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GLOBAL 100 GREENHOUSE GAS PERFORMANCE

NEW PATHWAYS FOR GROWTH AND LEADERSHIP

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INTRODUCTION

A relatively small number of global companies will make a big difference in fighting climate change. The greenhouse gas (GHG) emissions from the 100 largest emitting companies of the world[1] (including their value chains) account for approximately a quarter of global annual emissions.[2] At a time when the geopolitical winds are shifting on climate change, this report presents a global invitation to these top emitters of GHG to become transformative leaders.[3]

In doing so, they would join the ranks of companies such as **Enel**, **NRG** and **Xcel Energy**, who, among others, are executing on strategies to diversify and decarbonize their business models in heavily carbon-intensive industries. Their plans, begun a decade or more ago, have proven results and provide a pathway to a clean energy future that stretches to 2050. Any carbon-intensive business can start on this journey, and doing it now will bring maximum benefit over all time horizons for a business and its stakeholders. Not doing so now risks losing the opportunity altogether and incurring considerable risks as climate change worsens, sea levels rise and populations are displaced.

This analysis is not about naming and shaming into action. Many of the largest emitters have brought badly needed energy, infrastructure, housing and food to people throughout the world. This is about a closer look at the scale of climate impact of the Global 100 and the progress some have made embracing the new business logic of decarbonization. It is core to their strategies for financial success and responsible growth on our increasingly fragile and resource-constrained planet. It's also about the urgent need to reduce our warming impact on our atmosphere while there is still time to do so.

[1] This report builds on and supports the **Global 100 CalPERS initiative based on the PRI Montreal Pledge**.Only publicly traded companies are included in this analysis; the 100 firms listed in this report are part of a larger group of carbon-intensive companies that have an extraordinary opportunity to lead on climate and grow their businesses over the long term. These companies primarily come from the fossil fuel energy, utility, infrastructure, consumer goods, mining, cement, steel, automobile and aviation sectors.

[2] This is measured against total anthropogenic emissions, including land use of approximately 52 gigatons CO_2e. This number includes direct, indirect and value chain emissions (scopes 1, 2 and 3) adjusted for double counting of 55% which is equivalent to the total energy companies' emissions of 15.7 Gigatons being double counted.

[3] This is detailed later in the report, but leadership is primarily about diversifying risk away from carbon-intensive business models in a step-by-step, strategic transformation spread out over the next 35 years. Less than 10% of the Global 100 is currently demonstrating leadership on transparency and decarbonization.

Reuters/Issel Kato

A GROWING SIGNAL FROM INVESTORS

The 100 companies[4] named in this report have a unique opportunity to lead and keep the world within 2 degrees C of warming. These companies are particularly important because the Paris climate treaty is unlikely to provide a viable solution to climate change without their leadership.[5] Non-state actors are crucially important.

And there is growing upside for leadership. Today, investors and policy makers better understand the climate risk imposed by individual companies. Increasingly, investors see the value creation potential from companies that are transparent on their emissions and offer product portfolios designed to compete in the emerging low-carbon economy. It's no accident that some of the largest investors in the world are part of the authorship of this report, as we see in the following observation from State Street Global Exchange.[6]

An investor's perspective on carbon-intensive business models

Mark McDivitt, Managing Director, Head of ESG Solutions, State Street Global Exchange, part of a firm with $28 trillion in assets under custody and administration and $2.5 trillion in assets under management, offers the following observations from an investor perspective on carbon-intensive business models:

- The Paris Agreement, unlike Copenhagen, Kyoto and other COP gatherings, drove home the point that the private sector, partnered with individual country INDCs, will be the impetus needed to start to limit overall global warming to less than 2°C.
- The global investor community will not be limited to "playing defense" with negative screening and divestiture strategies designed to limit exposure to carbon-intensive assets, particularly those not positioned to decarbonize in line with scientific and policy guidance. Right now, many leading owners, asset managers, endowments, insurance companies and hedge funds are "playing offense," investing in innovative leaders in carbon-intensive business sectors who are delivering sustainable solutions and above-market returns.
- In addition, there is increasing evidence that investors and managers may be able to outperform their benchmarks by integrating more broad-based environmental, social and governance (ESG) factors, beyond climate, into their investment strategy and decision-making process. This growing base of ESG integrators has seen a rapid inflow of capital to these strategies in the past two years.
- The investor community knows that business operations are responsible for the vast majority of addressable GHG emissions, and it is these same business operators and their owners, among other stakeholders, who will experience results of climate change.

For global financial players of all stripes, it's time to answer the question ... **Are you in the game of integrating climate impacts into investment strategies or still on the bench?**

This report is an urgent invitation. It's an invitation to leadership on behalf of the investors, policy makers, consumers and billions of inhabitants of our fragile world. It's an invitation to "play offense" on climate change, as McDivitt says above, by finding the right equilibrium between risk, opportunity and responsibility to your ecosystem of stakeholders.

[4] These "Global 100" vary and depend on the transparency of the companies. Thomson Reuters and CDP have collaborated on this report to bring together the latest data from companies that do report and the latest estimates for those that do not. The finance sector was excluded, as there are insufficient estimates on their Scope 3.

[5] Even if all Intended Nationally Determined Contributions (INDCs) were fully implemented from the COP21 agreement, warming would be about 3 degrees C, according to UNEP.

[6] State Street was founded in 1792 and is the **second-oldest** financial institution in the U.S. It has approximately $28 trillion in assets under custody and administration and $2.5 trillion in assets under management.

PERFORMANCE: THE GLOBAL 100[7] AND OUR PLANET

As mentioned earlier, the Global 100 emitters matter because they represent a large portion of annual GHG emissions, and they can immediately influence their marketplaces and policy makers to drive significant but manageable reductions of at least 2% per year in line with the latest policy guidance from the scientific community.[8] Lance Pierce, President of CDP North America, remarks, "It's important to remember the catalyzing effect that can occur from leadership at the top of these carbon-intensive industries. With enough momentum from the largest industry players, we can reach a tipping point whereby a new norm emerges. Leadership is then expected as part of core business strategy."

Looking at the performance of this group of companies (see appendix 1 for complete list), we see in Figure 1 the top 30 emitters among the largest publicly traded companies of the world, across all scopes. On the next page, we have included the "State of the Climate," with the latest trends in global climate conditions as the actual measurement for our progress on climate change.

Figure 1: Top 30 of Global 100 Emitters of GHG

		GHG emissions Tons CO2e Scope 1+2+3		GHG Index*	Revenues USD		Decoupling Index*
Source GHG	Company Name	2015	2014	Baseline 2014 =100	2015	2014	Baseline 2014 =100
CDP	Coal India	2,014,693,250	1,850,080,574	109	11,903,683,242	11,770,273,584	93
CDP	PJSC Gazprom	1,247,624,306	1,264,855,340	99	83,315,971,620	95,924,596,230	88
CDP	ExxonMobil Corporation	1,096,498,615	1,145,083,349	96	259,488,000,000	394,105,000,000	69
CDP	China Petroleum & Chemical Corp	873,898,581	902,075,103	97	310,968,548,490	455,452,559,380	70
CDP	Rosneft OAO	835,887,091	833,148,361	100	70,606,500,000	94,816,690,000	74
CDP	PETROCHINA Company Limited	730,914,625	693,615,195	105	265,767,674,840	367,944,985,540	69
Thomson Reuters	Rio Tinto Ltd	663,900,000	628,700,000	106	34,829,000,000	47,664,000,000	69
CDP	China Shenhua Energy	643,810,940	728,365,957	88	27,273,938,070	40,789,064,770	76
Thomson Reuters	Royal Dutch Shell PLC	641,000,000	686,000,000	93	264,960,000,000	421,105,000,000	67
CDP	Petróleo Brasileiro SA - Petrobras	629,174,567	634,294,435	99	96,468,000,000	143,657,000,000	68
Thomson Reuters	Total SA	575,800,000	598,400,000	96	143,421,000,000	212,018,000,000	70
CDP	United Technologies Corporation	530,627,775	530,627,775	100	56,098,000,000	57,900,000,000	97
CDP	BHP Billiton PLC	474,376,663	436,331,000	109	30,912,000,000	44,636,000,000	64
Thomson Reuters	Eni SpA	466,131,372	450,838,037	103	73,565,665,012	112,728,482,429	63
Thomson Reuters	BP PLC	457,800,000	461,400,000	99	222,894,000,000	353,568,000,000	64
CDP	Valero Energy Corporation	438,076,129	448,800,949	98	87,804,000,000	130,844,000,000	69
Thomson Reuters	Chevron Corp	428,000,000	414,000,000	103	129,648,000,000	199,941,000,000	63
Thomson Reuters	Korea Electric Power Corp	399,984,300	443,325,000	90	50,178,919,954	52,589,333,882	106
CDP	Peabody Energy Corporation	397,079,232	433,138,945	92	5,609,200,000	6,792,200,000	90
CDP	Toyota Motor Corporation	377,020,000	383,198,000	98	226,863,559,930	248,954,617,590	93
CDP	YTL Corp	372,995,902	393,967,914	95	4,441,845,410	6,003,908,864	78
Thomson Reuters	General Motors Co	359,381,663	333,986,186	108	152,356,000,000	155,929,000,000	91
CDP	Phillips 66	331,341,051	323,169,655	103	98,975,000,000	161,212,000,000	60
CDP	Volkswagen AG	328,330,937	336,875,378	97	236,618,000,000	268,484,000,000	90
CDP	ENGIE	319,709,310	350,307,803	91	77,526,000,000	99,043,000,000	86
Thomson Reuters	Statoil ASA	313,800,000	304,600,000	103	57,900,000,000	96,708,000,000	58
CDP	Exor S.p.A.	295,542,540	234,989,334	126	148,086,960,000	145,287,389,400	81
Thomson Reuters	Glencore PLC	290,714,000	312,923,000	93	170,497,000,000	221,073,000,000	83
Thomson Reuters	Honda Motor Co Ltd	284,160,000	279,007,000	102	129,718,825,515	110,956,535,132	115
CDP	Marathon Petroleum	279,703,599	260,251,261	107	72,251,000,000	98,081,000,000	69
	Global 30	**17,097,976,448**	**17,096,355,551**	**100**	**3,600,946,292,084**	**4,855,978,636,801**	**74**
	Global 100	**28,407,556,866**	**28,453,074,124**	**100**	**6,345,922,512,313**	**7,938,498,561,200**	**80**

* A GHG Index over 100 indicates growing emissions, and a Decoupling Index over 100 indicates revenues increasing faster than emissions.[9]

[7] See footnote 82.

