relationship over the life of the target. For example, Asahi Kasei states that although the base year for their target is 2005, the emissions reduction activity will take place from 2011-20; we see this in our results, and encourage this kind of visibility from companies.

Note:

- For absolute emissions targets, we use an adapted data set relative to that used in metrics 1) and 2) (which analyzed intensity). Wherever a company restated its emissions, we used restated numbers as far as we could go back towards the base year for the target.

- Some companies were better than others for providing transparent restated emissions data. DuPont was a leader, restating its emissions all the way back to 2004 after any current corporate action, and also had data going back to 1990. We acknowledge there are significant error bounds in doing so, the further back in time a company goes, but nevertheless appreciate some visibility.

- Other companies that provided restated numbers include: Evonik, Dow Chemical, DSM and Sumitomo.

- For emissions intensity targets, we use the normalization factor chosen by the company. In most cases this was production (in tonnes).

- There were two exceptions: Toray uses revenue and DSM uses volume-relative revenue, which is revenue adjusted for movements in pricing and foreign exchange. We had insufficient data to assess the performance of DSM's target, which is a shame because it was the leading target in metric 3), with a 24% beat versus Science-Based Targets.

Transparency on emissions

This is the first time in our quarterly research series that we have formulated a transparency on emissions metric. We adopt a scorecard approach. The maximum score available is 20 (10 for transparency on Scope 1, and 10 for transparency on Scope 2). We rank the companies according to their score.

Metric 5): Transparency on emissions

- We outline the steps for scoring transparency on Scope 1 on emissions below. The procedure is exactly the same for Scope 2.
  - The start point in the analysis is the proportion of emissions verified by a third party. We score this out of 10. If 100% of scope is verified, this achieves 10 points. Then points are awarded as follows: nine points for % scopes in the 90s, eight points for 80s, seven points for 70s, and so on until one point for 10s, and finally 0 points for anything under 10%.

  - 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 apply the above steps to transparency on both Scope 1 emissions and Scope 2 emissions. We then combine the score (max 10 each).

- Finally, we multiply the combined score (out of 20) according to the boundary of the emissions reported as follows: operational control = 100%; financial control = 75-95%; equity method = 75-95%.

- Operational control is the most comprehensive boundary. It reflects accounting consolidation, i.e. 100% of emissions for all subsidiaries controlled by the group regardless of ownership share and % owned (or controlled) of JVs and associated companies.

- Financial control requires consolidation of 100% of emissions for subsidiaries controlled by the group (regardless of ownership share) BUT does not require emissions from JVs or associated companies to be included. There is a risk that chemical companies with manufacturing JVs or associated companies are not taking account of all of their attributable emissions. For instance, Solvay has noted that its emissions accounted for under the financial control method are 73% of that under the operational control method.

- Equity method requires a group to account for the emissions of all entities it can exert an influence over according to its % shareholding in those entities. The downside risk here comes from where a company has a material number of 51% subsidiaries (to use an extreme example) that would have been consolidated using the financial control or operational control methods according to 100% of their emissions, but under the equity method would be understated at just 51% of emissions.

Product innovation

- DSM, BASF and DuPont are ranked top three. They all disclose their green product sales and have related targets. BASF and DSM are also leaders in LCA analysis.
- Ashland is ranked last place. It was bottom in all three metrics.
- Six companies provide no quantitative data whatsoever on sales or R&D spend on green products.

Overview

Availability of cheaper natural gas has spurred increased production of high-value chemicals (HVCs), particularly in the US. Specialty products are generally more emissions-intensive to make – but can lead to significantly greater reductions through their use and through their lifecycle. Many of these products make dramatic efficiencies possible across almost every industry as well as enabling sustainable energy, including wind, concentrated solar and advanced PV. Furthermore, a number of the end-markets for these products experience high growth rates; early movers are set to benefit from these opportunities and laggards may miss out.

Companies provide varying levels of detail on green or eco-products and LCA (Life Cycle Assessment) to CDP and in public information sources; some qualitative, some quantitative and with significant inconsistencies and differing levels of quality. In this chapter, we try to make sense of this information and differentiate between the companies in our study. We perform a mostly qualitative review on whether companies are integrating sustainability analysis into their decision-making processes, goals setting and resource allocation. We have extracted information from more than six years of CDP responses and publicly available company data. We believe companies that publicly address these issues demonstrate a better awareness of the impact of sustainability on their business and are potentially more advanced in product development. We identify leaders and laggards through four key metrics:

- **Metric 1) Green product leadership:** we assess the companies based on information provided on "green" or "eco" products, including targets for sales and R&D spend.
- **Metric 2) Life Cycle Assessment (LCA) leadership:** LCA is a technique to assess all environmental impacts occurring at any stage of the lifecycle of a product, i.e. from raw material extraction through manufacturing to use and disposal. This metric assesses the extent to which companies incorporates LCA into their product development or other decision-making processes. We look at the level of details provided, application methodology, relevant targets and data on avoided emissions.
- **Metric 3) R&D as a percentage of sales:** this is the only truly quantitative metric in this area. We believe it is a good measure of not only product innovation but also optimization of processes relating to the cradle-to-grave emissions of products and therefore links directly with LCA leadership. We rank companies on their median R&D as a percentage of sales over the period 2012-14.

Highlights

- Over 40% of companies in our study do not provide any data on earnings from green products and related targets.
- Disclosure on green R&D is worse: close to 60% of companies in our study do not provide any data on R&D spending allocated for green products or related targets.
- DSM, BASF and DuPont are ranked top three overall. They all disclose data on green product sales and R&D, and all have related targets for green sales. DSM and DuPont also have green R&D-related targets.
- DSM is the only company to have a target for green sales, green R&D and life cycle emissions.
- Ashland is ranked last place. It was bottom in all three metrics.

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Metric 1) Green product leadership

- We acknowledge that companies have differing definitions for what constitutes green or eco products and flag this as a limitation of our results.
- Asahi Kasei, Ashland, Evonik, Mitsubishi Chemical, Nitto Denko and Sumitomo Chemical did not provide any quantitative data whatsoever on green sales or R&D or related targets. We flag this as an engagement point for investors. These six companies rank bottom for this metric.
- Only Toray, DSM and DuPont provided quantitative information on both green sales and R&D and provided related targets.

Green sales and related targets:

- Eight companies provided data on green product sales, ranging from 7% to 49% of sales. DSM is the highest.
- Five of these companies have green product sales targets for 2015 and five companies have targets for 2020. Toray and AkzoNobel are the only two companies that have a target for both 2015 and 2020.

Green R&D and related targets:

- BASF has the highest (recently disclosed) R&D spend on green products with US$660m (EUR600m) in 2013, equating to more than 30% of its R&D spend in that year. DuPont is targeting a similar amount in 2015 (US$600m on green products), which equates to more than 30% of its 2014 R&D.
- Toray has the highest green R&D target at 50% of total R&D spend over the period 2014-16

Metric 2) LCA leadership

- Sixteen companies provided varying levels of detail on LCA and related methodologies. Ashland and PPG were the only two companies which did not provide any information on LCA. Shin-Etsu didn't provide explicit details on its use of LCA, but did provide LCA emissions data to CDP.

Product innovation summary

Company	Green product leadership	LCA leadership	R&D as % sales	Overall weighted rank	Product innovation rank	Product innovation grade
DSM	2	6	4	4.0	1	A
BASF	3	1	13	5.3	2	A
DuPont	4	11	2	5.9	3	A
Dow Chemical	8	2	12	7.1	4	B
Asahi Kasei	13	3	6	7.4	5	B
Toray	1	11	11	7.5	6	B
AkzoNobel	6	4	15	8.0	7	C
Mitsubishi Chemical	13	8	5	8.9	8	C
Bayer	10	13	3	9.0	9	C
Solvay	5	8	17	9.7	10	C
Sumitomo Chemical	13	14	1	9.8	11	C
Eastman	11	7	14	10.5	12	D
LG Chem	12	5	16	10.8	13	D
PPG	6	17	9	10.8	13	D
Evonik	13	10	10	11.1	15	E
Shin-Etsu	9	16	8	11.2	16	E
Nitto Denko	13	15	7	11.9	17	E
Ashland	13	17	18	15.9	18	E
Weighting	**35%**	**35%**	**30%**			

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

LCA early leaders:

- BASF and LG Chem were the only two companies that (disclosed they) were using LCA analysis pre-2000, so could potentially be early movers in this area.

- Nine of the companies that provided details on their use of LCA have been doing so since 2010; four since 2000, and two pre-2000.

LCA emissions targets:

- Five companies provided clear LCA emissions targets. A further four companies provided less-well defined goals or intentions.

Avoided emissions/total emissions:

- Nine companies provided quantitative data to CDP on avoided emissions for their products. We combined this with data on total emissions (Scope 1+2+3) where available to calculate an avoided emissions/total emissions ratio for the companies. We were able to calculate this ratio for five companies.

- Leaders for avoided emissions/total emissions are Dow Chemical with 2.7 and BASF with 1.9. Asahi Kasei has the third highest ratio with 0.7. The ratio was under 0.1 for Mitsubishi Chemical and AkzoNobel. All these ratios are based on data provided in response to CDP's 2014 questionnaire.

- We acknowledge that companies provide avoided emissions data on varying numbers of products, which is a limitation in a like-for-like comparison. Our metric implicitly rewards those companies that provide data on a larger proportion of their products.

- We encourage companies that believe their avoided emissions/total emissions is higher to provide increased visibility on this data in future CDP responses. We believe investors require comprehensive LCA emissions data on as many products as possible.

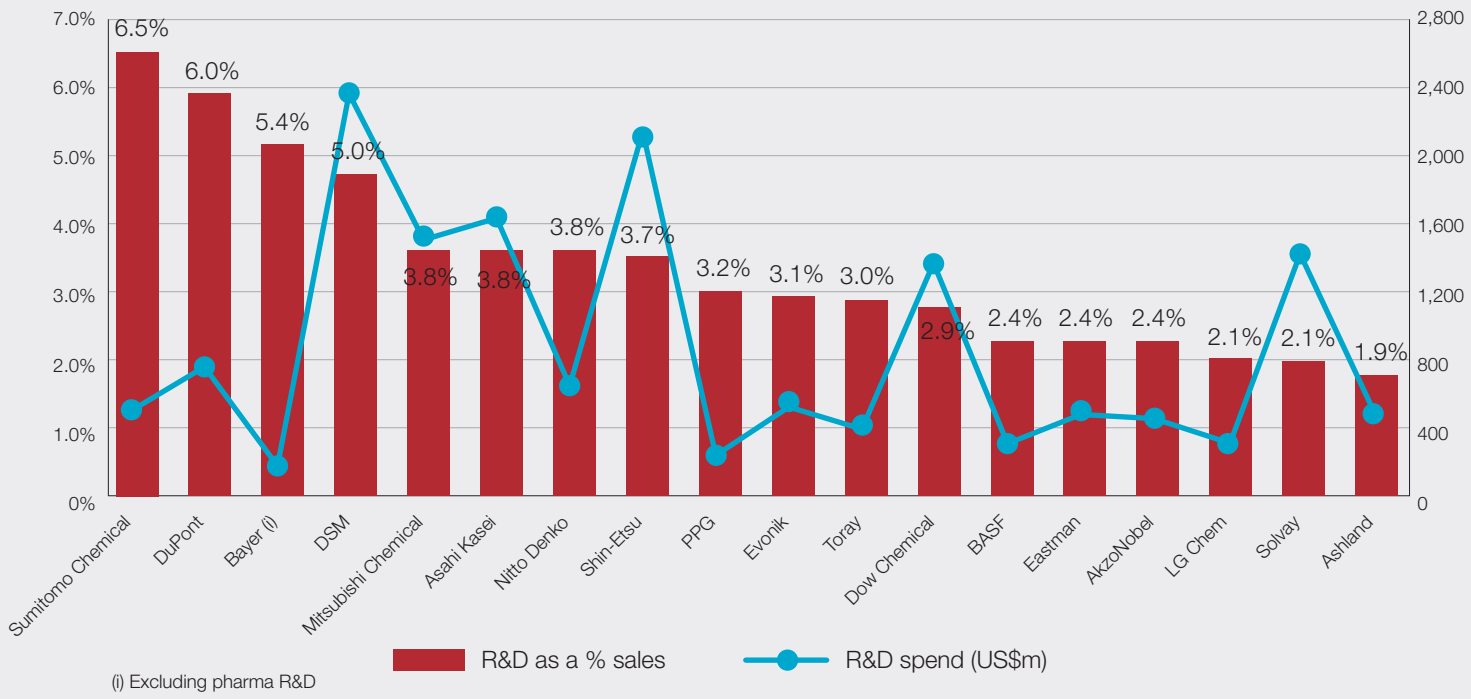
Metric 3) R&D as a percentage of sales

- Sumitomo and DuPont have the highest R&D as a % sales at 6.5% and 6.0%; notably above the average of 3.5%.

