

2018

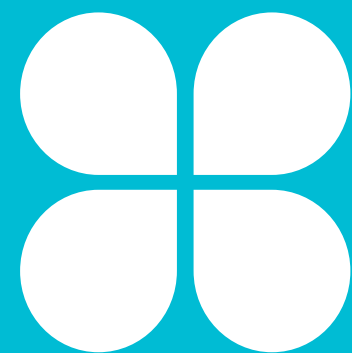
# State of Green Business

By Joel Makower and the editors of [GreenBiz.com](http://GreenBiz.com)

**GreenBiz**  
group



S&P Dow Jones Indices  
ESG Analysis



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## 55 THE INDEX

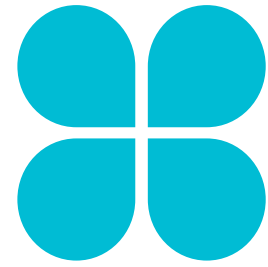
- 57 The big picture
- 60 Corporate performance
- 64 Risk management
- 69 Customer preference
- 72 Investment in greener business models

## 08 THE TRENDS

- 11 ESG moves from the margins to the mainstream
- 15 Science-based targets gain traction
- 18 GreenFin funds the sustainability transition
- 22 Rethinking carbon for the new economy
- 25 Economic inclusion becomes a sustainability imperative
- 29 Energy storage charges forward
- 33 Cities mobilize to avert “peak delivery” congestion
- 36 Artificial intelligence gets smarter
- 40 Enter the electrification of everything
- 44 Synthetic biology hacks the code for sustainability

## MORE

- 03 Introduction
- 05 Foreword
- 50 Key players to watch
- 75 Methodology
- 78 About GreenBiz
- 79 About Trucost
- 80 Credits
- 81 Disclaimer



# INTRODUCTION

**Joel Makower**

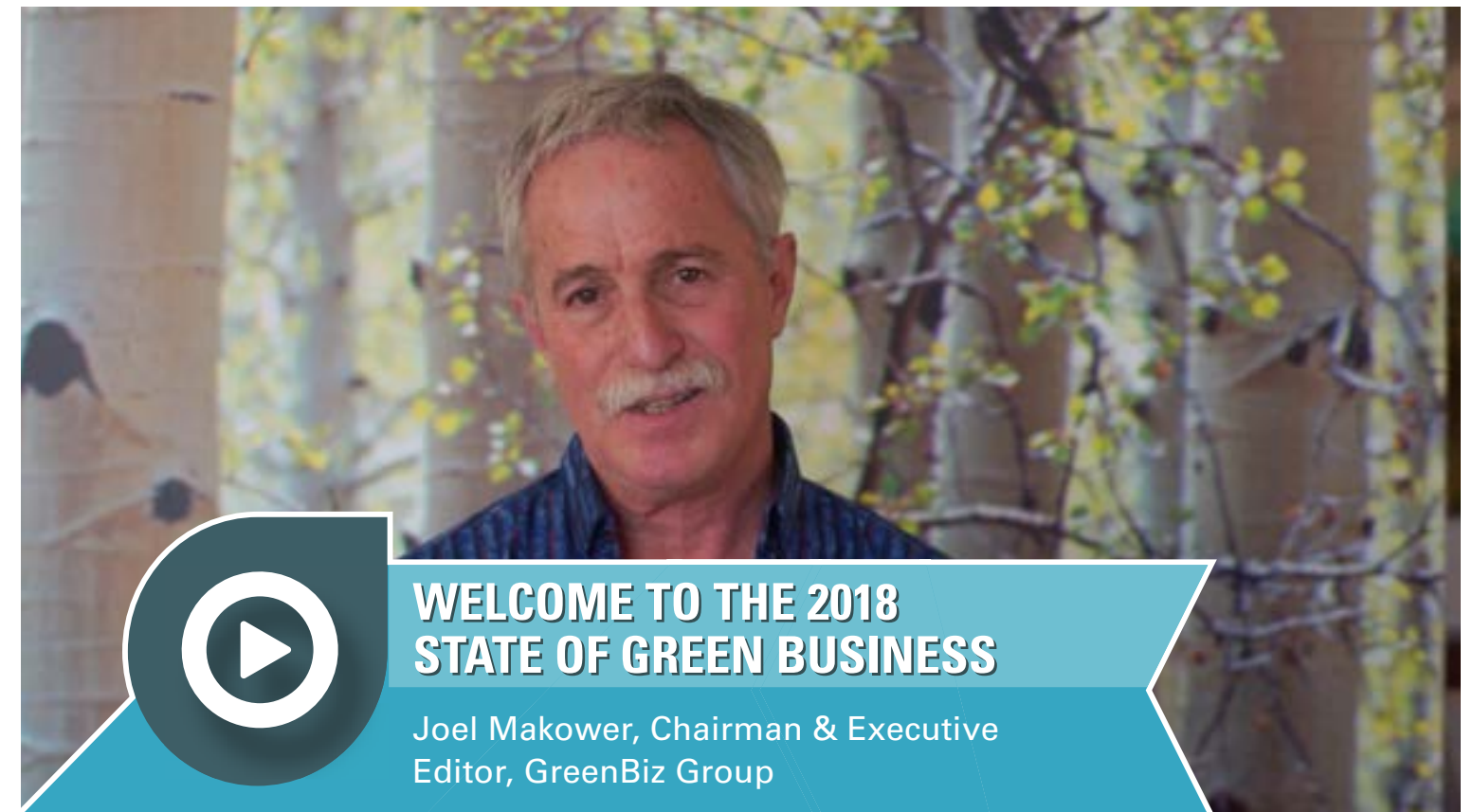
**Chairman & Executive Editor, GreenBiz Group**