[8] This is the guidance from the latest analysis from the IPCC and UNEP gap report.

[9] GHG Index = (GHG emissions 2015/GHG emissions 2014)*100Revenue Index = (Revenues 2015/ Revenues 2014)*100. Decoupling index = Revenues Index/GHG Index.

The Global 100 were responsible directly and through their value chains for 28.4 gigatons CO_2e of emissions in 2015 (unadjusted for double counting). They accounted for about one-fourth of total annual anthropogenic emissions of 52.2 gigatons CO_2e (assuming 55% of Global 100 emissions were double counted, which equals all Global 100 Energy sector emissions or 15.6 gigatons). Coal India was the biggest emitter, with over 2 gigatons CO_2e (includes value chain), followed by Gazprom and ExxonMobil, all three major suppliers of fossil fuels, respectively coal, natural gas and oil.

Total emissions were flat for the Global 100 from 2014 to 2015 (when they should have been decreasing), and revenues decreased by 20% (26% for the Global 30), largely due to volitility in exchange rates and energy prices. Some companies stood out by reducing emissions faster than their revenues grew from 2014 to 2015, for example, Duke Energy, Ingersoll-Rand Co. Ltd. and BASF. It is critically important that this data is used to launch a deeper discussion into the latest emissions figures and company plans for decarbonization. The Global 100 companies themselves may have more up-to-date information than is currently available through public sources or expert estimate, and their input is welcome.

It is difficult to see how these planetary trends change without leadership from this top group of emitters, even if thousands of smaller companies and millions of households continue to demonstrate leadership themselves. This long tail of cities, companies, households and individuals is valiant and important, but we will need leadership in the next five years and beyond across the Global 100 to stay within 2 degrees C warming.

STATE OF THE CLIMATE 2016

CLIMATE CHANGE BY THE NUMBERS

An unprecedented third "warmest year on record" globally. Record Arctic warmth. Live coverage of the latest extreme weather event. There are many ways we observe and experience climate change. Climate change impacts becomes more real and hit closer to home every year. What is the current state of earth's climate by the numbers?

16 of 17 warmest years on record globally have occurred since 2000

1 in 27 million odds that string of hottest years globally since 2000 occurred naturally

1.48 C – global average temperature change from early industrial levels most likely for the whole of 2016 **scientificamerican.com/article/earth-flirts-with-a-1-5-degree-celsius-global-warming-threshold1/**

2016 - unprecedented third consecutive "warmest year on record" globally **ncdc.noaa.gov/sotc/global/201613**

2015 – second straight warmest year on record globally since 1880

2014 – previous warmest year on record globally since 1880

410 ppm – atmospheric CO_2 likely to reach unprecedented level in 2017 **scripps.ucsd.edu/programs/keelingcurve/wp-content/plugins/sio-bluemoon/graphs/mlo_one_year.png**

22 to 44 cm – IPCC projected sea level rise by 2100

1 trillion tons – cumulative ice loss in Greenland between 2011 and 2014 **independent.co.uk/environment/climate-change-global-warming-greenland-ice-melting-rate-sea-levels-rise-a7147846.html**

12% per decade – rate of Arctic Sea ice decline **twitter.com/ZLabe/status/844573790138916865**

Contributed by Minnesota Public Radio Chief Meteorologist Paul Huttner, **theguardian.com/environment/climate-consensus-97-per-cent/2014/aug/21/scientist-in-focus-meteorologist-paul-huttner**

Time is simply running out on climate change, and these firms matter most. As they delay reducing total emissions, they exacerbate the problem, with more drastic, disruptive and expensive reductions necessary later to stay within 2 degrees C.[10] Unless we start to change now, as these firms have the unique opportunity to do, we are unlikely to change enough and in time to matter.

[10] **voxeu.org/article/cost-delaying-action-stem-climate-change-meta-analysis**

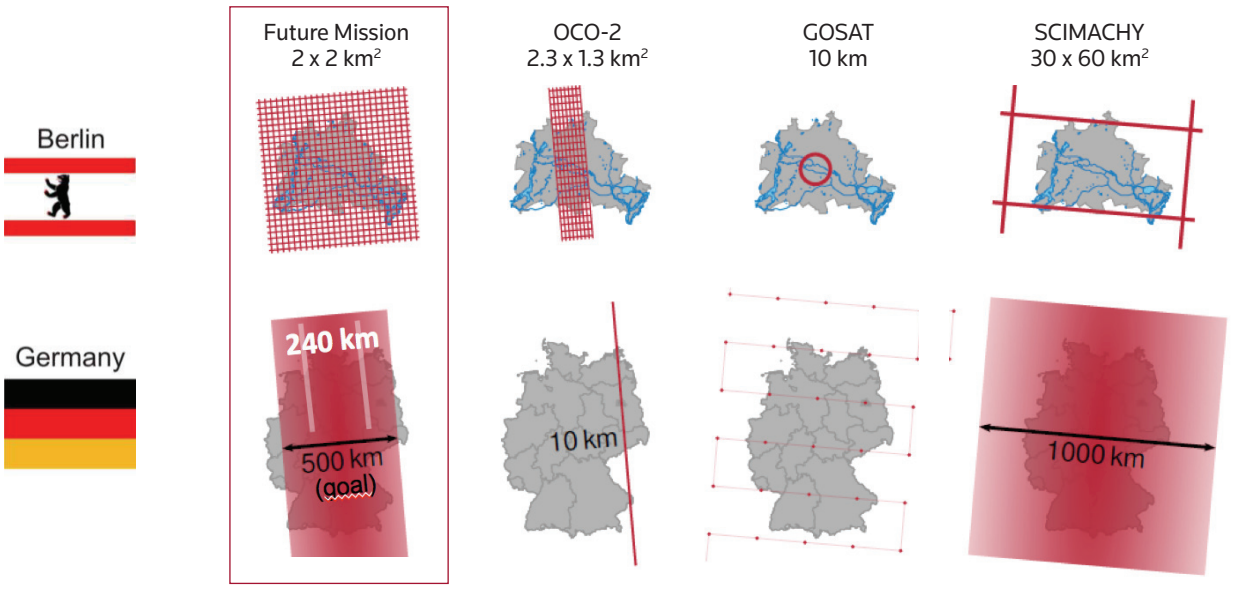
WHAT DOES LEADERSHIP LOOK LIKE?

It's very important to note that some of these companies are already demonstrating leadership. These include companies such as Enel and others just outside of Global 100, such as Xcel, Iberdrola and PG&E, all of which are top emitters.

But what do we mean by leadership? A few basic things:

1. **Leaders are transparent.** Currently over 50% of companies of the Global 100 report on their emissions from their operations, purchase of energy and value chains.[11] Interestingly, this level of transparency will be improving dramatically in the next few years due to improvements in satellite measuring, which will allow for verification of existing, point source GHG reporting and new measurement where there is currently no transparency. The European Space Agency has provided Figure 2 for inclusion in the report, and they are leading this part of the effort. Note the "Future Mission" section.
2. **Alongside transparency, leaders are also reducing their emissions** in line with IPCC guidance.[12] This means reducing GHG emissions at least 1.4% per year starting from a 2010 baseline for a 2-degree C pathway, and 2.1% for a 1.5-degree pathway, typically by decoupling growth from emissions. From a 2016 baseline, because of the general failure to reduce global emissions from 2010, firms will need to reduce GHG by at least 2% per year to stay within 2 degrees C.[13]
3. **Leaders have the confidence to challenge their organizations with publicly announced long-term GHG goals from the 2020s out to 2050, even when the solutions are still unknown.** This typically means setting transparent plans for getting to major milestones within a decade and aspirational goals to drive the reach for longer-term decarbonization. Note that even if a company has not been demonstrating past reductions, it can still qualify as a "climate leader" by transparently planning on more aggressive decarbonization from today forward.
4) **Leaders are using their influence to encourage leadership** from policy makers and their peers. These top firms have significant influence on regulatory direction in their economies,[14] and leadership is about promoting manageable decarbonization to achieve 2050 goals.

Figure 2: Work in progress towards a future anthropogenic CO_2 Emission Monitoring Sentinel Constellation Spatial Resolution and Coverage



IMPROVED SPATIAL RESOLUTION AND COVERAGE ENABLES NEW IMPORTANT APPLICATION AREAS: ANTHROPOGENIC C02 (AND CH4) EMISSION MEASUREMENTS FROM POINT SOURCES.

Source: Institute of Environmental Physics, University of Bremen, Germany

[11] The **Greenhouse Gas Protocol** is the most widely used emissions measurement and reporting standard.

[12] Over 260 firms have publicly committed to **Science-Based Targets**, a joint initiative of CDP, UN Global Compact, World Resources Institute and World Wildlife Fund. The initiative provides practical guidance and methodologies for target-setting as well as a free quality check service for submitted targets.