- DSM and Shin-Etsu spend the most in absolute terms (US$2.4bn and US$2.1bn).

- Although Bayer is third highest for R&D as a % of sales, it has the lowest spend in absolute terms.

Metric 3): R&D as a % sales



(i) Excluding pharma R&D

Methodology

The production innovation rank and grade is determined as follows:

- We combine the weighted ranks of the three metrics in this key area using the following weightings: metric 1) 35%; metric 2) 35%; and metric 3) 30%. This determines the overall weighted rank for product innovation, from which we award the product innovation grade.

We apply the following methodologies to determine the weighted ranks for each metric:

Metric 1) Green product leadership

- We collect data related to companies' revenue from "green" products as well as R&D spending on "green" products from companies' responses to CDP and their publicly available sources including annual reports, CSR reports and company websites.

- We rank companies based on the "green" revenue as a percentage of total revenue. For companies that do not provide such data but relevant information, e.g. "green" revenue as X % of new product revenue, we acknowledge their disclosure, so we award them the second lowest rank instead of bottom for companies have no disclosure or no such accounting at all. We assign a 30% weighting to this metric.

- Secondly, we identify whether companies set any "green" revenue target. We rank companies based on the targeted percentage of total sales. Similar to the previous metric, for companies that do not provide concrete figures of targets, e.g. "green" revenue to be X % of new product revenue, we award them the second lowest rank instead of bottom for companies have no disclosure or no targets at all. We assign a 30% weighting to this metric.

- Thirdly, we assess companies' "green" R&D. Since these data are very patchy, we consider both historic and targeted "green" R&D as a percentage of total R&D. We rank companies in the descending order of setting targets, providing historic data, mentioning past expenses but not providing data, and no mentioning at all. We assign a 40% weighting to this metric.

Metric 2) Life Cycle Assessment (LCA) leadership

- We collect qualitative and quantitative information related to the application of LCA from companies' responses to CDP and their publicly available sources including company websites, annual reports and CSR reports (both from 2009 onwards).

- We assess whether companies publicly address the use of LCA in their product development or other decision-making processes. If yes, we assess the level of details disclosed (20%), when did the companies first mention it (20%), and whether companies set any target in relation to the use of LCA (30%). Additionally, we assess whether companies provide any data on avoided emissions due to the use of their products (30%). For the last area, we rank companies based on the ratio of avoided emissions to total emissions occurred in their entire value chain.

Metric 3) R&D intensity

- We adjust companies' R&D expenses by including relevant amortisation and capital expenditure; we then calculate the R&D expenses as a percentage of sales over the period of 2012-2014.

- We take the median of the results in order to exclude any anomalies, based on which we rank the companies.

Limitations

- If no relevant information could be found from companies' publicly available sources, we assume that they do not have relevant applications and targets in relation to LCA, earnings from and R&D spending on "green" products. However, it is possible that companies have this information but it is not disclosed publicly, or cannot be found with reasonable effort.

- We acknowledge that there is no clear and agreed definition of "green" products, and in this study we solely rely on companies' own definitions of such products. We understand that such data on revenue and R&D may not be comparable between companies; moreover, we are not able to analyze how profitable and in which development stage the "green" products are, by simply looking at the revenue and R&D data respectively.

- Notwithstanding the limitations mentioned above, we believe companies that publicly address these issues demonstrate a better awareness of the impact of sustainability on their business and are potentially more advanced in product development. We believe these companies are better placed to benefit from the many high growth opportunities relating to green and eco products. Better disclosure of data on these areas for investors to assess companies would be a main engagement area.

Supply chain optimization

- AkzoNobel is the clear leader in both supply chain engagement and supply chain strategy as it has a holistic approach.
- It is of concern that Mitsubishi Chemical, Nitto Denko and PPG reported to CDP in 2015 that they do not engage with suppliers or customers.
- The five US companies all ranked in the bottom six places.

Overview

It is becoming essential for companies to engage with practices beyond their own business operations and pay attention to supply chains to fully manage their environmental risks. The adaptability of supply chains to climate change risks will determine how effectively the operations run and how well they can perform compared to competitors. According to research published in 2014 by PwC and APIC[15], prioritizing sustainability strategies will unlock value in the supply chain by helping to manage reputational risk, reduce costs, improve quality and continuity of supply chain, increase revenue and innovate.

As a consequence, audits of the sustainability of the supply chain are increasingly becoming expected by investors in the chemical sector, as they facilitate the ability to set up systems to help lower long-term environmental risks. For example, TfS (Together for Sustainability) is a supply chain management system and is used by many of world's leading chemical companies such as BASF, DuPont and Bayer. The most severe disruption to supply chains is expected to arise from weather extremes, which in turn could delay production lines, risking brand reputation. If investors do not see companies making a significant effort to manage their supply chain risks, it may increase uncertainty and could deter future investment. To ensure companies remain competitive and are able to sustain production capacities in the future, it makes business sense to manage supply chains to help prepare them for environmental impacts.

In this chapter we assess companies' supply chain management, analyzing how they engage with their suppliers and customers on environmental topics and how they manage their supply chain emissions:

- **Metric 1) Supply chain engagement:** this metric identifies the companies that are the most active in engaging with their suppliers and customers. We look at the proportion of suppliers by total spend that are included in the supply chain engagement process.
- **Metric 2) Supply chain strategy:** this metric assesses how companies are using environmental data provided by the suppliers. It also assesses the strategy set up by companies to reduce their supply chain risks, focusing mainly on their efforts to decrease their scope 3 emissions.
- **Metric 3) Manufacturing emissions intensity:** this is the most important metric in this chapter. We assess companies' total manufacturing emissions (including supplier emissions) intensity normalized by revenue and by value-added, over the period of 2011-2014. We define total manufacturing emissions as the sum of direct emissions from facilities owned or controlled by companies (scope 1), indirect emissions from energy consumption by companies (scope 2), as well as indirect emissions from the upstream part of their value chain (part of scope 3)[16].

15. Sustainable Supply Chains: Making value the priority
16. Based on the two most relevant upstream indirect emissions categories, i.e. emissions from purchased goods and services, and emissions from capital goods.

Supply chain optimization summary

Companies	Supply chain engagement	Supply chain strategy	Manufacturing emissions intensity	Overall weighted rank	Supply chain optimization rank	Supply chain optimization grade
Bayer	5	6	2	3.8	1	A
AkzoNobel	3	2	7	4.8	2	A
Shin-Etsu	2	6	4	5.0	3	A
Toray	6	3	4	5.3	4	A
Sumitomo Chemical	11	11	1	6.3	5	B
DSM	1	6	10	6.5	6	B
Asahi Kasei	11	11	3	6.8	7	B
BASF	8	3	9	7.3	8	C
Solvay	3	1	12	7.3	8	C
Evonik	8	3	10	7.5	10	C
LG Chem	11	9	7	8.5	11	C
Mitsubishi Chemical	16	11	4	9.8	12	D
DuPont	7	10	13	11.0	13	D
Dow Chemical	11	11	14	12.5	14	D
Eastman	11	11	14	12.5	14	D
Ashland	8	11	16	12.8	16	D
Nitto Denko	16	11	16	14.8	17	E
PPG	16	11	16	14.8	17	E
Weighting	**25%**	**25%**	**50%**			

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

- AkzoNobel is the clear leader in both supply chain engagement and supply chain strategy. It has a holistic supply chain strategy: not only do they have scope 3 targets but they also work to help their suppliers reduce emissions.
- DSM finished first in engagement, with their suppliers asking close to 100% of their suppliers to disclose on environmental issues.
- We note that the five US companies are all ranked in the bottom six places.
- Ashland, Nitto Denko and PPG are at the bottom of the ranking because they do not engage at all with suppliers on environmental matters, do not have a supply chain strategy, or effective scope 3 reduction management.

