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Aligning corporate greenhouse-gas emissions targets with climate goals

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Corporate climate action is increasingly considered important in driving the transition towards a low-carbon economy[1]. For this, it is critical to ensure translation of global goals to greenhouse-gas (GHG) emissions reduction targets at company level[2,3]. At the moment, however, there is a lack of clear methods to derive consistent corporate target setting that keeps cumulative corporate GHG emissions within a specific carbon budget (for example, 550–1,300 $GtCO_2$ between 2011 and 2050 for the 2 °C target[4]). Here we propose a method for corporate emissions target setting that derives carbon intensity pathways for companies based on sectoral pathways from existing mitigation scenarios: the Sectoral Decarbonization Approach (SDA). These company targets take activity growth and initial performance into account. Next to target setting on company level, the SDA can be used by companies, policymakers, investors or other stakeholders as a benchmark for tracking corporate climate performance and actions, providing a mechanism for corporate accountability.

Both climate negotiations and scientific literature focus primarily on global or country-level abatement efforts. Reaching climate agreements between countries, however, has proved to be a complex and slow process. There is a growing recognition that more actively involving other actors (for example, at the city or company level) in defining climate action may be key in effectively tackling climate change[1,5,6]. This would, however, require simple, transparent methods that link the potential efforts of these actors to global climate projections. A large body of literature is available on setting country targets[4,7], some of them even applying sectoral approaches to derive national targets[8–10].

In contrast, methods that set targets for actors other than countries are much less common. Most of the literature is specific to particular case studies[11], or calculate only sectoral level targets to finally derive national targets[9,12]. Although several companies have applied methods that presumably align to a below 2 °C carbon budget, the method to derive targets is not always disclosed[13,14]. Moreover, some methods simply apply an equal decarbonization pathway to all sectors, regardless of structural differences across sectors, such as mitigation potential, mitigation costs, or expected activity growth[15,16]. For example, the GEVA approach derives a global intensity reduction rate by combining an assumed annual global gross domestic product (GDP) growth of 3.5% with the global target of reducing GHG emissions by 50% from 2000 levels in 2050 (ref. 16). Globally, the rate of decline of GHG emissions per unit of global GDP (that is, monetary emissions intensity) would need to be around 5% per year to achieve a 50% emission goal in 2050. In the GEVA approach this decarbonization rate is subsequently applied to sectors and companies. Applying the same rate to all sectors does, however, not account for differences between sectors (for example, different mitigation potentials and costs) and may not always result in feasible targets. The GEVA method also does not account for current performance, by applying a uniform decarbonization trajectory that is applied to all companies. Finally, this method does not necessarily limit emissions within the carbon budget.

Any method for deriving sectoral targets needs to comply to a number of criteria: it should be applicable to different global targets; be transparent so that all actors can follow the calculations; allow for heterogeneity; and be acceptable to different actors. On the basis of these criteria, we propose an alternative method, the Sectoral Decarbonization Approach (SDA). We illustrate the SDA here by relating it to the global carbon budget associated with an at least 50% chance of keeping global warming below 2 °C from pre-industrial levels (550–1,300 Gt anthropogenic CO_2 emissions from 2011 to 2050), as stated by the IPCC (ref. 4). For reasons of data availability, we use one specific global scenario to allocate this global carbon budget to sectors—namely, the 2DS scenario from the International Energy Agency (IEA; ref. 17). Cumulative emissions in this scenario are 1,054 $GtCO_2$ in the 2011–2050 time frame from fossil fuel combustion and industrial processes. Taking into account an average estimate for land-use CO_2 emissions (104 $GtCO_2$ from 2011 to 2050 (ref. 18)) this is in line with the 2 °C carbon budget as determined by the IPCC. A comparison of the emission pathways in the 2DS scenario with the 2 °C scenarios in the IPCC scenario database can be found in the Supplementary Information.

Translating the sectoral emission pathways into sectoral intensity pathways (intensity pathway = emission pathway/activity projections) can be done using either physical indicators (for example, tonne of crude steel produced) or monetary indicators (for example, value added). As the ratio between energy use and physical indicators can be better related to emissions and mitigation potential, these indicators are preferable. Such indicators can only be used in sectors with one main product (for example, commodities such as cement, crude steel, and so on) or sectors where activity is relatively uniform (for example, passenger transportation by cars). Fortunately, 76% of the total carbon budget

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Table 1 | Input data hypothetical steel companies.