[13] And a 3% reduction for CO_2 (as previously described in a private sector emissions report) See **carbonbrief.org/analysis-four-years-left-one-point-five-carbon-budget** and the prior report at **thomsonreuters.com/content/dam/openweb/documents/pdf/corporate/Reports/global-500-greenhouse-gases-performance-trends-2010-2013.pdf** page 4).

[14] As a policy instrument, an internal carbon price – sometimes referred to as a shadow price – bakes the consequences of carbon pollution into a firm's internal accounting and capital budgeting processes, helping to incentivize low-carbon investments. There are multiple ways to design a carbon pricing scheme, but as this **executive guide** to carbon pricing explains, it does not need to be complicated. **Nearly 80 firms** have already committed to carbon pricing through the We Mean Business coalition.

These aspects of leadership are made possible by good governance. Given the emerging regulatory, reputational and operational risks with carbon-intensive business models, boards of directors from these companies have a fiduciary duty to these corporations to consider these aspects carefully, and investors and stakeholders generally will applaud and encourage that process. Professors Bob Eccles and Tim Youmans summarize their recent work[15] (see text at right) on the fiduciary duty owed by boards of directors to corporations, which includes considering the material regulatory and legal risks as atmospheric concentrations of CO_2 continue to rise.

David Hackett, partner at the global law firm Baker & McKenzie, summarizes that "greater marketplace and legal scrutiny lies ahead for major emitters of greenhouse gases, and as the climate leaders accelerate their emission reduction efforts, others will find their positions increasingly untenable accompanied by the growing potential for expanded risk and liability. Charged with the responsibility for assessing material risk, corporate boards of directors will find this duty more demanding and significant in light of the emerging trends and risks associated with climate change considerations."

Commentary from Eccles and Youmans on the role of the boards of directors from the Global 100

- Leadership on climate in these carbon giants is about the fiduciary duty owed by boards of directors to their corporations and what this means to the company's relationship with its shareholders and other key stakeholders.
- Leadership must begin with the board of directors; otherwise, top executives will be held hostage by short-term shareholders.
- A key way the board can communicate this leadership is to publish an annual one-page "Statement of Significant Audiences and Materiality (The Statement)."
- For the Global 100, a Statement is where the board publicly states its position on addressing climate change.
- Such a Statement also specifies which stakeholders are material for the corporation and the time frames for assessing progress.
- In publishing and acting on a Statement, boards of carbon-intensive emitters can provide critical leadership on mitigating emerging regulatory, reputational and operational risks.

[15] For more on the statement, see Eccles' and Youmans' survey of the fiduciary duty owed by boards of directors to corporations, to shareholders and to other stakeholders: **Materiality in Corporate Governance: The Statement of Significant Audiences and Materiality** – Journal of Applied Corporate Finance. Also: **The Board That Embraced Stakeholders Beyond Shareholders** – MIT Sloan Management Review, **Why Boards Must Look Beyond Shareholders** – MIT Sloan Management Review, **Why It's Time For Boards To Take A Stand On Sustainability** – Forbes.com

HOW TO BECOME A LEADER: THE SUSTAINABILITY PREMIUM

Few climate leaders have achieved their position by "bet the company" radical transformations. Instead, with a new appreciation of how increasing constraints posed by climate impacts drive deep and persistent change in customer needs and wants, they build their case for change and mobilize their organizations. Climate leaders develop a new value creation vision and a business case for evolving their company's capabilities over time. This vision propels progress on a decade-long pathway or *maturity curve* that closely resembles the stages described below.

As an example, let's follow Xcel Energy's journey. In 2004, the company issued its first carbon management plan. Then, in 2005, Richard Kelly was appointed Chairman and CEO, and the company issued its first Triple Bottom Line Report stating that *"comprehensive action is needed to address climate change today, including greatly increasing our use of resources that produce lower or no CO_2 emissions, increasing our energy conservation opportunities for customers, and participating in research and development on carbon sequestration … regardless of regulation our company is implementing voluntary carbon management targets …"*[16] This story continues below, explained in a four-stage framework applicable to all carbon-intensive companies.[17]

Stage 1: Doing Old Things in New Ways

First, companies capture early wins from operational improvements that typically reduce costs, as well as regulatory, financial and reputational risks. Emissions reduction is a by-product of improved operational efficiency and risk management. Continuing the example with Xcel Energy, in 2005, renewables account for about 9% of Xcel Energy's energy mix and are seen as "a cost-effective hedge against more volatile fuel prices." Xcel Energy has begun to focus on capturing efficiency gains for itself and its customers by rolling out energy-saving programs that have the added benefit of enabling better demand management. The capacity and economics of renewable initiatives is being actively tested.

Stage 2: Doing New Things in New Ways

Now with greater confidence, companies begin to evolve their operations and products, proving the market for innovations that meet customer needs while simultaneously delivering benefits on the climate challenge. As new models are proven, change in products, processes and whole systems becomes widespread.

Continuing the example,[18] in 2010, Xcel Energy reported expanded energy efficiency programs saving customers 987 GWh of power. Overall efforts to implement Xcel Energy's clean energy vision reduced CO_2 emissions from 2005 by 10%, with a 2020 goal set at a 20% reduction. Xcel Energy's Solar*Rewards® program to encourage solar usage grew from 300 customers in 2006 to 7300 in 2010, and Xcel Energy became a founding member of the Solar Technology Acceleration Center to build and share knowledge.

Stage 3: Transforming the Core

As vision becomes reality, eco-advantaged innovations drive durable and material sources of new revenues and profits. Often the growth of these new eco-advantaged portfolios far exceeds the rate of overall revenue growth. Old business lines give way to the new.

[16] **xcelenergy.com/staticfiles/xe/Corporate/Corporate%20PDFs/2005_Xcel_Energy_Triple_Bottom_Line.pdf**

[17] Adapted from The Sustainability Imperative, David A Lubin and Daniel C Esty. *Harvard Business Review*, May, 2010.

[18] **ral.ucar.edu/solutions/bringing-the-wind-to-the-grid**

Continuing our example,[19] Xcel Energy maintained its commitment to clean energy through a leadership change in 2011 to its new CEO and chairman, Ben Fowke. By 2015, Xcel Energy was recognized by the EPA as a climate leader. Emissions have declined 24% from 2005 levels, well ahead of targets, and the company produces 34% of its total energy from renewables with a goal of 43% by 2020. Xcel Energy introduced Renewable* Connect® in Minnesota and Colorado, a new way for consumers to set the dial on purchasing renewable energy for home or business all the way up to 100%.

Stage 4: New Business Model Creation and Differentiation

At the top of the curve, firms fully exploit the climate and environment megatrend as a source of differentiation in business model, brand, employee engagement and other intangibles, fundamentally repositioning the company and redefining its strategy for competitive advantage.

Finishing the example, Xcel Energy's 2017 investor presentation[20] opened with an assertion that its business strategy enables earnings growth without bill increases to its customers, resulting from key factors including reduced fuel, operating and maintenance costs from its renewables-heavy portfolio. Xcel Energy positions its brand with investors, consumers and employees as the leading clean energy provider, with a goal to add another 4000 MW from wind and solar by 2021, pushing its CO_2 reductions to 45% below 2005 by that year. Xcel Energy has climbed the maturity curve, and in prior three- and five-year comparisons has produced total returns that significantly outperform their EEI Index peer group.[21]

How to Become a Leader Summary

The pathway to the top is not an easy climb. It takes years, and in many cases a decade or more, of hard work. Not all firms have the scope of vision to see the opportunity. For some, it may not exist without radical transformation. Others may start strong but stop along the way as management changes shift priorities. Some CEOs prefer to wait to see if the demand is real.

For such companies the risks are great. Catching up may be hard or impossible – think of digital photography and Kodak. And even among those that see the opportunity, not all can build the capacity to execute successfully – remember BP's initial effort to get "Beyond Petroleum"?

Companies at the top of the curve are delivering a Sustainability Premium to their shareholders. Firms not yet there, but maintaining strong momentum as they climb the curve, have a significant sustainability premium potential. Understanding how to spot companies as they are rising may be an important insight for investors seeking an opportunity to outperform.

INNOVATION FOR A SUSTAINABILITY PREMIUM

Climbing this sustainable value curve requires innovation. The GHG-intensive industry sectors profiled below are significant contributors to global emissions.

Carbon dioxide (CO_2) accounts for 76% of GHG emissions (65% from fossil fuels and industrial processes, 11% from forestry and other land use).[22] Of the fossil fuels, coal is responsible for the most (24.8%) GHG emissions, followed by oil (20%) and natural gas (18.5%) for a total of 63.3%.[23] In other words, ending the use of fossil fuels would constitute a nearly 2/3 direct decrease in GHG emissions. However, fossil fuels power and have powered the world economy since the industrial revolution. The challenge is how to decarbonize the economy to achieve the low-carbon and ultimately net-zero status in the time needed to minimize climate impacts, ranging from serious disruptions to potential catastrophe.

For this innovation has a critical role to play in the fossil fuel producing industries as well as the carbon-intensive sectors. In each, leaders have the potential to create their own sustainability premium as they gain market share and increase their productivity with innovative solutions for a low-carbon future. These sector competitors are moving across a broad base of technologies and approaches. Making good strategic choices can be expected to pay big dividends as the constraints of climate change tighten. Let's take a closer look at existing and future pathways and see what is happening in some key sectors.

The industries mentioned below are reviewed in terms of the decarbonization pathways they will likely follow (to stay within 2 degrees C warming) and some of the innovations, whether technological or in terms of business models, likely to get them there.