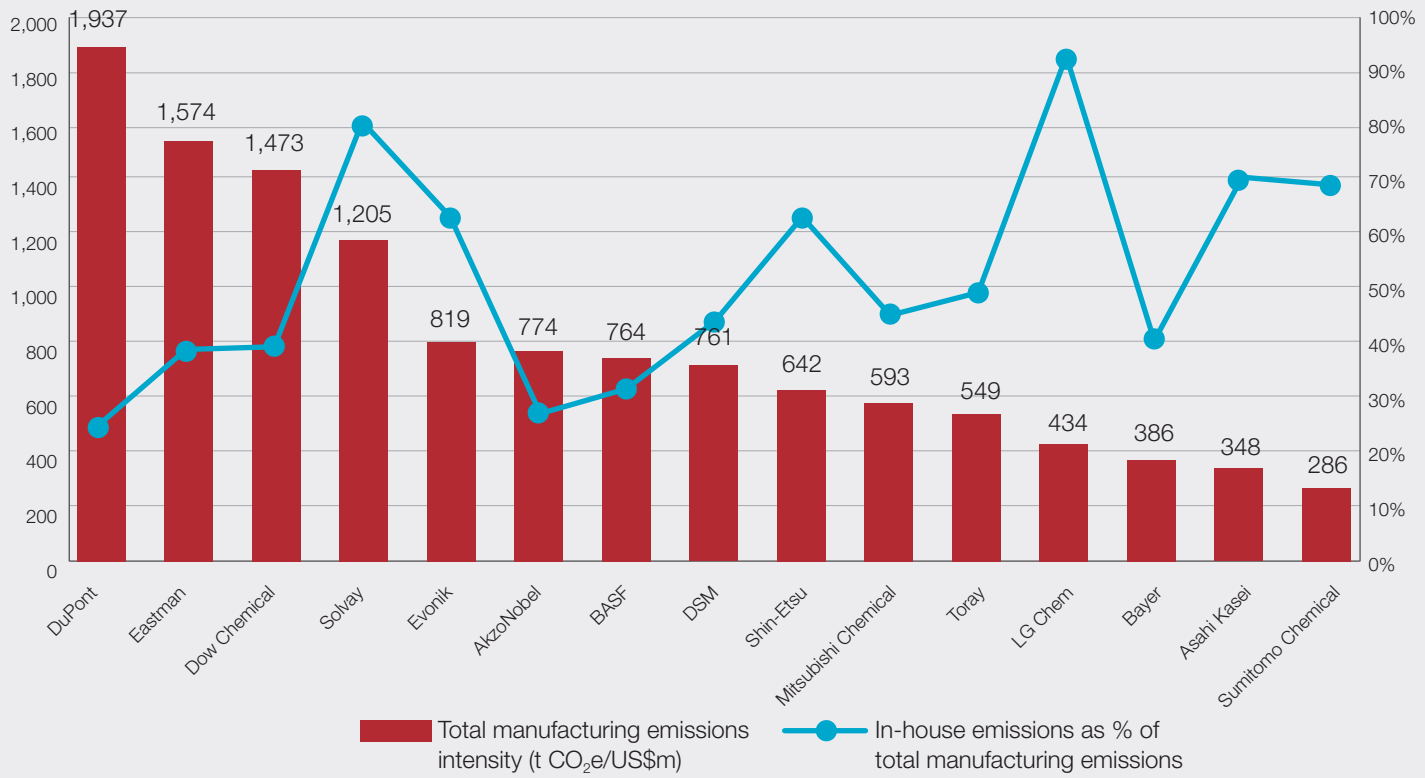
Metric 1: Supply chain engagement

- One third of the companies (six) report to CDP that they do not engage at all with their suppliers on emissions-related issues.
- Mitsubishi Chemical, Nitto Denko, and PPG report to CDP that they do not engage with any stakeholders whatsoever on emissions-related issues.
- DSM, Shin-Etsu, Solvay, and AkzoNobel are the most active, engaging with more than half of their suppliers

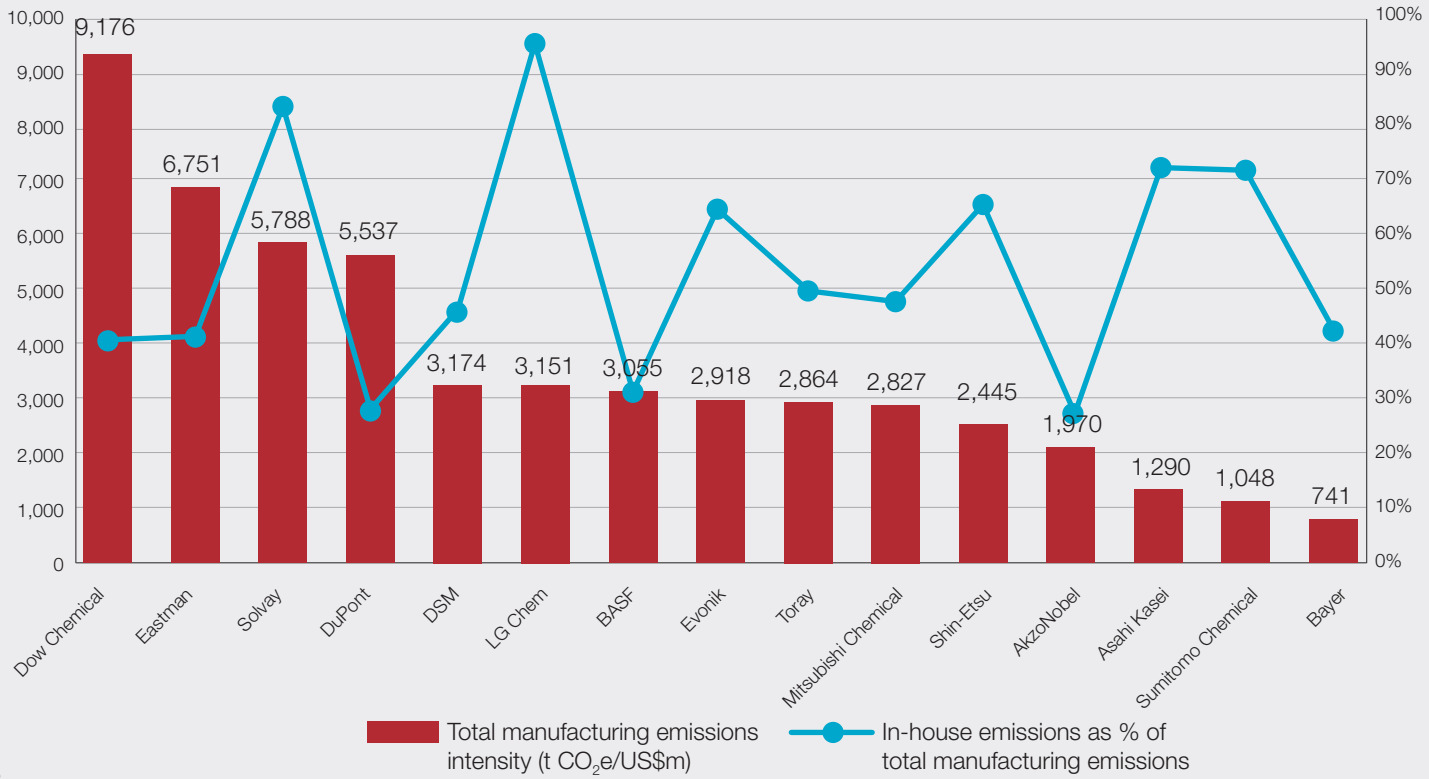
Metric 2: Supply chain strategy

- Eight companies do not disclose any supply chain strategy.
- Solvay is ranked top as it has a holistic approach to the supply chain addressing physical risks. It analyses the total environment impact of the production process of products from cradle to gate.
- AkzoNobel has a key supplier management program in which they cooperate with suppliers to enhance eco-premium solutions for their customers. This appears to be the most comprehensive strategy from a product development perspective.

Metric 3) (i) Total manufacturing emissions normalized by revenue



Metric 3) (ii) Total manufacturing emissions normalized by value-added



Methodology

The supply chain optimization rank and grade is determined as follow:

- We combine the weighted ranks of the three metrics in this key area using the following weightings: metric 1) 25%; metric 2) 25%; and metric 3) 50%. This determines the overall weighted rank for supply chain optimization, from which we award the supply chain optimization grade.

- We apply the following methodologies to determine the weighted ranks for each metric:

Metric 1: Value chain engagement

- We assess the companies' acknowledgment of the importance to engage with customers, suppliers and other partners in the value chain. We also assess the level of engagement with suppliers based on percentage of total spend.

- The better-ranked companies engage with both customers and suppliers, and the suppliers they engage with account for the highest proportion of their total spend.

- We use data from responses to questions 14.4 and 14.4b of CDP's 2015 climate change questionnaire.

Metric 2: Supply chain strategy

- We gave the best rank to companies collecting data to manage physical risks in their supply chain (and identifying GHG sources to prioritize for reduction actions), and those that have the most holistic value chain strategy (i.e.: set scope 3 targets, help suppliers reduce their emissions, find new processes to make more environmental friendly products for their customers, etc.)

- We use data from responses to question 14.4c of CDP's 2015 climate change questionnaire.

Metric 3: Manufacturing emissions intensity

- We consider the manufacturing emissions as the sum of: (i) Scope 1 emissions; (ii) Scope 2 emissions; (iii) emissions from purchased goods; and (iv) emissions from capital goods.

- Based on these emissions, we assess companies' emissions intensity normalized by revenue and by value-added, over the period of 2011-2014.

- We take the median of the results in order to exclude any anomalies, and rank the companies on this basis.

- We apply the above methodology for each of the two normalization factors, revenue and value-added.

- We combine the ranks for each normalization factor in a ratio of 50:50. This determines the weighted rank for this metric.

Carbon exposure

- China's national emissions trading scheme to be launched next year could be a powerful signal of the global acceleration of carbon markets.
- Solvay is ranked bottom. It carries the highest carbon risk of the companies in our study, both in terms of current exposure to existing schemes and also future carbon market exposure.
- Four companies could have more than 20% of EBIT at risk under our US$30 per tonne carbon price scenario.

Overview

The world's first carbon market, the EU emissions trading systems (ETS), was launched a decade ago. Over the last few years, there has been an increase in the number of carbon markets globally, at a city, regional and country level, perhaps the most significant being the development of markets in five major cities and two provinces of China. This has caused the emissions coverage of carbon markets globally to more than double since the start of 2013. These ETSs now cover more than 10% of global GHG emissions. The companies in our study have on average 45% exposure[17] to existing or planned schemes. There is considerable variation between the companies, ranging from LG Chem, with 100% exposure, to Sumitomo with just an estimated 1% exposure.

In this chapter, we assess the cost exposure of the companies to carbon markets. We note that currently free allowances exist for chemical companies in most systems. A key reason for this is to prevent carbon leakage[18]. In our view, the impact of carbon leakage is mitigated as more major industrialized countries set up carbon trading systems of their own. We argue that at some point, to achieve global goals on climate change mitigation, the free allowances will simply have to be removed. The Chinese NDRC has scheduled the roll-out of a country-wide ETS from 2016, under its national climate change plan of 2014-20. We believe this is an important signal on carbon regulation and could cause an acceleration in the roll-out of further national and regional ETSs.

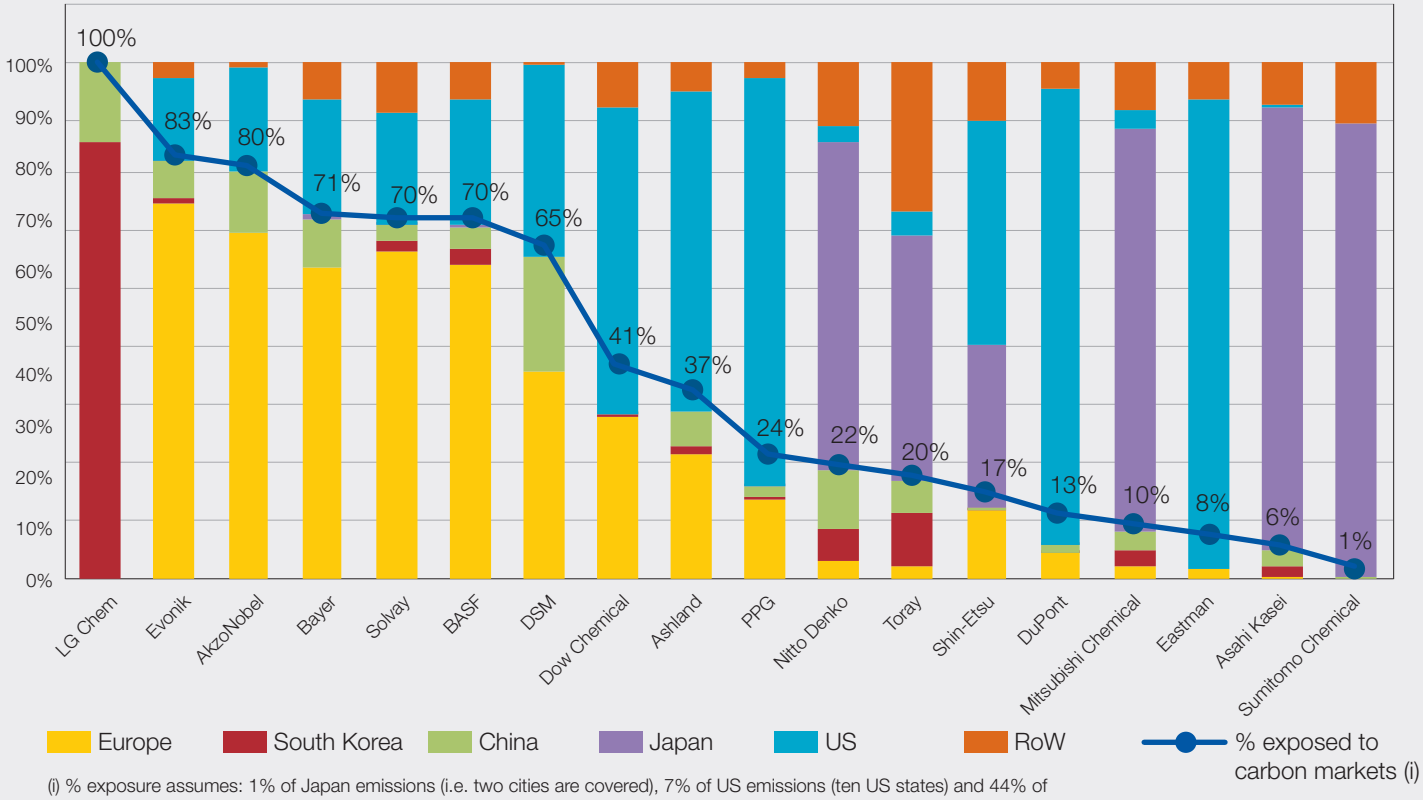
We use the following metrics in our assessment of carbon exposure:

- **Metric 1) Current carbon exposure:** as determined by current exposure of the companies to existing or planned ETSs. We calculate a carbon cost for the companies based on the YTD carbon cost for each existing ETS multiplied by the companies' exposure to those geographies; we divide by recurring EBIT for 2014 to determine the cost exposure.
- **Metric 2) Potential future exposure:** this is based on the companies' total global emissions. We consider three scenarios: (1) YTD weighted average carbon price for existing carbon schemes of US$7.75 per tonne; (2) Carbon price of US$20 per tonne; (3) Carbon price of US$30 per tonne. However we only consider scenario (1) in our ranking for this metric.

In our carbon exposure assessment, we use both direct emissions (Scope 1) and indirect emissions from power consumption (Scope 2), as we assume that utilities will pass on any cost of carbon in electricity price (though this is not the case for China as the electricity market in China is highly regulated). Our scenarios (2) and (3) are designed to give a basic sense of carbon cost exposure based on the companies' 2014 recurring EBIT. They do not include real option analysis, which would consider the companies' ability to pass some or all of their carbon costs onto their customers.

17. By emissions reported to CDP in response to our 2015 climate change questionnaire
18. Carbon leakage is the hypothetical relocation of companies' facilities to regions without (or with lower) carbon costs.

Emissions by geography, including % exposure to carbon markets



(i) % exposure assumes: 1% of Japan emissions (i.e. two cities are covered), 7% of US emissions (ten US states) and 44% of Canada emissions (two provinces) for each company, as well as 100% exposure to EU, South Korea and China.

Existing emissions trading systems

ETS name	Country	Jurisdiction	Start year	Sector coverage	% of emissions covered by all ETS
EU ETS	EU28 + Liechtenstein, Iceland and Norway	Regional level	2005	Industry, Aviation, Power	42%
Alberta SGER	Canada	State level	2007	Industry, Power	3%
New Zealand ETS	New Zealand	National level	2008	Industry, Forestry, Transport, Waste	1%
Switzerland ETS	Switzerland	National level	2008	Power, Building	0.1%
RGGI	USA	State level	Jan-09	Power	2%
Tokyo CaT	Japan	City level	Apr-10	Building	0.2%
Saitama ETS	Japan	City level	Apr-11	Building	0.2%
California CaT	USA	State level	Jan-13	Industry, Power	8%
Kazakhstan ETS	Kazakhstan	National level	Jan-13	Industry, Transport, Power, Agriculture	3%
Quebec CaT	Canada	State level	Jan-13	Industry, Power	1%
Shenzhen Pilot ETS	China	City level	Jun-13	Industry, Power, Building	1%
Beijing Pilot ETS	China	City level	Nov-13	Industry, Power, Building	1%
Shanghai Pilot ETS	China	City level	Nov-13	Industry, Aviation, Transport, Buildings	3%
Guangdong Pilot ETS	China	Province level	Dec-13	Industry, Power	9%
Tianjin Pilot ETS	China	City level	Dec-13	Industry, Power, Building	3%
Hubei Pilot ETS	China	Province level	Apr-14	Industry, Power	7%
Chongqing ETS	China	City level	Jun-14	Power	3%
South Korea ETS	South Korea	National level	Jan-15	Industry, Power	12%

Source: CDP, World Bank, International Carbon Action Partnership

Highlights

- Solvay is ranked bottom. It carries the highest carbon risk of the companies in our study, both in terms of current exposure to existing schemes and also future carbon market exposure. This is no great surprise since Solvay has the highest carbon intensity of the companies (see metric 2 of the process & energy efficiency chapter).
- Dow Chemical and LG Chem are ranked bottom-three based on future carbon market exposure. In addition, LG Chem is second from bottom on existing ETS exposure. This is due to its high exposure to both Korea, its domestic market, and China.
- We see additional risk for Dow Chemical and Mitsubishi Chemical, which both rank towards the bottom, and have notable below-average EBIT margins.
- We see lower risk for most companies above DSM in the rankings. These are the companies that are graded C or above.
- In our scenario (3) for future carbon market exposure, Solvay has 34% of EBIT at risk, Dow Chemical, LG Chem and Mitsubishi Chemical all have more than 20% of EBIT at risk. Scenarios (2) and (3) are for illustrative purposes as they assume zero carbon costs are passed onto customers. In reality, the companies may be able to pass on some of the carbon cost. In this chapter, we merely seek to highlight those companies that are at higher risk, should there be positive development on carbon regulation globally.
- We note that several companies, including Ashland and Dow Chemical, admit that they are not always able to pass on carbon costs as it is dependent on market conditions.

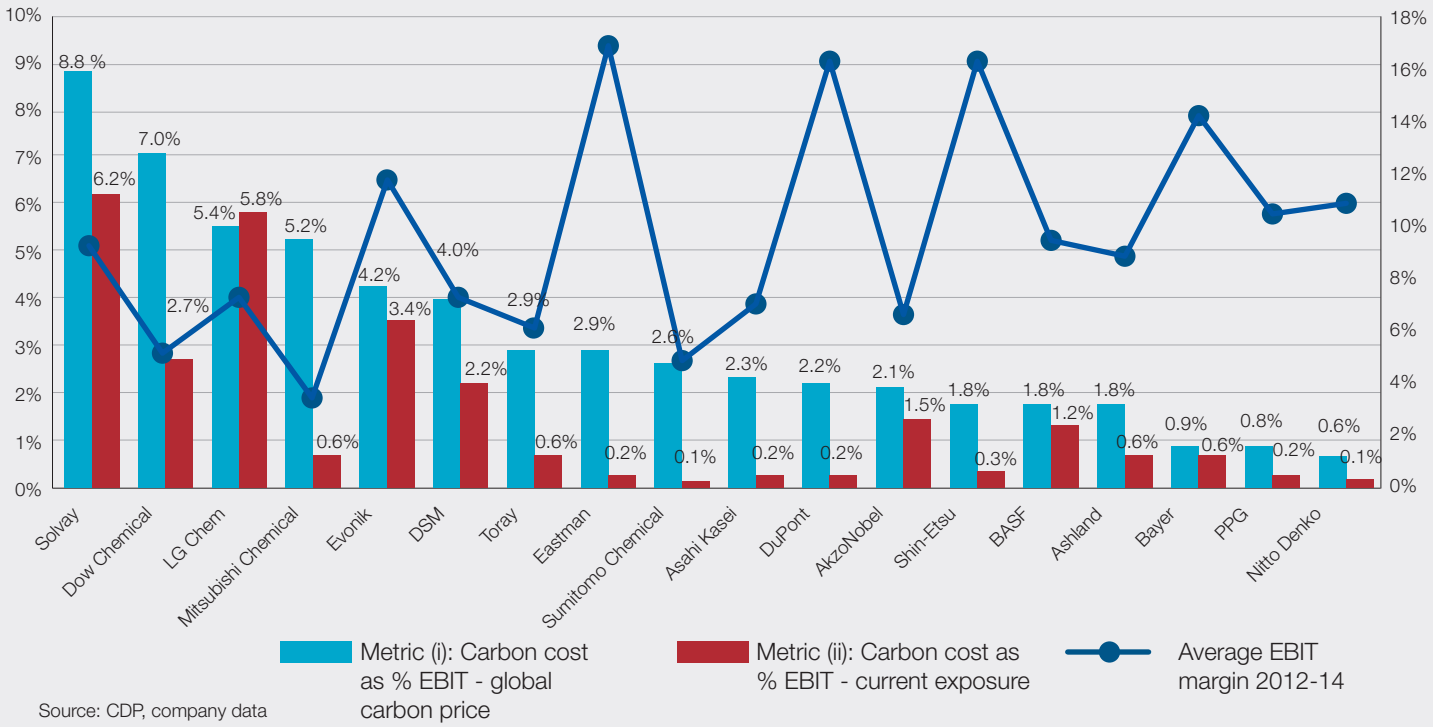
Carbon exposure summary

Company	Current carbon exposure rank	Potential future carbon exposure rank	Overall weighted rank	Carbon exposure rank	Carbon exposure grade
Nitto Denko	2	1	1.5	1	A
PPG	3	2	2.5	2	A
Sumitomo Chemical	1	10	5.5	3	A
Ashland	8	4	6	4	B
Asahi Kasei	4	9	6.5	5	B
Bayer	10	3	6.5	5	B
DuPont	5	8	6.5	5	B
Shin-Etsu	7	6	6.5	5	B
BASF	12	5	8.5	9	C
Eastman	6	12	9	10	C
AkzoNobel	13	7	10	11	C
Toray	9	11	10	11	C
Mitsubishi Chemical	11	15	13	13	D
DSM	14	13	13.5	14	D
Evonik	16	14	15	15	D
Dow Chemical	15	17	16	16	E
LG Chem	17	16	16.5	17	E
Solvay	18	18	18	18	E
Weighting	**50%**	**50%**			

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.