Company	2011 activity (Mt crude steel)	2011 CO_2 emissions ($MtCO_2$)	Year-on-year market share growth (percentage of previous year market share)	Abbreviation
High intensity & growing market share	200	500	1.5%	HI&GMS
High intensity & constant market share	200	500	0%	HI&CMS
High intensity & decreasing market share	200	500	−1.5%	HI&DMS
Low intensity & growing market share	200	300	1.5%	LI&GMS
Low intensity & constant market share	200	300	0%	LI&CMS
Low intensity & decreasing market share	200	300	−1.5%	LI&DMS
Rest of sector	318	591		

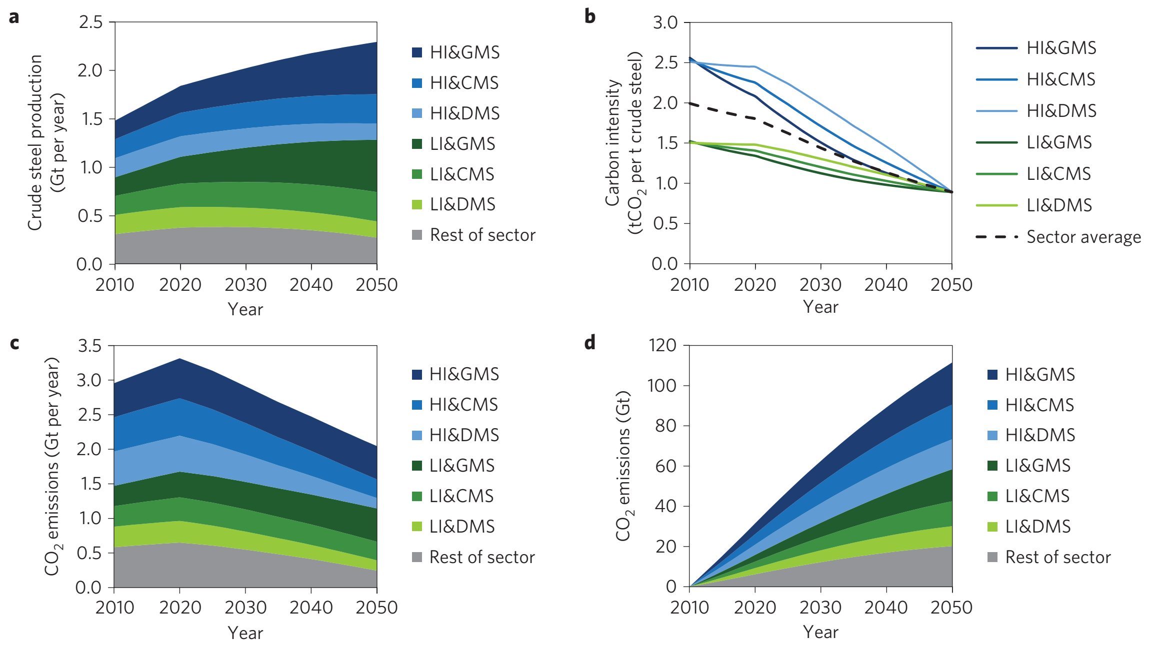

Figure 1 | Targets for six hypothetical steel companies. a–d, Expected steel production (**a**), carbon intensity targets (**b**), annual CO_2 emissions targets (**c**), and resulting carbon budgets (**d**).

in IEA 2DS can be translated to sectoral intensity pathways using a physical indicator[17]. For more heterogeneous sectors (for example, the pharmaceutical industry), the monetary value added can be used as a proxy for the sector's activity and can be assumed to grow parallel to GDP growth to create an intensity pathway. This approach is similar to the GEVA approach discussed before.

Based on the sectoral intensity pathways, individual company intensity pathways can be determined on which the company target per year can be derived. In the formulae of the SDA we comply with the following conditions: for every year the sum of all individual company emissions targets does not exceed the sector's total carbon budget; the sum of all company outputs (that is, activity) should equal the projected sector output; the current performance of a company should be accounted for; and the carbon intensities of companies converge from their initial intensity to the sectoral carbon intensity in 2050, meaning that in 2050 the carbon intensity of a company in a certain sector is equal to the overall sector carbon intensity. This last condition applies only to homogeneous sectors that can be described with a physical indicator.