Fossil Fuel Energy

- Natural Gas – While natural gas is the least carbon-intensive of the fossil fuels and provides a current economically viable alternative to more carbon-intensive fuels, deep decarbonization[24] requires natural gas to be progressively replaced by hydrogen[25], bio natural gas[26], treated bio gas[27] and Bio-SNG.[28] All these natural gas substitutes can be produced locally using waste and natural sources for both transport and heating purposes. Bio-SNG is produced by gasification of cellulosic materials (e.g., forestry residues, energy crops), whereas "biogas" is produced by a biological process – anaerobic digestion of organic materials (e.g., manure, organic waste).[29] Taking these technologies to scale remains a significant challenge. Companies such as Gazprom can play a key role in this progressive substitution.[30]

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[19] perrytonwind.com/quote_of_the_day_ben_fowke_xcel_energy_ceo

[20] Xcel Energy Morgan Stanley Investor Presentation Mar. 2, 2017, Xcel Doc No. 1001220683

[21] Ibid.

[22] epa.gov/ghgemissions/global-greenhouse-gas-emissions-data

[23] ecofys.com/files/files/world-ghg-emission-flow-chart-2012_v9-c-asn-ecofys-2016_02.pdf

[24] project-syndicate.org/commentary/paris-climate-talks-deep-decarbonization-by-jeffrey-d-sachs-et-al-2015-12

[25] ukerc.ac.uk/network/network-news/guest-blog-decarbonising-heat-by-replacing-natural-gas-with-hydrogen.html

[26] eon.com/en/business-areas/renewable-energy-source/bio-energy/bio-natural-gas/from-biogas-to-bio-natural-gas.html

[27] environbusiness.com/eeae/biogas

[28] biofuelstp.eu/bio-sng.html

[29] Ibid.

[30] dsmbiogas.com/en-us/News/Gazprom-to-Prepare-Investment-Plan-for-Producing-Exporting-Green-Gas-Russia

- Oil and Gas – The most viable innovation pathway for oil and gas is business model transformation and diversification. This is exemplified by Total with their Renewable Energy & Infrastructure[31] program (solar and battery/storage), and Statoil (offshore wind).[32] Another pathway is the progressive switch to natural gas away from oil, for example at Eni.[33] Making fossil fuel extraction less carbon-intensive by reductions in methane emissions and gas flaring and electrically powered platforms also has a material role to play. However, oil in a deep decarbonization model requires progressive substitution by renewable alternative fuels, such as biodiesel, bio alcohol (methanol, ethanol, butanol), refuse-derived fuel, chemically stored electricity (batteries and fuel cells), hydrogen, non-fossil methane, non-fossil natural gas, vegetable oil, propane and other biomass sources.[34]

- Coal – Increasing regulatory scrutiny, unsolved technological challenges and growing pressure from lower-cost alternatives, have largely closed the pathways for lower-emission coal-fired energy.[35] Even best practice supercritical (SC) and ultra-supercritical (USC) coal-fired power plants that produce 35% fewer emissions than conventional coal plants still produce more emissions per KWh than natural gas,[36] thus attracting more regulatory scrutiny than the alternatives. Carbon Capture and Storage (CCS) is an important innovation that can reduce emissions by 90%, but this makes coal significantly more expensive in an environment of steadily decreasing costs from renewables and alternatives.

Transport

- Aviation – Current projections estimate that airlines will purchase approximately 39,000 new aircraft valued at $5.9T between 2016 and 2035.[37] Similarly, the 3.4B passengers and 34.5M tonnes of freight airlines carry annually will grow at 4.6% per year during this period.[38]

  The aviation pathway to a low-carbon future took a major step forward with the introduction of the Boeing Dreamliner, a carbon fiber aircraft with a new generation of super-efficient engines, together reducing fuel consumption by approximately 20-30%. The success of the Dreamliner, which recently became Boeing's top-selling wide-body jet,[39] has inspired other R & D efforts that will drive gains across the emerging super-efficient fleet.[40]

  Another area ripe for innovation that will result in fuel savings and reduced GHGs is flight management systems. Big data analytic tools and services are now being sold from vendors such as Rolls Royce and Honeywell to optimize how aircraft are flown, from takeoff to landing. Predictive analytics are optimizing fuel efficiency and the emissions reductions from climb to cruise to descent and taxiing. While currently yielding only 2-3% gains,[41] that's off a very big base.

  The shift to biofuels is the third leg in the aviation pathway. The Commercial Aviation Alternative Fuels Initiative (CAAFI), formed in 2006 with more than 400 members, is well on its way to meeting the goal of 1 billion gallons of biofuel in use by 2018, yielding a 30-80% GHG reduction over conventional jet aviation fuel (over 67 billion gallons of aviation jet fuel were consumed in 2013).[42] These innovations hold the potential for net neutral growth in emissions from commercial aircraft in the 2020s. Ultimately, if we fully progress on the biofuels pathway, CO_2 emissions can be reduced to 0.2GT by 2050, (50% of the 2005 levels) as opposed to 2.1 GT projected in the business-as-usual case.[43]

  Finally, electric-powered flight is the biggest leap into the low-carbon aviation future, and both Airbus and Boeing are in. Zunum Aero, the three-year-old electric commercial airplane startup now partnered with Boeing and Jet Blue, hopes to dominate the regional travel market in the 2030s with 10- to 50-passenger ultra-efficient hybrid electric craft now in development.[44] Airbus, too, is serious enough about electric flight to put the E-Fan (electric powered jet engine) into production as a pilot-training aircraft. It will go on sale towards the end of 2017, to be followed by a four-seat version.[45] The battery versus fuel weight trade-off appears to be workable, especially for the short-haul regional travel market.

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31 CDP In the Pipeline by Tarek Soliman, Luke Fletcher and Charles Fruitiere – November 2016 – Which oil and gas companies are preparing for the future?

32 Ibid.

33 Ibid.

34 **en.wikipedia.org/wiki/Alternative_fuel**

35 Subsidized coal (due to lack of meaningful carbon pricing globally) is undoing much of the work being done to decarbonize the economy **wri.org/publication/global-coal-risk-assessment**

36 **glencore.com/assets/sustainability/doc/GLEN-Sustainable-Development-Presentation-20160613.pdf**

37 **boeing.com/resources/boeingdotcom/commercial/about-our-market/assets/downloads/cmo_print_2016_final_updated.pdf**

38 **airbus.com/company/market/forecast/**

39 **bizjournals.com/wichita/news/2017/02/24/boeings-787-dreamliner-hits-an-order-book.html**

40 Build Something Cleaner, Boeing Environmental Report, **2015_environment_report.pdf**

41 Going Beyond Fuel Management to Holistic Fuel Efficiency Service Solutions. Aviation Week Network, Nov 30, 2015

42 According to **indexmundi.com/energy/?product=jet-fuel**, at least 5,000,000 barrels of jet fuel were consumed per day in 2013 X 365 days X 36 gallons/barrel = 65.7 Bio gallons/year

43 **caafi.org/resources/pdf/Government_Partners_Activities_Update_Panel.pdf**

44 **fortune.com/2017/04/05/zunum-aero-boeing-jetblue-electric-planes/**

45 **economist.com/news/science-and-technology/21664944-using-electric-and-hybrid-forms-propulsion-very-different-looking-aircraft**

These advances hold great promise for increasing the interconnectedness of the world's people, itself an important stabilizing force, while reducing the burden on our atmosphere.

- **Automobiles –** Automobile manufacturers' biggest impact on climate change is through the cars they sell, as 79% of manufacturers' emissions comes from fleet emissions.[46] Renault, Nissan, BMW, Toyota and specialists like Tesla are leading the way in decarbonizing fleet emissions by increasingly selling cars that are battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs) and fuel cell vehicles (FCVs) rather than internal combustion engines (ICE).[47] From a resource use perspective, ICE cars are highly inefficient, with only 14% of energy reaching the wheels.[48]

  Beyond repowering, the industry is ripe for business model innovation, as ride-sharing businesses have demonstrated. Cars are not used most of the time (a car is parked 96% of its lifetime).[49] New car-sharing business models mean that 4 to 10[50] and even up to 15 cars could be replaced by one shared car.[51] Other usage patterns can also have huge impacts, with a factor of 9.3 reduction in energy consumed by commuting one time per week versus the typical five times per week.[52] Similarly, switching from cars to rapid transit buses can reduce emissions by a factor of five.[53]

  Pricing parking according to market forces and maximum limits (The Shard in London has 48 parking places for its 96 storeys) instead of being free or subsidized can bring significant economic benefits (€190 million for Amsterdam in revenues alone), encourage car sharing and public transport use, and stop subsidizing those that drive to work alone (76% of Americans in 2014).[54] Even Apple's new 318,000-square-meter HQ, planned to be one of the most resource-efficient buildings in the world, still must allocate 325,000 square meters to parking, due in large part to limited mass transit options.

  As more and more demand comes from the developing world's booming middle class, cars will need to be much cleaner, shared, and ultimately smart and driverless, which means safer and healthier for all, with less congestion and air pollution. There is great potential on the automobile pathway if we continue developing low-impact products and strategies.

Mining

Mining is highly energy-intensive as it goes deeper in more remote locations for poorer grade ores that require more processing and transportation. Mined thermal coal (for electricity generation) and coking coal (for steel production) are the most carbon-intensive due to their combustion. Others, such as iron ore (for steel), bauxite (for aluminum) and limestone, are carbon-intensive due to the energy intensity of their processing and, in the case of cement, additional release of CO_2 during production. Mining companies have, with few exceptions, opposed low-carbon regulations, and none have both absolute and intensity emission targets.[55] Their emissions are generally increasing when they should be decreasing.