In this 11th annual edition of State of Green Business, we continue our assessment of how, and how much, the private sector is addressing its environmental impacts. In partnership with Trucost, part of S&P Dow Jones Indices, which provides the key data and metrics, our goal is to step back from the daily headlines to take stock of progress, or lack thereof, in sustainable business practices.

As in previous years, we continue to refine the metrics we present, reflecting the evolving state of the art. For example, the Index portion of the report, which begins on page 57, this year looks at how companies are managing risk: their key strategies; their efforts to improve their understanding of risks from water, natural capital and carbon pricing; and their increasing awareness of their downstream and indirect risks. Such metrics simply wouldn't have been possible a few short years ago. Today, with more companies engaging in these activities, we can reveal trends.

The first half of the report offers the 10 trends sustainability professionals should be tracking in the year ahead. Each year, the GreenBiz editorial team identifies emerging arenas and technologies we believe will be impactful as companies address their environmental and social challenges and opportunities. The trends reflect some of the untapped potential of sustainable business: to go beyond cutting costs and reducing risks, by fostering product innovation, new revenue streams and new business models. Some of these will happen over several years, even decades, while others will become mainstream in a surprisingly short time.

To be sure, this is no rose-colored view of planetary problems. When it comes to transforming products, value chains and entire economies to align with the environmental and social goals of sustainability, the dynamics are significant. They



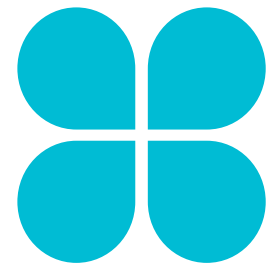
include a lack of U.S. political leadership but the rise of subnational actors, such as cities and companies; the short-termism of investors but the rising awareness of the relationship between climate and risk; the many difficulties of transforming supply chains but the growing number of companies investing in their suppliers' well-being. Simply put: This is hard work, and progress at times can be elusive. But we are seeing such obstacles being overcome in company after company, across sectors and borders.

That is what makes this field so exciting and inspiring to cover, as companies push the barriers of what's possible, gradually moving from an era of inadvertently negative environmental impacts to deliberately positive ones.

That's the promise of sustainable business we're proud to track and illuminate through our editorial, events and research offerings at GreenBiz every business day, and which is the basis for the pages that follow.

I hope you enjoy this report and look forward to your feedback.