We illustrate the SDA method by testing the method on the six hypothetical steel-producing companies depicted in Table 1. In base year 2011 all six companies produced 200 Mt crude steel (13.2% of global production), three of the companies had high direct emissions (500 $MtCO_2$), and three companies had low direct emissions (300 $MtCO_2$; see Table 1 for all company input data), the carbon intensities of the high-intensity companies were 2.50, those of the low-intensity companies were 1.50, and the sector average intensity was 1.97 tonne CO_2 per tonne crude steel.

To show that the SDA method stays within the carbon budget, we assume that both within the group of high-intensity companies and the group of low-intensity companies, one company has a market share that is growing at a rate of 1.5% per year (that is, to 13.4% in 2012 and so on), one has a constant market share, and one has a market share that is decreasing at a rate of 1.5% per year (that is, to 13.0% in 2012 and so on). Using these inputs and the sector projections from the IEA's 2DS scenario we are able to project the activity and market share of the six companies and the rest of the sector (Fig. 1a).

Next, the company intensity pathways are calculated using the formulae in the Methods section. Their intensities converge towards the 2050 level of 0.89 tonne CO_2 per tonne crude steel (Fig. 1b). The two companies that have a constant market share converge linearly towards the sector average intensity pathway. The intensity pathways of the fast-growing companies are steepened to account for their increase in market share. If this is not accounted for, the sector average intensity will increase owing to the growth, resulting in an exceedance of the sector's carbon budget. The opposite happens to the intensity pathways of the companies that show a decreasing market share. Although this might seem unrealistic or unfair, it makes sense from a business perspective, because when a

Table 2 | Carbon intensity pathways of sectors derived from IEA's 2DS.

Sector	Unit	Scope	2011	2015	2020	2025	2030	2035	2040	2045	2050
Power generation	gCO_2 per kWh	1	591	517	444	357	254	157	78.8	42.4	28.7
Cement	tCO_2 per t cement	1	0.60	0.59	0.58	0.56	0.54	0.50	0.46	0.42	0.38
		2	0.06	0.05	0.04	0.03	0.02	0.02	0.01	0.00	0.00
Iron and steel	tCO_2 per t crude steel	1	1.97	1.89	1.80	1.62	1.44	1.27	1.14	1.01	0.89
		2	0.43	0.39	0.35	0.28	0.20	0.13	0.07	0.04	0.03
Pulp and paper	tCO_2 per t paper and cardboard	1	0.59	0.53	0.46	0.4	0.35	0.3	0.27	0.24	0.22
		2	0.74	0.62	0.5	0.38	0.26	0.16	0.08	0.04	0.03
Aluminium	tCO_2 per t aluminium	1	1.61	1.61	1.61	1.58	1.54	1.5	1.47	1.45	1.42
		2	4.30	3.65	3.05	2.36	1.61	0.96	0.46	0.24	0.16
Chemicals and petrochemicals	tCO_2 per 2011 US$*	1	100%	109%	114%	98%	81%	70%	61%	53%	46%
		2	100%	89%	76%	55%	35%	18%	8%	4%	2%
Other industry	tCO_2 per 2011 US$*	1	100%	76%	53%	39%	27%	20%	18%	15%	13%
		2	100%	84%	67%	50%	32%	19%	8%	4%	2%
Air passenger transport	gCO_2 per pkm†	1	176	172	164	157	153	147	142	137	131
		2	0	0	0	0	0	0	0	0	0
Light road passenger transport	gCO_2 per pkm†	1	102	94.3	79.0	67.0	56.0	46.4	38.2	31.3	24.6
		2	0.51	0.41	0.32	0.50	0.90	1.21	1.09	0.89	0.78
Heavy road passenger transport	gCO_2 per pkm†	1	45.9	35.5	32.5	28.9	26.0	23.7	21.2	19.0	17.1
		2	0	0	0	0	0	0	0	0	0
Rail passenger transport	gCO_2 per pkm†	1	6.7	5.23	7.08	6.42	5.91	5.39	4.45	3.47	2.45
		2	14.1	9.41	6.55	5.99	4.29	2.72	1.51	0.86	0.62
Service sector buildings	$kgCO_2$ per m^2 per year	1	22.9	22.1	21.3	18.4	15.6	14.2	12.9	11.6	10.3
		2	65.5	58.7	51.7	40.2	27.9	16.4	8.25	4.25	2.88

*Sector's contribution to global GDP (value added), which is assumed to grow proportionally with global GDP. On a company level, added value equals gross profit. †Passenger-kilometres (pkm) are a measure of travel distance, calculated by multiplying passengers with the kilometres travelled.

company's market share is decreasing, it will probably invest less in new, more efficient technologies, and vice versa.