Part of the answer lies in renewables (solar and wind) powering mining, as is the case, particularly, in remote locations in India, Africa and Chile, with the surplus electricity being sold locally.[56] Coal mining will be increasingly unviable due to cost, regulatory change and competition from renewable energy sources for electricity generation (e.g., solar) and steel manufacture (e.g., hydrogen). This will only happen if developing countries also make the leap to renewables rather than build coal-fired plants that damage health and cause the climate change that is expected to affect them most. The transformation of existing coal mines to components of a renewable energy infrastructure can be made complete by converting them, for example, to geothermal power sources[57] or as giant batteries for renewable energy storage.[58]

Cement

Cement manufacturing is highly carbon-intensive, estimated to be 3.8% of global emissions.[59] Beginning as early as 2002, the Cement Sustainability Initiative (CSI) started the search for solutions to the GHG challenge posed by and potentially imposed on the cement industry. With 23 major cement companies operating in 100 countries producing approximately 30% of global volume, these firms are committed to keeping cement a viable product well into the 21st century. Through the work of the CSI, companies are reducing GHGs and other toxins in their value chain. From 1990 to 2010, cement production grew globally by 61% while GHG emissions increased by 39%, showing evidence of meaningful reductions in intensity.

Still, getting on a 2-degree pathway requires aggressively decreasing absolute emissions from current levels. For this scenario to occur, the cement industry will need to step up its use of low GHG materials and kiln operators will need to shift to cleaner sources of energy.

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46 Emission impossible: Which car makers are driving into trouble? Chloe Chan, Pedro Carqueija and James Magness, CDP, March 2016

47 Ibid.

48 Reinventing Fire: Bold Business Solutions for the New Energy Era, Amory B. Lovins and the Rocky Mountain Institute

49 Ibid.

50 MOMO (2010). The state of European car-sharing. Final Report D 2.4 Work Package 2.MOSES (2005). Mobility Services for Urban Sustainability. Moses deliverable 6.2.

51 The future of driving: Seeing the back of the car, *The Economist*

52 **cta.tech/CTA/media/policyImages/Telecommuting-e-Commerce-Study.pdf** analysis of page 33 table

53 **wricities.org/**

54 Briefing: Parking, *The Economist*, April 17th, 2017

55 Making the grade: Are some miners chasing fool's Gold? CDP, November 2015

56 **wbcsdcement.org/index.php/key-issues/climate-protection/sectoral-market-mechanisms/modeling-results-sectoral-approach?id=116**

57 **cleantechnica.com/2012/05/03/mining-old-coal-mines-for-instant-geothermal-energy/**

58 **independent.co.uk/news/world/europe/germany-coal-mine-convert-renewable-battery-hydroelectric-prosper-haniel-north-rhine-westphalia-a7648841.html**

59 **epa.gov/ghgemissions/global-greenhouse-gas-emissions-data#Sector**

Given the demand projections for cement in the rapidly urbanizing global economy, absolute increases are expected through the 2020s. However, if the potential of these advances are adopted by 2030, absolute emissions could be approximately 2110 MT of CO_2, down from their expected peak in the 2020s and back near to levels reported in 2010.[60]

Additionally, developers also may diversify and switch to more sustainable building materials (such as bamboo, lumber and dimension stone)[61] combined with modular construction (67% less energy in construction, 80% less energy consumed during use, 100 % recyclable)[62] to manage a more sustainable overall demand for cement.

Steel

With global steel demand, emissions and energy intensity increasing in recent years, emerging technologies have still to prove their potential.[63] Combined with a highly competitive and recently oversupplied market, three steel manufacturers stand out as leading in technology investment needed for a sustainable future: POSCO, SSAB and Thyssenkrupp. Following is an extract from CDP's report on Steel:[64]

- POSCO's FINEX technology provides incremental emissions reductions from steelmaking by eliminating sintering and coke oven processes that can be combined with Carbon Capture and Storage CCS. POSCO is in the early stages of hydrogen-based steelmaking.
- SSAB emissions intensity is low, driven by significant electric arc furnace (EAF) operations and Europe-based blast furnace-basic oxygen furnace (BF-BOF) plants, that it states benchmark as among the most carbon efficient globally. It recently announced a long-term breakthrough emissions reduction project, HYBRIT, working toward a hydrogen-based steelmaking process using renewable energy that envisages elimination of almost all the process emissions of steelmaking. It is aiming for a working demonstration plant around 2025, with potential for commercialization envisaged a further one to two decades later.
- Thyssenkrupp's intensity is the lowest of companies focused on the blast furnace steelmaking route – only Hyundai Steel and SSAB with significant electric arc furnace operations have lower emissions intensities. Thyssenkrupp is pursuing a CCU project, Carbon2Chems, seeking to create usable chemicals from CO and CO_2 waste gases from steelmaking.

Given the required 70% reduction in GHG required for the steel sector to stay within 2 degrees C by 2050,[65] and the early stages of decarbonization technologies, much more needs to happen, especially by preserving steel, which can be endlessly recycled. In addition to substitution by carbon fiber (e.g., in aviation and automobiles), polymers, wood, alloys, etc., steel can be produced as high-strength steel, which is 25-40% lighter with the consequent drops in energy use and emissions produced.[66]

Finished products with high steel content (e.g., cars), can be designed for much longer life-spans and shared (e.g., five 2,000-cycle washing machines can be replaced by one 10,000-cycle washing machine).[67] Over 50% of steel is used in long-life buildings and infrastructure, trains and ships. With flexible building design, the life of buildings can be extended to 200 years and automobiles to 300,000 miles.[68] Maersk is using the design phase of its container ships (that are made up of 98% steel) to improve their recovery and recyclability through its cradle-to-cradle passport program; existing ships can also benefit from such documentation for up to 70% of their materials.[69] Finally recycling of steel reduces energy use by 70%, and each 1 ton of steel recycled avoids extraction of 1.4 tons of iron ore, burning 720 kg of coal and 120 kg of limestone.[70]

[60] **wbcsdcement.org/index.php/key-issues/climate-protection/sectoral-market-mechanisms/modeling-results-sectoral-approach?id=116**

[61] **sustainabilityworkshop.autodesk.com/buildings/green-building-materials; en.wikipedia.org/wiki/Green_building**

[62] **constructionglobal.com/majorprojects/492/3-reasons-why-modular-construction-is-more-sustainable-than-traditional-methodology**

[63] Nerves of Steel: Who's ready to get tough on emissions? Drew Fryer, Chloe Chan and Tom Crocker, CDP, October 2016

[64] Ibid.

[65] Ibid.

[66] **circulareconomy-worldsteel.org/**

[67] **ellenmacarthurfoundation.org/circular-economy/interactive-diagram/in-depth-washing-machines**

[68] **lcmp.eng.cam.ac.uk/wp-content/uploads/allwood-and-cullen-r09-davos.pdf**

[69] **ellenmacarthurfoundation.org/case-studies/using-product-passports-to-improve-the-recovery-and-reuse-of-shipping-steel**

[70] **circulareconomy-worldsteel.org/**

Buildings

Globally, buildings account for nearly 16% of the total GHG emissions and consume approximately 40% of electricity production in the U.S.[71]

Many studies and research reports from experts in the field of sustainable buildings report that trillions of dollars in energy costs could be saved with currently available technologies. The widely referenced retrofit of the iconic Empire State Building has reduced energy consumption by 38% and produced annual cost savings of approximately $4 million.[72] The net-zero pathway for both residential and commercial is still in its early stages. Design strategies and life cycle ownership cost comparisons are being tested, but cost differentials are falling. Major innovations in building technologies from companies such as UTC, Ingersoll-Rand, Johnson Controls and others will enable both near-term high-efficiency gains and the path to net-zero.

However, there are two pieces of research that, if more widely understood, could significantly influence the flow of capital to "green buildings," especially as our urban populations rapidly grow, along with investments in new commercial construction.

First, a 2015 report from the U.S. Department of Energy presents a review of prior research studies on LEED and Energy Star–certified buildings. The report offers some powerful conclusions reflecting the business logic of sustainable design. LEED and Energy Star buildings have higher rental rates, a premium of approximately 16 and 8 percent, respectively, compared to similar properties. Likewise they have higher occupancy rates (on average 17 and 10 percent), and a sales prices per square foot increase of approximately 20 and 8 percent. All while reducing utility bills and incurring only a small construction cost premium of approximately 2 percent.[73]

The second 2015 report from Harvard University's Chan School of Public Health cites an even more startling finding. People who work in green buildings have higher levels of cognitive functioning and make better decisions than their peers in non–green buildings, where ventilation, air quality and other environmental factors adversely affect cognitive functioning. Professor Joseph Allen, the report's author, suggests that "even modest improvements on indoor environmental quality may have profound impact on the decision making performance of workers."[74]

Taken together, these findings on the business logic of decarbonizing our homes and offices should inform the flows of capital toward a new low-carbon future.

Innovation Summary

Of course, these are just examples of what is driving decarbonization in these different sectors. In each, innovative research and development is producing advances that create the potential for leading companies to expand products and markets, while simultaneously significantly reducing their (and their customers') GHG emissions.

Utilities sit at the crucial intersection of most of these sectors. Electricity is a common denominator. The emerging experience with solar photovoltaic (PV) cells will likely have parallels in other sectors. The risks and costs associated with coal are rising, with little potential for decline, while the risks and cost of clean energy alternatives such as PV cells continue to fall. According to Swanson's Law,[75] the price of solar photovoltaic panels will drop in the future, as it has in the past, roughly 20 percent for every doubling of cumulative shipped volume. At present rates, costs halve about every 10 years,[76] and will continue to do so, as the volume continues to grow.