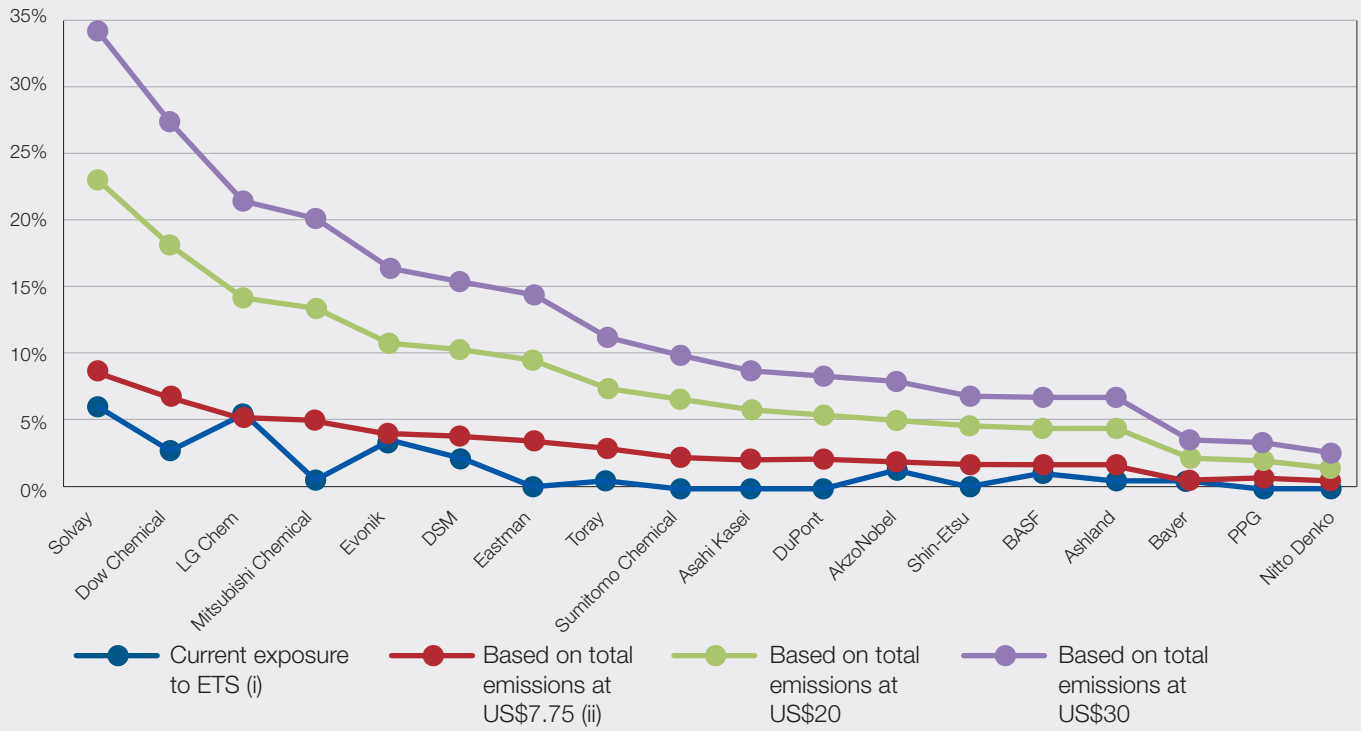
Source: CDP, company data

Metric: carbon exposure



Source: CDP, company data

Scenario analysis: carbon cost exposure as % EBIT



(i) Based on YTD2015 carbon prices for the carbon markets the companies are currently exposed to.
(ii) Based on YTD2015 weighted-average carbon price across all carbon markets globally.

Source: CDP, company data

Development of key emission trading schemes

EU

Following the oversupply of emissions allowances in the EU ETS, the European Commission has implemented a short-term measure of postponing (also known as “back-loading”) the auctioning of 900 million allowances until the later years of phase 3. This is designed to address the imbalance between supply and demand, and reduce carbon price volatility. A long-term solution of structural reform by establishing a market stability reserve (MSR) which will allow a flexible supply of allowances. The proposal was approved by the European Parliament in July 2015 and is expecting approval by the European council and to be implemented in 2019.

China

Currently there are seven pilot schemes, namely Shenzhen, Beijing, Shanghai, Tianjin, Chongqing (city-level), Guangdong and Hubei (province-level). These schemes collectively cover around 20% of emissions and 26% of the GDP of China, and making it world’s second largest ETS after the EU. Building on the experience from these pilot schemes, China has scheduled a national ETS starting with a test run in 2016, followed by full implementation during 2017-2020.

North America

Currently there are four schemes operating in this region; i.e. the Regional Greenhouse Gas Initiative (RGGI) covering 9 states and the California cap-and-trade program in the US, Alberta Specified Gas Emitters Regulation (Alberta SGER) and Quebec cap-and-trade system in Canada. These schemes cover 7% of total GHG emissions in the US and 48% of total GHG emissions in Canada. As mentioned previously, although a truly global carbon market is unlikely, there is an emerging trend of linking regional markets, e.g. the California ETS and Quebec ETS were linked in January 2014. Furthermore, the Ontario government announced in April 2015 that it would establish an ETS and link it to that of California and Quebec. Such linkage will enhance price stability and liquidity, as well as mitigate carbon leakage risk by reducing price differences across regions.

Methodology

The carbon exposure rank and grade is determined as follows:

- We combine the weighted ranks of the two metrics in this key area using the following weightings: metric 1) 50% and metric 2) 50%. This determines the overall weighted rank for carbon exposure, from which we award the carbon exposure grade.

- We apply the following methodologies to determine the weighted ranks for each metric:

Metric 1) Current carbon exposure

- We use 2014 emissions data from companies' responses to CDP'S 2015 questionnaire and companies' publicly available sources, 2014 recurring EBIT data from companies' annual reports, Year to date (YTD) 2015 carbon prices of all ETSs from various sources (see "global weighted average carbon price" below).

- We calculate each company's current carbon cost (in the absence of free allowances) in the EU28 (plus Liechtenstein, Iceland and Norway), South Korea and China by multiplying their emissions in each jurisdiction with the corresponding YTD 2015 carbon prices. For the carbon price of China, we take the weighted average price based on the percentage of emissions in all seven pilot schemes combined and their corresponding prices.

- For carbon cost in US and Japan, we use an approach similar to the above. However, instead of taking 100% of each company's emissions in US and Japan, we only take 7% and 1% respectively, as these percentages correspond to the percentage of emissions covered by existing ETS in the two countries.

- We calculate the current carbon exposure by combining the carbon costs for the five countries/regions and then dividing by the company's 2014 recurring EBIT.

Metric 2) potential future carbon exposure

- We calculate each company's potential future carbon cost by multiplying their total global emissions in 2014 by a global weighted average carbon price of US7.75 (methodology of this price please see below).

- We calculate the potential future carbon exposure by dividing the potential future carbon cost by the company's 2014 recurring EBIT.

- We do the same with a carbon price of US$20 and US$30 in other scenarios for illustrative purposed but do not include them in the ranking.

For the global weighted average carbon price

- For each of the existing 18 schemes, we calculate the year to date (YTD) carbon price by averaging over daily carbon prices (if traded/auctioned daily) or otherwise from 1 January to 13 July.

- We then convert the price from local currency to US$ by using an annual average exchange rate. We obtain the prices from Bloomberg, official sources such as emissions registries and datasets compiled by environmental NGOs. However, for the schemes of Tokyo, Kazakhstan and South Korea, we obtain the carbon prices from the Carbon Pricing Watch 2015 report published by the World Bank in May 2015.

- We collect data on emissions covered by each ETS and calculate the percentage of each ETS in this "global ETS market", except for the Saitama ETS as its carbon price is not readily available. Saitama only accounts for 0.2% of emissions in the ETS markets globally so its exclusion does not have any material impact on the global weighted average carbon price.

- We multiply each scheme's percentage of emissions relative to the global ETS market by its annual average carbon price to obtain the global weighted average carbon price.

Limitations

- In our analysis, we use companies' emissions data in 2014 and the annual average carbon price in YTD 2015. We use emissions data in 2014 as it is the latest data set; we use 2015 carbon price because it represents more schemes launched in the past two years, hence capturing a higher coverage of emissions, especially in China where many companies in our study have operations. The mismatch in the data years assumes that companies have constant emissions at 2014 levels. We appreciate that if the free allowances are removed or carbon prices increase, companies may reduce their emissions intensity by various measures, so their exposure to carbon costs is not as constant as we show in this study.

- We acknowledge that putting the same carbon price on emissions occurred in various jurisdictions is not the most accurate measurement of companies' exposure to carbon cost. Only if all companies provide emissions data at facility level could we conduct a more accurate assessment.

Carbon regulation readiness

- Leaders are Dutch companies AkzoNobel and DSM, and US company Dupont.
- German companies BASF and Bayer are ranked in the bottom three. Their perceived opposition to EU regulation may indicate a competitive disadvantage in a stronger low-carbon regulatory regime.
- The Japanese chemicals industry tends to engage in lobbying through its trade associations; hence the companies score within a fairly tight range.

Overview

The chemicals industry is undergoing rapid structural change as it faces major challenges, including increased competition to access raw materials and energy, and more stringent industrial and environmental regulations. It is increasingly important to understand how chemical companies are preparing for a shift towards a low-carbon regulatory regime. We believe that companies that are truly supportive of low-carbon regulations and measures, and are thus strategically shifting their own activities in that direction, are more likely to gain a competitive advantage should legislation become more stringent and punitive on emissions. Conversely, companies engaged in overt or covert obstruction of climate change policies may be less likely to be strategically shifting their activities in a similar manner and could be at a higher risk of regulatory shocks[19].

In this chapter, we adopt InfluenceMap's[20] proprietary analysis to assess readiness for a shift towards a low carbon regulatory framework. We believe that truly supportive firms are the most likely to benefit should the regulatory regime change quickly in their favour. InfluenceMap analyses the behavior of the chemical companies regarding the key regulatory items affecting their business, including the EU Emissions Trading System (European Union), the Energy Efficiency Directive (European Union) and the Clean Air Act (USA).

InfluenceMap scores companies in two ways:

1) Organizational score: represents the degree to which the company is directly influencing climate policy and legislation.

2) Relationship score: represents the strength of a company's relationship with trade bodies or other entities and their ability to influence climate policy and legislation.

We use these two scores to calculate our CDP carbon regulation readiness metric by applying a 60% weighting to the organizational score and a 40% weighting to the relationship score.

Highlights

- AkzoNobel, DSM and DuPont are the clear leaders.
- AkzoNobel actively supports the transition of the energy mix, supporting initiatives calling for a move towards a low carbon economy. It also directly engaged with the UK Prime Minister to advocate for energy efficiency standards.
- DSM has a very clear position and is supportive of legislative responses to climate change, particularly regarding energy efficiency and GHG emissions targets.
- DuPont appears to have advocated for policy makers to support energy efficiency standards and GHG emissions standards; however, it lacks transparency about its engagement regarding climate change.
- The Japanese companies do not engage in significant individual lobbying. They are scored largely through their relationships with the Japanese Federation of Industries and the Japan Chemicals Association, who have consistently opposed climate regulations, lobbying hard for voluntary plans instead.
- The laggards are Bayer, Toray and BASF. Toray's Chairman leads the Keidanren (Japanese Federation of Industries), which has consistently opposed climate regulations.
- BASF appears to not support a number of policies relating to climate change in the EU, including the potential reforms to the EU ETS to make it more efficient.
- Bayer appears to exhibit misalignment on various strands of climate policy. Although it expresses a clear position on climate change science, it seems less transparent with its official position towards climate change policies.