Figure 1b also shows how the 2DS sector pathway impacts the emissions pathways of individual companies. The converging term of the formula described in the Methods decreases over time, implying that medium-term targets are affected both by the company's current performance and the ultimate target, rather than by the sector pathway.

By multiplying the company's intensity pathways with the expected activity of a company, the absolute annual emissions target can be calculated. Figure 1c shows the emissions of the six companies and the rest of the sector. For companies HI&DMS and LI&DMS, most emission reductions occur as a result of their decreasing market share. The emissions of company LI&CMS decrease only slightly as a result of its low initial intensity combined with its constant market share.

Figure 1d shows the cumulative emissions of the steel sector example from 2011 to 2050. This figure illustrates that the SDA method guarantees that the sum of emissions of all companies is equal to the cumulative sector emissions prescribed by 2DS (that is, 111.5 $GtCO_2$).

The above focuses on direct emissions (defined as Scope 1 emissions in the GHG Protocol[19]). In addition, sufficient data is available in 2DS to construct carbon intensity pathways for indirect emissions from purchased electricity (Scope 2 emissions). Table 2 shows the sectoral intensity pathways for 12 sectors distinguished by the IEA. Furthermore, it shows sector-specific intensity indicators. The sectoral intensity pathways differ substantially among sectors, thereby justifying a sectoral approach. A company that is active in multiple sectors can set a total corporate target based on an analysis for each of its activities.

The SDA is the first method that applies a convergence approach to translate a sectoral pathway derived from a 2 °C scenario to set company-specific targets that account for growth and initial performance. By doing so, it solves two problems. First, a differentiation problem: the method can be reasonably applied to all companies irrespective of their starting point. Second, a temporal problem: for most companies it is not possible to adapt immediately and they are allowed to adapt over time.

SDA is designed to be simple and transparent. Because of its simplicity, SDA can easily become the basis of target-setting negotiations within companies, between companies and with third parties, and provide them with a clear and specific translation of the 2 °C target from the global to the company level. Next to setting near-term targets, companies can use the SDA method to set longer-term targets to avoid technology lock-in[20].

Besides its use as a target-setting method for companies themselves, the proposed method can also be used by others to benchmark corporate emissions targets. When using publicly available data as input, third parties can determine a company's carbon intensity and compare it to the sectoral average. This enables tracking and assessing corporate climate performance to identify companies with unambitious targets and encourage them to set more ambitious targets. An objective measure of corporate climate ambition can also be valuable for green investors.

Furthermore, the SDA method brings the corporate perspective of limiting global warming below 2 °C more clearly to the international climate negotiations and provides a potential mechanism for corporate accountability.

One of the critical elements is the projection of market share for a company. For 2050, its market share will of course be highly uncertain. However, in most cases targets will be set for much shorter time periods, for example, 5–15 yr ahead. The method explicitly allows for setting such interim targets. Note that as the market share is projected by the company, there is room for gaming: companies can assume a low growth to get a more lenient intensity target (such as that of HI&DMS). However, this also impacts the translation of that target into an absolute emissions target, making it more stringent if a company actually grows faster. Therefore, companies should report both the intensity and absolute emissions target.

Ideally, the method should not rely on just one mitigation scenario, but use a set of scenarios of different origins. Most scenarios do not contain sufficient sectoral detail to carry out the analysis needed for SDA. One sector for which this is possible is the power sector. We made a comparison between the scenarios in the IPCC database and the 2DS scenario and found that the IPCC median power intensity pathway is very much comparable with the pathway derived from 2DS (see Supplementary Information).

Note that the SDA does not include additional differentiation based on equity considerations as is often done for countries, but does implicitly account for differences of countries as it sets an intensity target, allowing faster-growing companies more absolute emissions (but improving intensity) and allowing companies to start from their individual starting intensity.