If the anticipated global infrastructure investment in utilities[77] follows the pathway shown by climate leaders such as Excel Energy, rather than a heavy reliance on fossil fuels, then upward volumes will continue to drive lower prices. If clean energy PV cell prices keep falling, then achievement of the 2050 target for energy sector global GHG emissions is a manageable challenge.[78]

Innovations across many of the sectors discussed will need to find and follow their own versions of Swanson's Law. Companies will allocate capital to research and development that should help them compete in a not-too-distant future that will likely be very different from the present. If those innovations follow the types of pathways described here, then competitive low-carbon solutions may become economically feasible and scale up. If supply of and demand for innovative solutions fails to fully materialize, then hard-to-recover ground will be lost.

We cannot and should not rely on last-minute solutions to make up for lost time on climate change and emissions.[79] There are no quick fixes to getting global scale innovations in place. The climate trend is not in line with scientific guidance and needs to be reversed by following key sector pathways like those described above. To do otherwise is to push even more risk onto future generations.

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[71] **eia.gov/tools/faqs/faq.php?id=86&t=1**

[72] **esbnyc.com/esb-sustainability**

[73] Energy Efficiency & Financial Performance: A Review of Studies in the Market. U.S Department of Energy, December 2015

[74] **green.harvard.edu/tools-resources/research-highlight/impact-green-buildings-cognitive-function**

[75] **en.wikipedia.org/wiki/Swanson%27s_law**

[76] Ibid.

[77] **web.stanford.edu/group/efmh/jacobson/Articles/I/CountriesWWS.pdf**

[78] Ibid.

[79] Ibid.

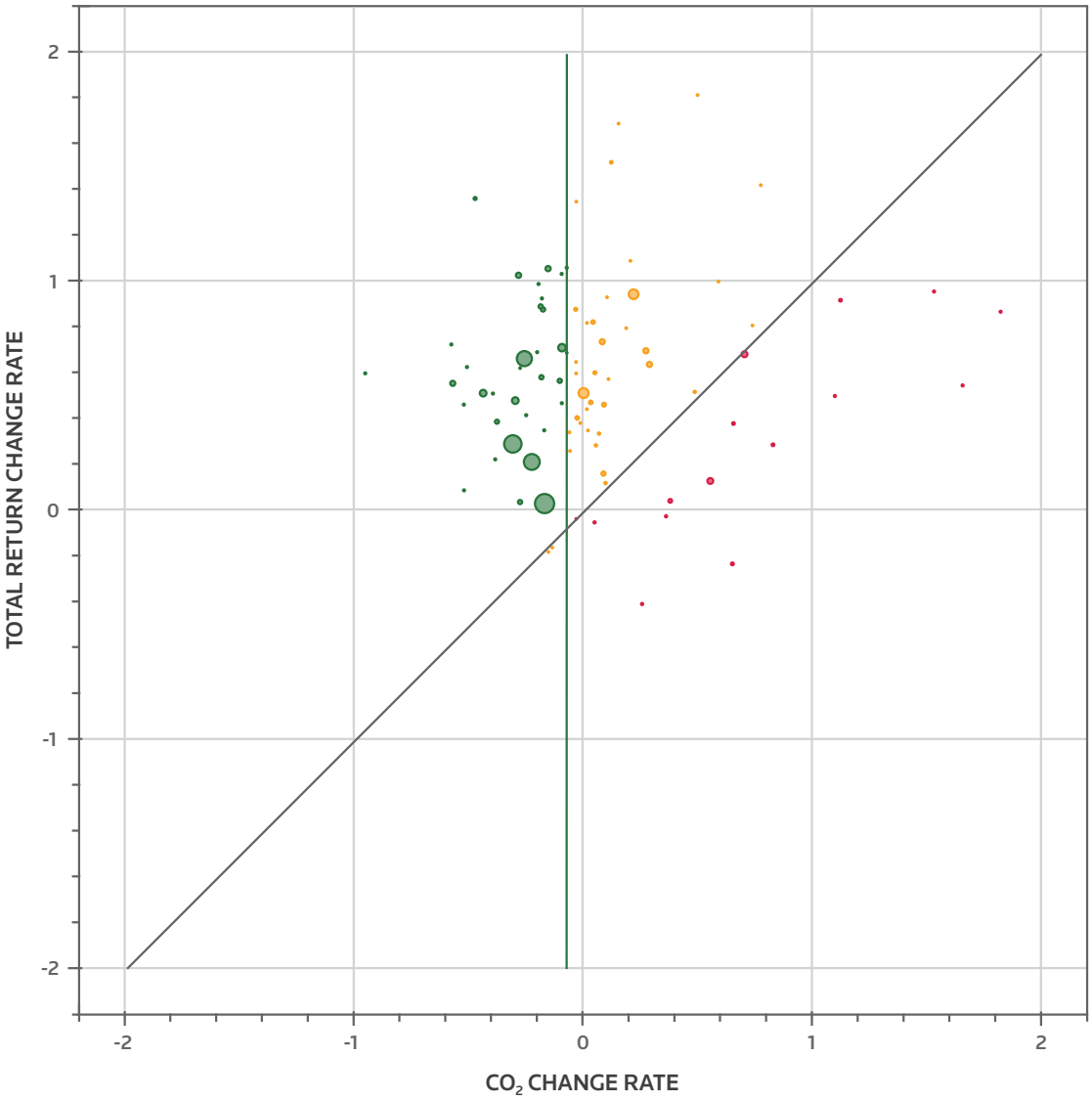
INDICATIONS OF A "SUSTAINABILITY PREMIUM"

Digging deeper into the relationship between financial performance and carbon emissions, we begin to see indications of a "sustainability premium." A Pearson correlation analysis of the top 100 emitters from North America and Europe, after excluding outliers, unsurprisingly shows a positive correlation between change of revenue and CO_2 emissions; however, no correlation between either rate of change in net income or total return and CO_2 emissions was found. In other words, while revenues tend to trend with emissions, financial performance may not. This could indicate that decoupling of economic performance with emissions reductions is beginning to occur in more regulated markets, meaning that shareholder value is not being negatively impacted from decarbonization.

In Figure 3, company momentum (positive or negative) on CO_2 emissions is plotted against momentum on total return to shareholders for the most recent four-year period. The larger the dot the higher the absolute level of emissions, typically reflecting both the scale of the enterprise and intensity of emissions. Companies to the left of the vertical green line are decarbonizing in line with guidance – often reflecting significant investment in transforming products and operations.

The creation of consistent profits independent from the amount of GHG being released points to a trend away from correlation between increased CO_2 emission leading to more net income. In fact, some of the largest emitters are demonstrating the potential of decoupling strategies with positive trends in both emissions reduction and earnings growth.

Figure 3: Correlation between CO_2 Change Rate and Total Return to Investors



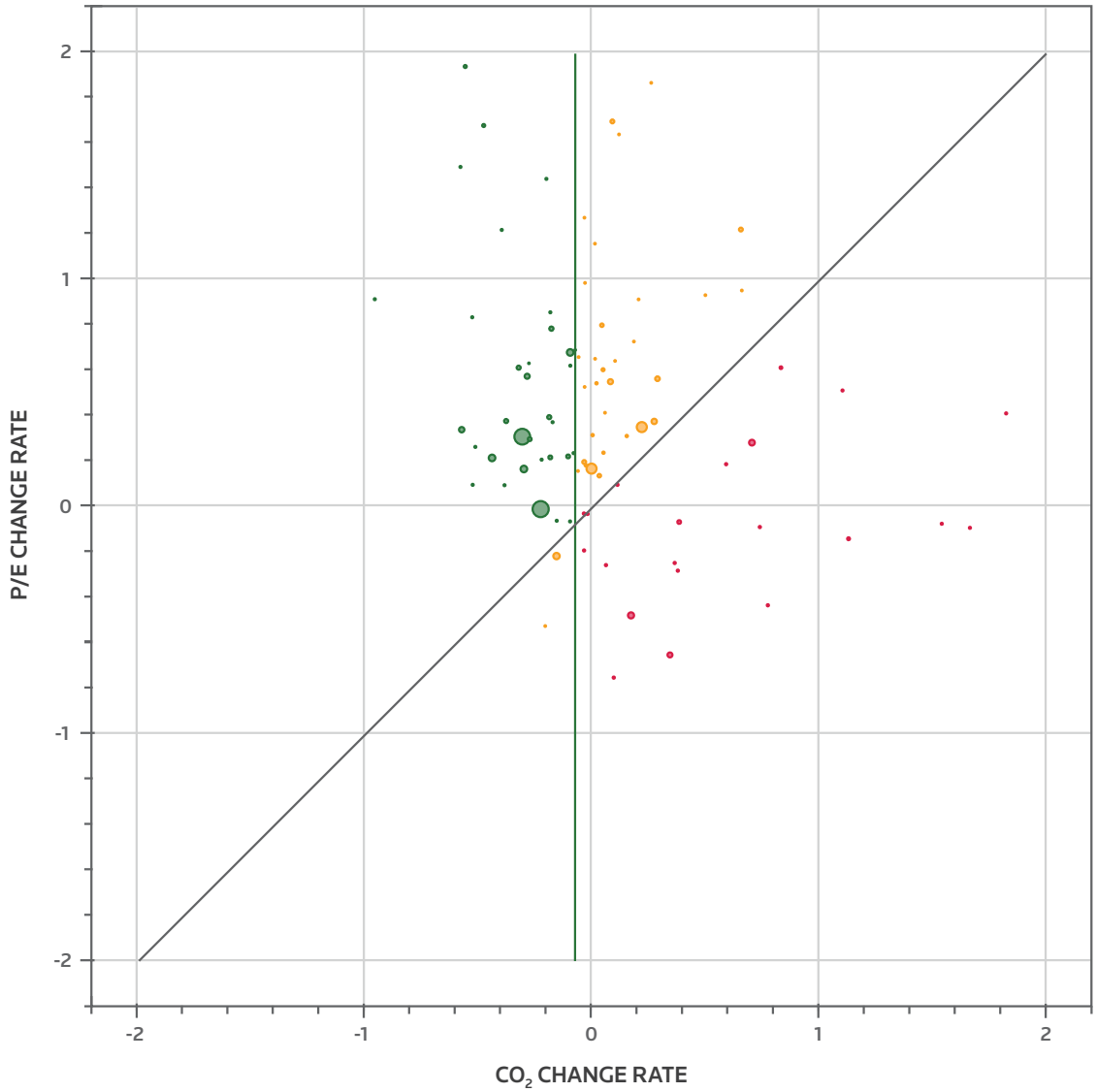
Interestingly enough, in Figure 4, a weak negative correlation (r = -0.22) can be found between momentum in price/earnings (P/E) ratio and momentum in GHG emission that is significant ($p < 0.05$). P/E momentum is often an indication of how investors assess the likely future value of a company via the current stock price.