19. We note that some companies may be lobbying against climate regulation for short-term gain yet also preparing themselves for a longer-term shift towards a low carbon economy.
20. A UK-based non-for profit whose remit is to map, analyze and score the extent to which corporations are influencing climate policy and legislation. http://www.influencemap.org/

Carbon regulation readiness summary

Companies	Organizational score (i)	Relationship score (i)	Weighted rank	Carbon regulation readiness rank	Carbon regulation readiness grade (ii)
AkzoNobel	89	39	69	1	A
DSM	75	40	61	2	A
DuPont	72	41	60	3	A
Eastman	56	39	49	4	B
Sumitomo Chemical	52	37	46	5	B
Ashland	53	33	45	6	B
Mitsubishi Chemical	48	39	44	7	C
Shin-Etsu	49	37	44	8	C
LG Chem	45	41	43	9	C
PPG	49	34	43	10	C
Nitto Denko	46	38	43	11	C
Asahi Kasei	45	37	42	12	D
Dow Chemical	42	39	41	13	D
Evonik	40	38	39	14	D
Solvay	36	40	38	15	D
Bayer	37	37	37	16	E
Toray	37	36	37	17	E
BASF	29	39	33	18	E
Weighting	**60%**	**40%**			

(i) Proprietary analysis and scoring by InfluenceMap
(ii) this is the CDP carbon regulation readiness grade which is relative to the chemical companies in our study. It is not in any way related to InfluenceMaps's own grades which are relative to their entire cross-sector coverage universe.

Source: InfluenceMap, CDP

Regional trends

We note that some of the companies, such as BASF, Bayer, Dow Chemical and DuPont, have a global footprint of manufacturing bases and thus are exposed to multi-regulatory regimes. Whereas some of the Asian companies, such as LG Chem, Sumitomo and Asahi Kasei, are more focused on their domestic market.

Japanese corporations: tend to act in a far more closely aligned fashion than their Western counterparts, in particular when engaging with the Japanese government on legislation, primarily for energy and industrial issues through the influential Japanese Federation of Industries (Keidanren). In spite of this, we note that Toray is a little behind its Japanese peers with a weighted score of 37. Its score is brought down by the strength of its relationship with the Keidanren, for which Sadayuki Sakakibara, Toray board member (and former chairman), is chairman. On the other hand, Sumitomo's score of 46 is slightly ahead of the Japanese peer group, assisted by transparency in its CDP disclosure on its engagement with trade associations and related climate change policy objectives.

The recent shutdown of the nuclear plants post-Fukushima 2011, which took away 30% of electricity generation, has made Japanese industrial planners wary of global warming commitments that may limit their access to fossil fuels and push electricity prices higher. As a result, the Keidanren is strongly against all legislation on climate change, arguing that voluntary industry measures are sufficient. It is likely, based on this collective stance, that the entire Japanese chemicals sector will be severely disadvantaged in the wake of stricter stronger climate regulations. Detailed data on corporate lobbying in relation to Japanese regulation is not available.

German energy issues: The big German firms BASF, Bayer and Evonik all appear to be opposed to more stringent climate legislation, with the major concern being access to economically viable energy supply for their national manufacturing bases. BASF and Bayer in particular wield significant economic clout on EU regulatory affairs, and their obstructive behavior may indicate a competitive disadvantage in a stronger low-carbon regulatory regime.

The US giants: US firm DuPont has long been regarded as a leader in many areas of sustainability and its stance on climate legislation, including advocating for energy efficiency and renewable energy legislation. Specifically, DuPont appears to have advocated for policy makers to support energy efficiency standards (The Energy Savings and Industrial Competitiveness Act in the US), renewable energy legislation around the world and GHG emissions standards in the US. Dow Chemical, on the other hand, has exhibited no such support of low-carbon regulations in the US. Through its European operations, Dow Chemical has adopted a similar stance to its German SLT peers in opposing various strands of EU climate policy.

Methodology

We calculate our CDP carbon regulation readiness metric by combining InfluenceMap's organization score and relationship score in a ratio of 60:40. From this, we determine the carbon regulation readiness rank and grade.

A full description of InfluenceMap's detailed methodology can be found on its website. Its methodology comprises three stages: (a) aggregation of suitable data sources (SEC disclosures, legislative consultations, CDP responses etc.); (b) assessment (via raw scores) of those data sources using suitable queries; and (c) input of the raw scores and other factors into its algorithm to arrive at comparable metrics of regulatory readiness for corporations. It analyzes these data sources with a series of 12 queries relating to various aspects of climate change policy and legislation (e.g. carbon tax, emissions trading, GHG emissions regulations, renewable energy legislation etc.). It then scores each data source/query intersection (or cell) on a 5-point scale, with clearly consistent evidence and guidelines.

- **Organizational score:** is computed over 96 scoring cells by InfluenceMap's proprietary algorithm that accounts for weightings and irrelevant data sources/queries. The organizational score is expressed as a percentage, with 100% representing very supportive influence on climate policy.

- **Relationship score:** is a reflection of a corporation's climate influencing activities through its influencers (i.e. trade association etc.). The relationship score is also expressed as a percentage, with 100% representing very supportive influence over climate policy.

Water risk

- Bayer, BASF and AkzoNobel are ranked in the top three for water risk.
- Nitto Denko, PPG and Solvay are ranked bottom of the league of those companies that did respond to CDP's water questionnaire in 2015.
- Asahi Kasei, Eastman, Toray and Sumitomo Chemical are true bottom of the league due to the fact that they failed to respond to CDP's water questionnaire in 2015 as well as in previous years.

Overview

Water is a key input and substantial output in a variety of chemical processes. As competition for this finite resource increases globally, there is a clear and urgent need for the chemical industry to develop effective and proactive management responses to water-related issues.

CDP's analysis of corporate responses to our 2015 water questionnaire indicates that worsening water security poses both a substantive risk and an opportunity for the sector. Attention should be paid to both direct operations as well as company supply chains, with a sustainable supply of good quality water being critical to business continuity.

Higher operating costs and the threat of closure of existing operations, as well as constrained future growth are the top water-related business risks chemical companies themselves identify. Increased regulation of water discharge quality and volumes leading to higher compliance costs and reputational risk are additional substantive issues facing companies in the sector.

The drivers of these risks are often varied and complex. A meaningful response to mitigate these risks therefore often requires much more than striving for greater efficiency. Water management at the river basin level, in addition to community, regulatory and supply chain engagement and adherence to regulatory standards, are critical success factors in enhancing water security for the chemical sector and wider environment.

Key findings from analysis of responses to CDP's water questionnaire:

- Substantive risks exist – two thirds (67%) of chemical respondents identify water security as a substantive risk to their business, either in their direct operations or across their supply chains.
- These risks are manifesting in the short term - 63% of the identified risks, which include reputational damage, increased water stress and flooding, are anticipated to impact businesses now or in the next three years.
- Strategic responses are improving - two thirds (67%) of chemical respondents have established specific water-related targets or goals.
- Where there's risk there's reward – two thirds (67%) of chemical respondents report opportunities to improve bottom line profitability which in turn can positively impact valuations. These include:
  - Decreasing operating costs by improving water use efficiency.
  - Undertaking capital investment projects to reduce water consumption and greater utilisation of recycled water.
  - Turning water risk management procedures into a competitive advantage to provide new products and services as well as enhancing brand value.

In this chapter, we assess and rank the water management strategies of the 16 companies targeted by investors via CDP's water program in 2015. The key metrics are as follows:

- **Metric 1) Risk & opportunities:** Establishes the comprehensiveness of each company's water risk assessment procedures, by analyzing the contextual factors considered in each assessment and how companies engage with their respective stakeholders. Furthermore, each company's water-related growth impact assessment and execution of opportunities is scored. Given its importance to how water risk is managed strategically within a company, this metric carries the largest weight in the water League Table.

- **Metric 2) Supply chain management:** Identifies the extent to which chemical companies engage with their supply chain on water risk and management.

- **Metric 3) Policy & regulatory compliance:** Appraises chemicals companies' water policies and their adherence to environmental regulatory standards, including discharge of toxic waste water. It is imperative that companies have a clear and publicly-stated policy relating to its water management commitments whilst non-compliance with water regulations can pose a direct financial burden.

- **Metric 4) Water withdrawal intensity:** This ranks companies according to their sales-adjusted water consumption (with the lowest being most desirable). Normalising water consumption by revenue, and thus producing a 'water intensity of sales' value, allows the selected companies to be compared on a relative basis. However, we recognise water use and supply are driven by local supply and demand characteristics across a company's geographical reach and may not imply risk exposure but are a good indicator of water dependency.

Highlights

- Bayer and BASF share first place in the water risk key area.

- Bayer is a leader in incorporating water-related issues into its strategic business model and into its active supply chain engagement as well as adherence to regulatory compliance.

- BASF topped the league table due to its outstanding approach to water risk assessment and strategy; however, the company was subject to penalties relating to violations of water and wastewater-related regulations in the reporting year.

- AkzoNobel is ranked third and was awarded an A-grade due to its consistently high performance across the three most important metrics (metrics 1), 2) and 3)).

- There are four B-grade companies: Mitsubishi Chemical boasts a high policy and regulatory compliance score; DuPont engages effectively with its suppliers; LG Chem has the lowest water withdrawal intensity; and, Dow Chemical which performs better than industry average in risks and opportunities.

- Solvay and Shin-Etsu were awarded a C-grade and are clustered around the industry mean for most of the metrics. DSM, which also was awarded a C-grade, underperformed only in the risk and opportunity metric (50% weight in the league table).

- Nitto Denko and PPG are ranked eleventh and twelfth (or bottom three of the responders). They perform poorly in all four metrics.

- Toray, Asahi Kasei and Sumitomo Chemical did not respond to investor requests for water data via CDP in 2015 and therefore receive an E-grade. They are bottom four in the table; however, Asahi Kasei is ranked thirteenth, above the rest, as it scored above average in metric 4) – the only metric where some data was available from public sources (outside of CDP). It should be noted that these companies are persistent non-responders to CDP's water questionnaire.

- Eastman also receives an E-grade. At the time of publication of the report, the questionnaire from Eastman is pending. For any companies submitting a response by 30 September, their response will be included in future refreshes of our SLT.

Water risk summary

Companies	Risks & opportunities	Supply chain management	Policy & regulatory compliance	Water withdrawal intensity	Overall weighted rank	Water risk rank	Water risk grade
BASF	1	3	2	8	2.3	1	A
Bayer	3	2	1	2	2.3	1	A
AkzoNobel	2	1	4	6	2.6	3	A
Mitsubishi Chemical	5	6	2	9	5.0	4	B
DuPont	6	3	7	4	5.4	5	B
LG Chem	7	6	7	1	6.2	6	B
Dow Chemical	4	6	10	11	6.3	7	B
DSM	10	6	4	3	7.3	8	C
Solvay	8	6	6	10	7.4	9	C
Shin-Etsu	9	5	7	7	7.6	10	C
Nitto Denko	11	6	10	13	10.0	11	D
PPG	12	6	10	13	10.5	12	D
Asahi Kasei	13	6	13	5	10.8	13	E
Eastman	13	6	13	12	11.5	14	E
Toray	13	6	13	13	11.6	15	E
Sumitomo Chemical	13	6	13	13	11.6	15	E
Weighting:	**50%**	**20%**	**20%**	**10%**			

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

Metric 1): Risks & opportunities

- The three American companies and Nitto Denko do not identify any water-related risks that could generate a substantive change in their business.
- PPG is the only responder that does not see water-related opportunities which could benefit their business.
- Asahi Kasei, Eastman, Toray and Sumitomo are the bottom 4 because they did not respond to the CDP's water information requests in 2015.