Some limitations of the proposed method arise owing to a lack of data availability. Ideally, the method would distinguish more products to make the targets more specific. We acknowledge that some sectors are still very aggregated and therefore we encourage further research that focuses on creating 2 °C scenarios that estimate emissions and activity for as many disaggregated sectors as possible. Furthermore, not only midpoint trajectories, but also uncertainty ranges could be added.

Methods

Methods and any associated references are available in the online version of the paper.

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Author contributions

O.K. acquired, analysed and interpreted the data, and drafted the manuscript. G.L. and K.B. designed and led the study and contributed to the analysis and interpretation of the data. W.C.-G., N.H. and D.P.v.V. critically reviewed the manuscript. P.F., N.A. and A.C.P. contributed to developing the methodological approach and aided in improving the mathematical formulae.

Additional information

Supplementary information is available in the online version of the paper. Reprints and permissions information is available online at www.nature.com/reprints. Correspondence and requests for materials should be addressed to G.L.

Competing financial interests

The authors declare no competing financial interests.

Methods

Company intensity pathways are derived from the company's base year intensity and the sectoral intensity pathway. To account for current performance, a factor d is formulated as the distance from the company intensity (CI,) in base year b to the sector intensity (SI) in year 2050:

$$d = CI_b - SI_{2050}$$

The company intensity in the base year is provided by the company, and the sector intensity provided by an external scenario. To converge the company's intensity towards the sectoral decarbonization pathway, we define p as a function of year y, which is essentially an index of the sector decarbonization, expressed from 0 to 1:

$$p_y = (SI_y - SI_{2050})/(SI_b - SI_{2050})$$

All sector intensities in this equation are derived from an existing scenario. Next we define m_y; a term that accounts for changes in market share (the share of company activity CA in sector activity SA):

$$m_y = (CA_b/SA_b)/(CA_y/SA_y)$$

The company's activity in the base year and the projected activity of the company are provided by the company. The sector activity is retrieved from an external scenario. This means that the total sector activity is not the actual activity, but rather the projection from the scenario. Note that the term m_y is not the change in market share, but rather the inverse, resulting in a decreasing m_y with increasing market share.

A company's intensity in year y can then be expressed as

$$CI_y = dp_y m_y + SI_{2050}$$

For the heterogeneous sectors, the sectoral activity (total sector value added) is unknown. However, when the assumption is made that the sector's value added grows proportionally to global GDP, the change in sectoral intensity can be derived by dividing the sectoral emissions by the change in global GDP. If the correction for change in market share $g_y = (GDP_y/GDP_b)/(CVA_y/CVA_b)$ is introduced the overall expression for the intensity pathway of heterogeneous sectors can be simplified to:

$$CI_y = \frac{CE_b}{CVA_y}\frac{SE_y}{SE_b}$$

where CVA is company value added, CE company emissions and SE sector emissions. Note that, in this case, the correction for market share disappears from the equation and the equation is simply translating the absolute emission reduction the company needs to deliver (which is proportional to the sector reduction) to an intensity reduction, by dividing the company emissions by the company activity in year y. This is similar to the GEVA method[16].

Data. The scenario data for the scenarios presented in the Energy Technology Perspectives 2014 report are publicly available and are retrieved from the International Energy Agency (IEA). The sectoral pathways shown in Table 2 and Fig. 1 are calculated by dividing annual sectoral emissions (tonnes CO_2) by annual sectoral activity (the activity indicators indicated in Table 2), both retrieved from the IEA (ref.17). The IEA provides this data for the years 2011, 2020, 2025, 2030, 2035, 2040, 2045 and 2050. For the years in between, the values are estimated using linear interpolation. Allowed Scope 2 emissions are calculated for each sector by multiplying modelled sectoral electricity use with the modelled global emission factor of electricity. For the heterogeneous sectors, total sectoral value added is unknown, but assumed to grow proportional to GDP. The amount of passenger-kilometres (pkm) is selected as the activity indicator for passenger transport because pkm data was available in 2DS. Better activity indicators can be thought of, such as pkm with volume correction, or vehicle-kilometres. However, this data was not available.

To calculate the share of the carbon budget for which targets can be set using physical activity indicators, the cumulative emissions were calculated for all sectors for which a physical indicator was available, and divided by the total cumulative emissions in 2DS.