Given the observed negative correlation, the results may indicate that investors in carbon-intensive sectors in a more regulated environment see a greater likelihood of increasing value for companies that are decarbonizing, in comparison to others that do not show progress on emission reduction.

Taken together, these finding support the new business logic, even among the world's largest emitters, that positive momentum in shareholder value and financial performance can be consistent with meaningful progress on GHG reductions.

Of course, there are also the myriad and growing number of analyses demonstrating the importance of ESG factors to effective risk management and long-term value creation generally, and climate leadership specifically.[80] This evidence will continue to mount, as real-world conditions worsen and the risks become more manifest for shareholders and the global community of inhabitants on our finite planet.

Figure 4: Correlation between CO_2 Change Rate and Price/Earnings Ratio



[80] cfapubs.org/doi/full/10.2469/cfm.v28.n1.13#%2EWNuDajS9ZNp%2Elinkedin

CONCLUSION

This report adds another voice to the urgent call for action to reduce the risks associated with GHG emissions that continue above the recommended guidance of the world's climate scientists. Many other reports have catalogued the scale of loss, both financial and societal, that we may experience. These are not new observations. The recognition of this situation has become more firmly planted in the minds of the largest investors, asset managers, corporate leaders, governing institutions and global citizens.

This report focuses on some of the largest emitters on our planet and the role they will inevitably play either enabling us to stay within the guardrails on the pathway to a sustainable future or veering dangerously off course, risking our economic and ethical foundation.

The cases and sector views presented demonstrate that making our way toward a low-carbon future is possible. The data suggest companies, even in carbon-intensive sectors, can have a winning strategy turning leadership into business opportunity. Dennis Whalen, leader of KPMG's Board Leadership Center,[81] states, "As we cross the threshold to a lower carbon world, there is a growing recognition of risks associated with long-term carbon intensive business models. Early movers that invest now in staying competitive in a low carbon future, could gain significant advantages as they integrate lower cost, lower risk and more resilient business models."

Our global business economy, and especially our Global 100 companies, will spend vast sums of money in the coming decades building new plants, buying new equipment, developing new products, and finding new sources of raw materials. Likewise, our civil societies and consumers will spend trillions on new infrastructure, construction materials, equipment and supplies in the same time period.

If those dollars push forward solutions that meet or exceed customer needs while simultaneously reducing climate impacts, then we will be on the right path. From the jet airplanes we fly to the cement runways we land on, innovative low-carbon solutions are within reach.

For companies who have been on the sidelines, this report offers some excellent examples of how firms translate vision into action – and action into results.

For investors seeking maximum risk-adjusted returns, there are early signs that companies leading us on this "green" pathway can also be generating higher total return for shareholders.

The world is entering a new chapter in meeting the climate challenge. Two things are true. First, the timeline for bending the GHG curve is tightening, adding urgency to the need for change. And second, the needed cost curve reductions on new climate-friendly technologies have arrived. This means "crossing the chasm" from early adoption to mainstream demand and accelerated growth is now underway.

The choices made by the Global 100 companies and the customers who buy from them will go a long way toward defining which path we are on and the state of our planet in 2050.

[81] Dennis Whalen is Leader of the KPMG Board Leadership Center (BLC). The BLC champions outstanding governance to help drive long-term corporate value and enhance investor confidence. Through an array of programs and perspectives—including KPMG's Audit Committee Institute, the Women Corporate Directors Foundation and Board Exchange – the BLC engages with directors and business leaders to help articulate their challenges and promote corporate governance.

[82] GHG emission data for this report is a result of a collaboration between Thomson Reuters and CDP, to combine and publish the most current (2015) and best estimates available on these companies. Generally, if a company reported its own emissions, those figures were used unless they are not sufficiently representative of the global footprint of the company. More specifically by source, Thomson Reuters source for data is Scopes 1, 2 and 3 public disclosures made by the company, or proprietary estimates in lieu of scopes 1 or 2. CDP sources for data from its Full GHG Emissions Dataset are:

- **Scopes 1 and 2:** CDP completed information requests, CDP data check of information requests, data collected from company filings, bottom-up estimations (physical activity data * EFs for O&G, coal, cement, electric utilities, and iron and steel), intracompany estimation (using previously reported values to estimate, interpolation, etc.) and multivariable regression analysis (revenue by activity as independent variables).
- **Scope 3:** CDP completed information requests, data collected from company filings, multivariable regression analysis (revenue by activity as independent variables with aggregation to higher industry groupings as needed) and bottom-up estimations (physical activity data * EFs for Scope 3 "Use of sold products" emissions for O&G, coal and automobile manufacturers).
- CDP's modelling methodology is publicly available from: **cdp.net/en/investor/ghg-emissions-dataset**

Indexes: GHG Index = (GHG emissions 2015/GHG emissions 2014)*100. Results of 120 = 20% increase in emissions, 80 = 20% decrease in emissions.

Revenues Index = (Revenues 2015/ Revenues 2014)*100. Results of 120 = 20% increase in revenues, 80 = 20% decrease in revenues. Decoupling index = Revenues Index/GHG Index. Results of 120 = Revenues growing at a 20% greater rate than GHG emissions growth rate, 80 = Revenues growing at a 20% lesser rate than GHG emissions growth rate.

Where changes in GHG from 2014 to 2015 are known to be due to changes in level of reporting, methodology used or estimation methods uses (e.g., in cases of cross-sectional regression analysis with differing test data), the 2015 value was used for 2014 (also if 2014 data was private). This was the case for United Technologies Corporation, Fairmount Santrol Holdings Inc., Procter & Gamble Company, General Electric Company, Boeing Company, Airbus Group, Michelin, Martin Marietta Materials, Inc. and Ford Motor Company. Financial years for GHG emissions and revenues may differ, and may differ with calendar years.

APPENDIX 1: GLOBAL 100[82]