Water risk assessment procedure

- Nine companies have a comprehensive company-wide risk assessment.
- Solvay, DSM and PPG have a water risk assessment which is undertaken independently of other risk assessments.
- It is worrying that only BASF, Bayer and PPG have a water risk assessment at the river basin level. We flag this as an engagement point for the other 9 companies that responded to CDP.

Stakeholders' engagement

- BASF and Bayer engage with all important stakeholders, including local communities, other water consumers, customers, regulators, etc.
- All responders but LG Chem engage at least with the other water users where they have operations.

Opportunities identification and execution

- PPG is the only responder that did not identify any water-related opportunities that could benefit their business.
- Bayer, Solvay and BASF have the best strategies to realise the opportunities they identified.
- BASF invest in R&D to develop fewer water-intensive products and solutions. For instance they created, together with Monsanto, DroughtGard Hybrids, a crop with higher yields and more resistance to adverse environmental conditions.
- Bayer identifies many ways to save costs. In the Bayer Integrated Site, Shanghai Bayer signed a technical agreement with a local partner on salt water recycling from polycarbonate plants. This new technology allows Bayer to transform salt water (generated) into high quality salt brine.
- Solvay still has not set up a strategy to realize the opportunities they identified.
- DSM and Shin-Etsu do not give any details on their water reduction projects.

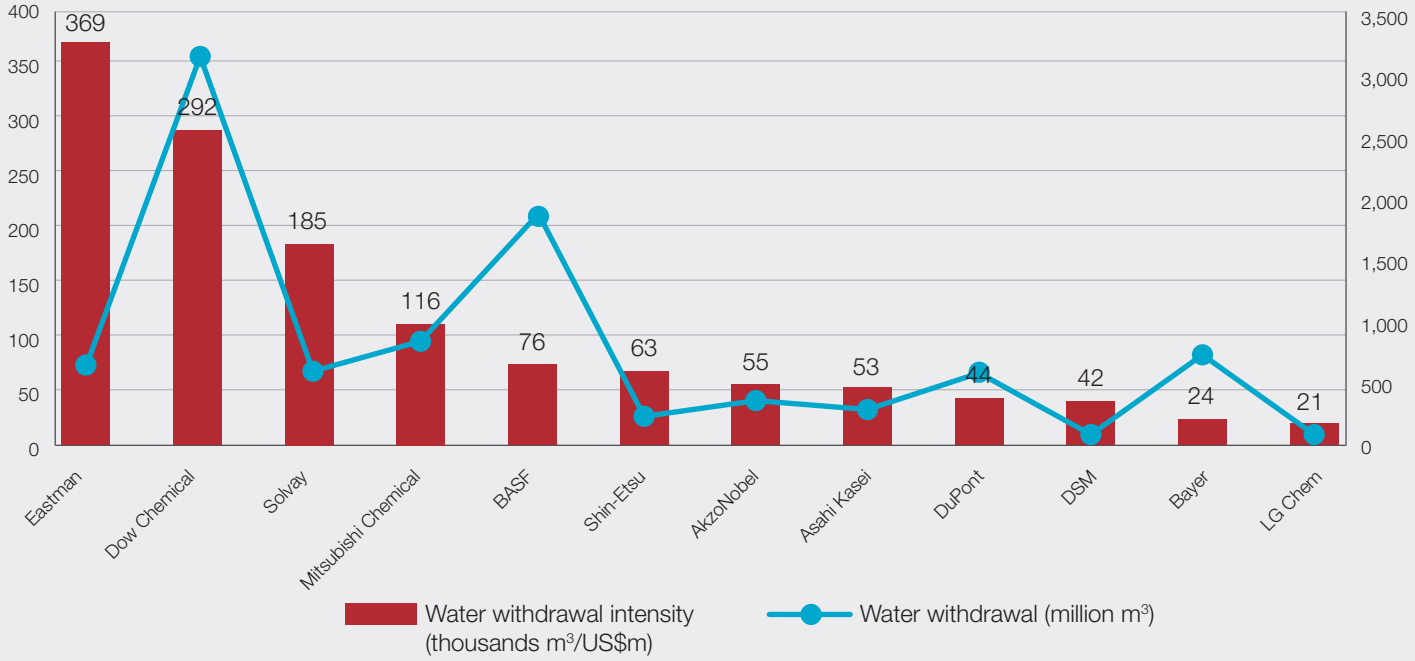
Metric 2): Supply chain management

- Solvay, DSM and Mitsubishi Chemical have reported they are exposed to water risks in their supply chain but do not request their suppliers to report on their water use, risks and management.
- On the contrary BASF, DuPont and Shin-Etsu ask their suppliers to report on their water risks even though they are not exposed to water risks in their supply chain.
- AkzoNobel is the clear leader since they asked 51% to 75% of their suppliers (in spending) to report their water risks.
- Shin-Etsu, which is 5th for this metric, would have been first last year. In 2014 they reported asking 51-75% of their suppliers (in both absolute and spending) to report on their water risks. In 2015 they did not respond to question 1.3a from CDP water program's 2015 questionnaire.
- Asahi Kasei, Eastman, Toray and Sumitomo are the bottom 4 because they did not respond to CDP's water information requests in 2015.

Metric 3): Policy and regulatory compliance

- BASF and Bayer have set the best water policies. They are publicly available, apply to the whole company, and set standards for direct and indirect operations together with procurement. Their water policy is incorporated within the group environmental policy and it incorporates commitment to customer education.
- Dow Chemical, Nitto Denko, PPG, Asahi Kasei, Eastman, Sumitomo Chemical and Toray have not set a policy or did not respond to the CDP's water information request in 2015.
- Only 3 companies reported fines and penalties: BASF, DuPont and DSM. However those fines were not financially significant.

Metric 4): Water withdrawal intensity



Methodology

The water risk rank and grades are determined as follows:

- We combine the weighted-rank of the four metrics defined previously in order to establish the water stewardship ranking.
- The water risk grade is awarded according to the rank.
- In determining the separate weighted ranks we apply the following weighting and methodologies to each metric:

Metric 1): Water risk & opportunity assessment:

- We use a weighting of 50% to reflect the importance of integrating water related risks and opportunities into the business planning.
- To obtain the maximum number of points, companies need to have a procedure whereby water is integrated into a comprehensive, company-wide risk assessment process covering both direct operations and supply chain for each river basin in which the company or suppliers operate. Additionally, their risk assessment needs to take into consideration all relevant stakeholders, particularly local communities and other water users. Finally, companies who score well will have explored potential water opportunities as well as analyzed future growth constraints and performed in line with their set water-reduction targets.
- We use data reported to CDP in 2015: questions 2.1, 2.2, 2.4a, 4.1a and 1.2 from the water questionnaire.

Metric 2): Supply chain management assessment:

- We assess the strength of water management in the supply chain. Firstly, we consider whether the company requests suppliers to report their water risks. To obtain the maximum score, a company must ask its suppliers to disclose their water risks and exposure. Secondly, we analyze the % of key suppliers (in number and spending) asked to disclose their water risks; with a greater number scoring more strongly.
- We use a weighting of 20%.
- We use data reported to CDP in 2015: questions 2.5 and 2.5a from the water questionnaires

Metric 3): Policy & regulatory compliance:

- We evaluate the strength of companies' water policies, with the best policy grade awarded to chemical companies who have a publicly available and company-wide water policy.
- We analyze any penalties and fines levied against the companies over the reporting period, with more severe disciplinary action by a regulator carrying a greater penalty on the company's ranking.
- We use a weighting of 20%.
- We use data reported to CDP in 2015: questions 6.3 and 7.1 from the water questionnaire.

Metric 4): Water withdrawal intensity:

- The financial intensity of water withdrawal (million m^3 / US$m value-added) of companies is calculated, with lower use per US$m of value added scoring more strongly.
- We use a weighting of 10% (only) to recognise the localized nature of water consumption and supply.
- We use data from question 1.2a of CDP water questionnaire and from companies' CSR reports

Appendix: engagement themes for chemical companies

Sector engagement themes:

In order to ensure robust and resilient business strategies and encourage a smooth transition to a low carbon economy, we are recommending some areas of engagement for investors to raise in their discussions with board and management of chemical companies. These are intended as proxies under which to 'stress test' business strategy to prepare for the medium and long term.

CDP is actively supporting institutional investors in their discussion with chemical companies and will provide additional information, support and coordination when needed.

A) Process and energy efficiency
Improvement in process and energy efficiency can lead to cost savings and thus enhanced earnings.

- Set up clear, strong, long-term emissions reduction targets, both absolute and intensity, in line with the methodology of Science-Based Targets' Sector-based Decarbonization Approach (SDA), which sets a meaningful emissions reduction target in 2050 and suggests an emissions pathway for each company. Emissions reduction is a key to meeting existing regulatory requirements, being prepared for future requirements and providing economic solutions for customers.
- Demonstrate targets and progress to achieve emission reductions.

B) Product innovation
Potentially high market growth in areas where carbon emissions reduction regulations are in place; first movers will benefit, laggards may miss out.

- Provide a clearer definition of "green" products.
- Have a better disclosure of sales and R&D spending related to "green" products.
- Demonstrate a clear strategy to develop "green" products in order to capture the opportunity of "green" products.

C) Supply chain optimization
A sustainable supply chain may help companies manage reputational risk, reduce costs, improve quality and ultimately lead to competitive advantage.

- Demonstrate a clear strategy to engage with supply chain on various environmental issues.

D) Carbon exposure
Cost exposure to meeting regulatory requirements on carbon emissions.

- Provide more detailed emissions data at facility or country level so that investors can make an accurate assessment of companies' exposure to regulations in place in various jurisdictions.

E) Carbon regulation readiness
Companies that are truly supportive of low-carbon regulations are more likely to gain a competitive advantage should the regulatory regime change quickly in their favor.

- Provide a clear stand on climate policy.

F) Water risk
Potential physical risks may constrain the growth of the chemical business.

- Demonstrate company's awareness of water risks and opportunities and how these could affect the success of its growth strategy.
- Set up clear, strong, long-term water targets and increase the quality and availability of water accounting data at river basin level.

For engagement facilitation support please contact us at investor@cdp.net

Company engagement: traffic light system

We use a traffic light system for each metric to highlight areas of engagement focus for each utility:

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 quantities for each metric.