		GHG emissions Tons CO_2e Scope 1+2+3		GHG Index*	Revenues USD		Decoupling Index*
Source GHG	Company Name	2015	2014	Baseline 2014 =100	2015	2014	Baseline 2014 =100
CDP	Coal India	2,014,693,250	1,850,080,574	109	11,903,683,242	11,770,273,584	93
CDP	PJSC Gazprom	1,247,624,306	1,264,855,340	99	83,315,971,620	95,924,596,230	88
CDP	ExxonMobil Corporation	1,096,498,615	1,145,083,349	96	259,488,000,000	394,105,000,000	69
CDP	China Petroleum & Chemical Corp	873,898,581	902,075,103	97	310,968,548,490	455,452,559,380	70
CDP	Rosneft OAO	835,887,091	833,148,361	100	70,606,500,000	94,816,690,000	74
CDP	PETROCHINA Company Limited	730,914,625	693,615,195	105	265,767,674,840	367,944,985,540	69
Thomson Reuters	Rio Tinto Ltd	663,900,000	628,700,000	106	34,829,000,000	47,664,000,000	69
CDP	China Shenhua Energy	643,810,940	728,365,957	88	27,273,938,070	40,789,064,770	76
Thomson Reuters	Royal Dutch Shell PLC	641,000,000	686,000,000	93	264,960,000,000	421,105,000,000	67
CDP	Petróleo Brasileiro SA - Petrobras	629,174,567	634,294,435	99	96,468,000,000	143,657,000,000	68
Thomson Reuters	Total SA	575,800,000	598,400,000	96	143,421,000,000	212,018,000,000	70
CDP	United Technologies Corporation	530,627,775	530,627,775	100	56,098,000,000	57,900,000,000	97
CDP	BHP Billiton PLC	474,376,663	436,331,000	109	30,912,000,000	44,636,000,000	64
Thomson Reuters	Eni SpA	466,131,372	450,838,037	103	73,565,665,012	112,728,482,429	63
Thomson Reuters	BP PLC	457,800,000	461,400,000	99	222,894,000,000	353,568,000,000	64
CDP	Valero Energy Corporation	438,076,129	448,800,949	98	87,804,000,000	130,844,000,000	69
Thomson Reuters	Chevron Corp	428,000,000	414,000,000	103	129,648,000,000	199,941,000,000	63
Thomson Reuters	Korea Electric Power Corp	399,984,300	443,325,000	90	50,178,919,954	52,589,333,882	106
CDP	Peabody Energy Corporation	397,079,232	433,138,945	92	5,609,200,000	6,792,200,000	90
CDP	Toyota Motor Corporation	377,020,000	383,198,000	98	226,863,559,930	248,954,617,590	93
CDP	YTL Corp	372,995,902	393,967,914	95	4,441,845,410	6,003,908,864	78
Thomson Reuters	General Motors Co	359,381,663	333,986,186	108	152,356,000,000	155,929,000,000	91
CDP	Phillips 66	331,341,051	323,169,655	103	98,975,000,000	161,212,000,000	60
CDP	Volkswagen AG	328,330,937	336,875,378	97	236,618,000,000	268,484,000,000	90
CDP	ENGIE	319,709,310	350,307,803	91	77,526,000,000	99,043,000,000	86
Thomson Reuters	Statoil ASA	313,800,000	304,600,000	103	57,900,000,000	96,708,000,000	58
CDP	Exor S.p.A.	295,542,540	234,989,334	126	148,086,960,000	145,287,389,400	81
Thomson Reuters	Glencore PLC	290,714,000	312,923,000	93	170,497,000,000	221,073,000,000	83
Thomson Reuters	Honda Motor Co Ltd	284,160,000	279,007,000	102	129,718,825,515	110,956,535,132	115
CDP	Marathon Petroleum	279,703,599	260,251,261	107	72,251,000,000	98,081,000,000	69
Thomson Reuters	Vale SA	274,600,000	270,900,000	101	25,643,458,573	37,520,838,605	67
CDP	Reliance Industries	268,120,610	256,820,959	104	60,294,861,000	72,424,482,000	80
Thomson Reuters	Fairmount Santrol Holdings Inc	267,847,451	267,847,451	100	828,709,000	1,356,458,000	61
Thomson Reuters	Hitachi Ltd	266,810,000	246,070,000	108	89,146,277,541	81,376,373,626	101
CDP	ConocoPhillips	254,391,143	254,350,422	100	29,456,000,000	52,366,000,000	56
CDP	Huaneng Power International	248,537,456	252,425,954	98	19,855,217,511	22,568,101,685	89
Thomson Reuters	RWE AG	247,500,000	248,800,000	99	50,343,719,117	55,826,528,761	91
CDP	Anglo American	244,372,036	332,688,759	73	20,455,000,000	27,073,000,000	103
CDP	CNOOC	235,533,813	209,869,268	112	26,406,441,110	44,262,761,780	53
CDP	MAN SE	225,234,175	200,242,542	112	14,880,372,000	17,281,774,200	77
CDP	Procter & Gamble Company	221,217,336	221,217,336	100	70,749,000,000	74,401,000,000	95
Thomson Reuters	Lafargeholcim Ltd	221,000,000	131,800,000	168	23,541,625,075	18,936,726,687	74
CDP	China Coal Energy	216,366,242	260,638,235	83	9,129,491,336	11,388,891,093	97
Thomson Reuters	ArcelorMittal SA	205,000,000	206,000,000	100	63,578,000,000	79,282,000,000	81
Thomson Reuters	E.ON SE	203,300,000	230,500,000	88	126,212,790,912	136,811,226,033	105
CDP	Anhui Conch Cement	197,501,682	188,471,477	105	7,851,838,827	9,792,447,593	77
CDP	General Electric Company	197,315,071	197,315,071	100	117,385,000,000	117,184,000,000	100
CDP	Saic Motor Corporation	185,737,143	204,344,712	91	103,000,000,000	102,000,000,000	111
CDP	NTPC Ltd	183,071,000	186,073,300	98	13,188,000,000	13,073,000,000	103
CDP	Goodyear Tire & Rubber Company	182,845,651	182,624,444	100	16,443,000,000	18,138,000,000	91
CDP	Audi AG	180,641,372	134,355,077	134	63,400,000,000	65,100,000,000	72

		GHG emissions Tons CO_2e Scope 1+2+3		GHG Index*	Revenues USD		Decoupling Index*
Source GHG	Company Name	2015	2014	Baseline 2014 =100	2015	2014	Baseline 2014 =100
CDP	China National Building Materials Company Limited	180,529,972	183,584,089	98	15,447,913,146	19,664,548,650	80
CDP	Boeing Company	178,391,357	178,391,357	100	96,114,000,000	90,762,000,000	106
CDP	China Resources Power Holdings Company Limited	173,417,583	171,340,129	101	9,217,370,951	9,115,680,593	100
CDP	Ingersoll-Rand Co Ltd	165,732,301	192,316,700	86	13,300,700,000	12,891,400,000	120
CDP	SK Innovation Co Ltd	165,158,319	157,767,203	105	41,102,872,352	59,933,248,482	66
CDP	BASF SE	160,155,082	225,199,703	71	76,507,614,000	89,912,162,200	120
CDP	JX Holdings, Inc	159,910,347	171,063,955	93	90,650,891,800	120,272,405,970	81
CDP	Oil & Natural Gas	159,908,391	164,954,450	97	25,890,603,356	29,085,325,235	92
Thomson Reuters	PTT PCL	158,639,426	157,001,887	101	56,271,836,987	79,181,227,499	70
CDP	Yanzhou Coal Mining	158,398,227	184,141,197	86	10,629,207,049	10,528,612,856	117
CDP	Novatek OAO	156,082,204	143,040,353	109	6,516,705,750	6,162,188,890	97
Thomson Reuters	Surgutneftegaz OAO	153,983,125	144,871,000	106	13,743,822,782	15,342,291,591	84
CDP	Nissan Motor Co, Ltd	148,144,914	144,556,655	102	94,755,474,310	101,575,618,800	91
CDP	Repsol	146,837,090	143,160,973	103	44,083,000,000	62,626,000,000	69
Thomson Reuters	Centrica PLC	144,120,328	150,107,507	96	41,223,545,363	45,796,866,727	94
CDP	Canadian Natural Resources Limited	142,348,671	121,864,524	117	8,933,503,800	16,235,949,990	47
CDP	Airbus Group	141,769,289	141,769,289	100	69,992,700,000	73,444,516,100	95
Thomson Reuters	Power Grid Corporation of India Ltd	138,671,500	118,941,782	117	3,222,991,698	2,835,282,822	98
Thomson Reuters	Gas Natural SDG SA	138,213,300	116,163,900	119	28,252,299,606	29,876,005,565	79
Thomson Reuters	Sumitomo Heavy Industries Ltd	137,500,000	134,500,000	102	6,226,350,391	5,553,604,729	110
Thomson Reuters	Dow Chemical Co	137,500,000	136,600,000	101	48,778,000,000	58,167,000,000	83
CDP	Rolls-Royce	133,041,391	130,866,127	102	20,227,905,000	21,391,072,800	93
CDP	EDF	129,190,322	133,668,810	97	81,456,516,000	88,771,415,100	95
CDP	Cloud Peak Energy Inc	128,995,633	149,539,488	86	1,120,000,000	1,320,000,000	98
CDP	A.P. Moller - Maersk	128,531,578	88,111,490	146	40,308,000,000	47,569,000,000	58
Thomson Reuters	Enel SpA	128,303,000	123,697,000	104	79,360,562,983	88,705,014,214	86
Thomson Reuters	Tokyo Electric Power Co Holdings Inc	128,049,054	129,800,000	99	53,926,154,940	56,630,569,431	97
Thomson Reuters	Bridgestone Corp	126,375,000	130,375,000	97	31,506,658,354	30,698,228,610	106
CDP	Michelin	125,146,604	125,146,604	100	23,022,114,000	23,653,264,100	97
CDP	American Electric Power Company, Inc	125,013,953	141,118,430	89	16,453,200,000	16,378,600,000	113
Thomson Reuters	OMV AG	124,300,000	125,100,000	99	24,464,330,318	43,444,021,049	57
Thomson Reuters	Kumba Iron Ore Ltd	124,149,454	118,725,812	105	2,280,503,185	4,115,251,600	53
CDP	Ecopetrol Sa	123,420,224	124,649,909	99	16,669,096,640	27,708,192,960	61
CDP	Martin Marietta Materials, Inc	122,090,246	122,090,246	100	3,539,570,000	2,957,951,000	120
CDP	Duke Energy Corporation	121,058,680	149,246,865	81	22,371,000,000	22,509,000,000	123
Thomson Reuters	Ford Motor Co	120,310,000	120,310,000	100	149,558,000,000	144,077,000,000	104
CDP	Huadian Power International Corp Ltd	119,430,410	134,492,585	89	10,938,393,163	12,350,981,064	100
Thomson Reuters	Nestle SA	118,628,768	102,847,141	115	88,625,474,147	92,155,718,741	83
CDP	The Southern Company	117,877,643	130,611,174	90	17,489,000,000	18,467,000,000	105
CDP	Anadarko Petroleum Corporation	116,026,758	117,568,847	99	8,698,000,000	18,470,000,000	48
Thomson Reuters	Exelon Corp	113,784,000	119,378,000	95	29,447,000,000	27,429,000,000	113
CDP	Royal Philips	113,442,754	140,251,616	81	26,328,984,000	25,876,692,700	126
CDP	Fiat Chrysler Automobiles NV	111,404,271	91,475,096	122	120,106,210,836	113,276,477,348	87
CDP	Datang International Power Generation	108,908,786	126,847,195	86	9,532,960,599	11,313,219,683	98
CDP	Daikin Industries, Ltd	107,050,117	69,376,108	154	15,952,058,290	17,322,609,510	60
Thomson Reuters	Posco	106,673,000	108,554,000	98	49,527,507,180	59,564,868,976	85
CDP	Occidental Petroleum Corporation	106,349,891	100,792,543	106	12,598,000,000	19,442,000,000	61
CDP	NRG Energy Inc	105,366,813	126,110,636	84	14,674,000,000	15,868,000,000	111
CDP	Korea Gas Corp	104,308,462	111,276,195	94	22,144,815,254	33,929,228,753	70
	Global 100	**28,407,556,866**	**28,453,074,124**	**100**	**6,345,922,512,313**	**7,938,498,561,200**	**80**

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