SLT

Engagement area:			Process and efficiency				Product innovation				Supply chain optimization				Carbon exposure			Carbon regulation readiness			Water risk					Number of RGA		
SLT rank	**Companies**	**Country**	**Process and energy rank**	**Emissions performance**	**Future Targets**	**Data transparency**	**Product innovation rank**	**Green product leadership**	**LCA leadership**	**R&D as % sales**	**Supply chain optimization rank**	**Supply chain engagement**	**Supply chain strategy**	**Manufacturing emissions intensity**	**Carbon exposure**	**Based on current exposure to ETSs**	**Based on total emissions with a carbon price of US$7.75**	**Carbon regulation readiness rank**	**Organizational score**	**Relationship score**	**Water risk rank**	**Risks & opportunities**	**Supply chain management**	**Policy & regulatory compliance**	**Water withdrawal intensity**	**Green**	**Amber**	**Red**
1	DuPont	USA	1	6	1	6	3	4	11	2	13	7	10	13	5	5	8	3	3	1	5	6	3	7	4	10	6	1
2	DSM	Netherlands	2	2	6	7	1	2	6	4	6	1	6	10	14	14	13	2	2	3	8	10	6	4	3	9	5	3
3	AkzoNobel	Netherlands	8	12	9	4	7	6	4	15	2	3	2	7	11	13	7	1	1	5	3	2	1	4	6	8	7	2
4	Sumitomo Chemical	Japan	4	5	4	8	11	13	14	1	5	11	11	1	3	1	10	5	6	12	15	13	6	13	13	6	3	8
5	BASF	Germany	5	3	11	3	2	3	1	13	8	8	3	9	9	12	5	18	18	5	1	1	3	2	8	9	5	3
6	Bayer	Germany	7	4	16	4	9	10	13	3	1	5	6	2	5	10	3	16	15	12	1	3	2	1	2	10	3	4
7	Mitsubishi Chemical	Japan	6	7	2	12	8	13	8	5	12	16	11	4	13	11	15	7	9	5	4	5	6	2	9	5	7	5
8	Asahi Kasei	Japan	11	9	5	15	5	13	3	6	7	11	11	3	5	4	9	12	11	12	13	13	6	13	5	6	5	6
9	Dow Chemical	USA	3	8	2	9	4	8	2	12	14	11	11	14	16	15	17	13	13	5	7	4	6	10	11	3	8	6
10	PPG	USA	9	1	11	16	13	6	17	9	17	16	11	16	2	3	2	10	7	17	12	12	6	10	13	3	3	11
11	LG Chem	South Korea	12	11	10	10	13	12	5	16	11	11	9	7	17	17	16	9	11	1	6	7	6	7	1	3	9	5
12	Shin-Etsu	Japan	17	16	17	1	16	9	16	8	3	2	6	4	5	7	6	8	7	12	10	9	5	7	7	4	9	4
13	Toray	Japan	13	10	11	14	6	1	11	11	4	6	3	4	11	9	11	17	15	16	15	13	6	13	13	4	5	8
14	Evonik (ii)	Germany	10	14	11	2	15	13	10	10	10	8	3	10	15	16	14	14	14	10	n/a	n/a	n/a	n/a	n/a	2	5	6
15	Nitto Denko	Japan	14	13	6	16	17	13	15	7	17	16	11	16	1	2	1	11	10	10	11	11	6	10	13	2	4	11
16	Eastman	USA	16	17	11	11	12	11	7	14	14	11	11	14	10	6	12	4	4	5	14	13	6	13	12	2	6	9
17	Solvay	Belgium	15	17	6	13	10	5	8	17	8	3	1	12	18	18	18	15	17	3	9	8	6	6	10	4	6	7
18	Ashland (ii)	USA	18	15	18	16	18	13	17	18	16	8	11	16	4	8	4	6	5	18	n/a	n/a	n/a	n/a	n/a	2	2	9
Weighting:		**Metric**		**30%**	**50%**	**20%**		**35%**	**30%**	**30%**		**25%**	**25%**	**50%**		**50%**	**50%**		**60%**	**40%**		**50%**	**20%**	**20%**	**10%**			
		Area (i)	**40%**				**15%**				**10%**				**10%**			**10%**			**10%**							
		Adjusted area (ii)	**44%**				**17%**				**11%**				**11%**			**11%**										

Notes:
(i) Does not equal 100% as we have excluded the CDP performance band (5%) from our engagement topics
(ii) Slightly different weighting applied for Evonik and Ashland.

Source: CDP

Process & efficiency: engagement areas through traffic light

SLT rank	Companies	Country	Process and efficiency rank	Emissions performance	Target	Data transparency
1	DuPont	USA	1	6	1	6
2	DSM	Netherlands	2	2	6	7
9	Dow Chemical	USA	3	8	2	9
4	Sumitomo Chemical	Japan	4	5	4	8
5	BASF	Germany	5	3	11	3
7	Mitsubishi Chemical	Japan	6	7	2	12
6	Bayer	Germany	7	4	16	4
3	AkzoNobel	Netherlands	8	12	9	4
10	PPG	USA	9	1	11	16
14	Evonik (i)	Germany	10	14	11	2
8	Asahi Kasei	Japan	11	9	5	15
11	LG Chem	South Korea	12	11	10	10
13	Toray	Japan	13	10	11	14
15	Nitto Denko	Japan	14	13	6	16
17	Solvay	Belgium	15	17	6	13
16	Eastman	USA	16	17	11	11
12	Shin-Etsu	Japan	17	16	17	1
18	Ashland (i)	USA	18	15	18	16

Weighting:	**Metric**	**30%**	**50%**	**20%**
Area (i)	**40%**			

Notes:
(i) 44% weighting for Evonik and Ashland as they are not assessed in water risk

Source: CDP

Supply chain optimization: engagement areas through traffic light

SLT rank	Companies	Country	Supply chain optimization rank	Supply chain engagement	Supply chain strategy	Manufacturing emissions intensity
6	Bayer	Germany	1	5	6	2
3	AkzoNobel	Nethlerlands	2	3	2	7
12	Shin-Etsu	Japan	3	2	6	4
13	Toray	Japan	4	6	3	4
4	Sumitomo Chemical	Japan	5	11	11	1
2	DSM	Netherlands	6	1	6	10
8	Asahi Kasei	Japan	7	11	11	3
5	BASF	Germany	8	8	3	9
17	Solvay	Belgium	8	3	1	12
14	Evonik (i)	Germany	10	8	3	10
11	LG Chem	South Korea	11	11	9	7
7	Mitsubishi Chemical	Japan	12	16	11	4
1	DuPont	USA	13	7	10	13
9	Dow Chemical	USA	14	11	11	14
16	Eastman	USA	15	11	11	14
18	Ashland (i)	USA	16	8	11	16
15	Nitto Denko	Japan	17	16	11	16
10	PPG	USA	17	16	11	16

Weighting:	**Metric**	**25%**	**25%**	**50%**
	Area (i)	**10%**		

Notes:
(i) 11% weighting for Evonik and Ashland as they are not assessed in water risk

Source: CDP

Product innovation: engagement areas through traffic light

SLT rank	Companies	Country	Product innovation rank	Green product leadership	LCA leadership	R&D intensity as % of sales
2	DSM	Netherlands	1	2	6	4
5	BASF	Germany	2	3	1	13
1	DuPont	USA	3	4	11	2
9	Dow Chemical	USA	4	8	2	12
8	Asahi Kasei	Japan	5	13	3	6
13	Toray	Japan	6	1	11	11
3	AkzoNobel	Netherlands	7	6	4	15
7	Mitsubishi Chemical	Japan	8	13	8	5
6	Bayer	Germany	9	10	13	3
17	Solvay	Belgium	10	5	8	17
4	Sumitomo Chemical	Japan	11	13	14	1
16	Eastman	USA	12	11	7	14
11	LG Chem	South Korea	13	12	5	16
10	PPG	USA	13	6	17	9
14	Evonik (i)	Germany	15	13	10	10
12	Shin-Etsu	Japan	16	9	16	8
15	Nitto Denko	Japan	17	13	15	7
18	Ashland (i)	USA	18	13	17	18
Weighting:		**Metric**		**35%**	**35%**	**30%**
		Area (i)	**15%**			

Notes:
(i) 17% weighting for Evonik and Ashland as they are not assessed in water risk

Source: CDP

Carbon exposure: engagement areas through traffic light

SLT rank	Companies	Country	Carbon cover rank	Based on current exposure to ETSs	Based on total emissions with a carbon price of US$7.75
15	Nitto Denko	Japan	1	2	1
10	PPG	USA	2	3	2
4	Sumitomo Chemical	Japan	3	1	10
18	Ashland (i)	USA	4	8	4
8	Asahi Kasei	Japan	5	4	9
6	Bayer	Germany	5	10	3
1	DuPont	USA	5	5	8
12	Shin-Etsu	Japan	5	7	6
5	BASF	Germany	9	12	5
16	Eastman	USA	10	6	12
3	AkzoNobel	Netherlands	11	13	7
13	Toray	Japan	12	9	11
7	Mitsubishi Chemical	Japan	13	11	15
2	DSM	Netherlands	14	14	13
14	Evonik (i)	Germany	15	16	14
9	Dow Chemical	USA	16	15	17
11	LG Chem	South Korea	17	17	16
17	Solvay	Belgium	18	18	18
Weighting:		**Metric**		**50%**	**50%**
		Area (i)	**10%**		

Notes:
(i) 11% weighting for Evonik and Ashland as they are not assessed in water risk

Source: CDP

Water risk: engagement areas through traffic light

SLT rank	Companies	Country	Water risk rank	Risks & opportunities	Supply chain management	Policy & regulatory compliance	Water withdrawal intensity
5	BASF	Germany	1	1	3	2	8
6	Bayer	Germany	1	3	2	1	2
3	AkzoNobel	Netherlands	3	2	1	4	6
7	Mitsubishi Chemical	Japan	4	5	6	2	9
1	DuPont	USA	5	6	3	7	4
11	LG Chem	South Korea	6	7	6	7	1
9	Dow Chemical	USA	7	4	6	10	11
2	DSM	Netherlands	8	10	6	4	3
17	Solvay	Belgium	9	8	6	6	10
12	Shin-Etsu	Japan	10	9	5	7	7
15	Nitto Denko	Japan	11	11	6	10	13
10	PPG	USA	12	12	6	10	13
8	Asahi Kasei	Japan	13	13	6	13	5
16	Eastman	USA	14	13	6	13	12
4	Sumitomo Chemical	Japan	15	13	6	13	13
13	Toray	Japan	15	13	6	13	13
18	Ashland (i)	USA	n/a	n/a	n/a	n/a	n/a
14	Evonik (i)	Germany	n/a	n/a	n/a	n/a	n/a
Weighting:		**Metric**		**50%**	**20%**	**20%**	**10%**
		Area (i)	**10%**				

Notes:
(i) Ashland and Evonik are not assessed in water risk

Source: CDP

Carbon regulation readiness: engagement areas through traffic light

SLT rank	Companies	Country	Carbon regulation rank	Organizational score	Relationship score
3	AkzoNobel	Netherlands	1	1	5
2	DSM	Netherlands	2	2	3
1	DuPont	USA	3	3	1
16	Eastman	USA	4	4	5
4	Sumitomo Chemical	Japan	5	6	12
18	Ashland (i)	USA	6	5	18
7	Mitsubishi Chemical	Japan	7	9	5
12	Shin-Etsu	Japan	8	7	12
11	LG Chem	South Korea	9	11	1
10	PPG	USA	10	7	17
15	Nitto Denko	Japan	11	10	10
8	Asahi Kasei	Japan	12	11	12
9	Dow Chemical	USA	13	13	5
14	Evonik (i)	Germany	14	14	10
17	Solvay	Belgium	15	17	3
6	Bayer	Germany	16	15	12
13	Toray	Japan	17	15	16
5	BASF	Germany	18	18	5
Weighting:		**Metric**		**60%**	**40%**
		Area (i)	**10%**		

Notes:
(i) 11% weighting for Evonik and Ashland as they are not assessed in water risk

Source: CDP

Notes

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