# FOREWORD

**Dr. Richard Mattison**  
Chief Executive Officer,  
Trucost, part of S&P Dow Jones Indices



The 2018 State of Green Business Index — Trucost’s annual assessment of corporate environmental performance among the world’s 1,200 largest companies and 500 largest firms in the United States — reveals a worrisome finding. The natural capital costs of companies had previously been falling, but the latest year’s results show a sharp increase. As a result, the natural capital cost generated by the largest global companies is nearly two times higher than their net income.

The cause seems to be increased production of agricultural commodities and, hence, increased farming-related environmental impacts, in particular water pollution from fertilizer and pesticide use. These impacts occur in the supply chains of large global companies, increasing their overall natural capital costs. This is more evidence of the failure of markets to price in the natural capital costs of production.

Nevertheless, there is good news. The Index shows that corporate carbon emissions continue to decrease in absolute terms, reaching the lowest level in the past five years, as a result of a switch to cleaner fuels. There have also been modest improvements globally in water use and waste management. The numbers of companies setting carbon and water reduction targets has increased by around 10 percent over the past five years.

By far the majority of environmental impacts are embedded in the supply chains of companies rather than their direct operations. This poses serious risks for companies as climate-related impacts such as droughts disrupt supplies of water-intensive commodities. So it is positive that more companies are disclosing supply chain carbon emissions and water use.

However, the carbon reduction targets set by the largest 1,200 global companies and by the largest 500 U.S. companies in 2016 account for only around a fifth of their share of the reductions needed by 2050.

This is likely to change, however. For the 2-degrees-Celsius scenario, Trucost calculates that carbon prices will need to reach \$120 per metric ton by 2030 to achieve the Paris Agreement goal. To date, some 42 national and 25 local governments have implemented carbon pricing initiatives or are planning to do so. Judging by the mood at the COP23 climate summit in Bonn, Germany in November, the U.S. decision to withdraw from the Paris Agreement appears to have made little difference to the resolve of other nations to continue to make progress, and in fact all nations bar the United States have now signed up. Meanwhile, U.S. market participants including companies, financial institutions, states and cities are demonstrating unrelenting commitment to, and significant leadership on, climate action.

Clearly, companies need to step up their commitments and understand the risks of a carbon pricing regime globally. We will therefore need forward-looking data and analytical tools capable of assessing carbon pricing risk under a variety of scenarios in different sectors and regions.

The use of such tools by companies and investors is being encouraged by the Financial Stability Board's Task Force on Climate-related Financial Disclosures. It marks a significant departure from reliance on historical carbon footprinting — which, while still an essential baseline that all companies need to measure, says little about future risks. Carbon footprints need to be augmented with additional data that provides a more strategic lens on carbon risks and opportunities.

The latest research by Trucost shows the potential impact of increasing carbon prices on companies. Trucost analyzed the greenhouse emissions and financial performance of almost 100 companies operating in 16 different countries in three sectors: automobile manufacturing, chemicals manufacturing and power generation. It found that 30 percent of profits in the automobile sector could be at risk by 2050, while the chemicals sector could have 60 percent of its profits at risk. The power sector could have its profits wiped out completely.

These risks are material. Many market participants we spoke with would agree that understanding carbon pricing risk in financial terms is the key to unlocking more ambitious carbon reduction initiatives and greater investment. Scenario analysis can be used to make the case for setting ambitious carbon targets that are aligned with climate science — so-called science-based targets — that publically demonstrate that companies mean business when it comes to tackling climate change and capitalizing on low-carbon opportunities. Investors we speak to want to understand how companies are using carbon pricing scenarios to mitigate risk and direct capital to innovations that will succeed in the transition to a low-carbon economy.

A low-carbon future that preserves and enhances natural capital will aid delivery of a stable and prosperous economy for all. We have just a few years to capitalize on the world's greatest growth opportunity. New tools and data will help inform the critical investment decisions we need to make. With growing investor interest in this agenda, we now have the opportunity to harness the power of capital markets to scale investment in green and sustainable solutions.

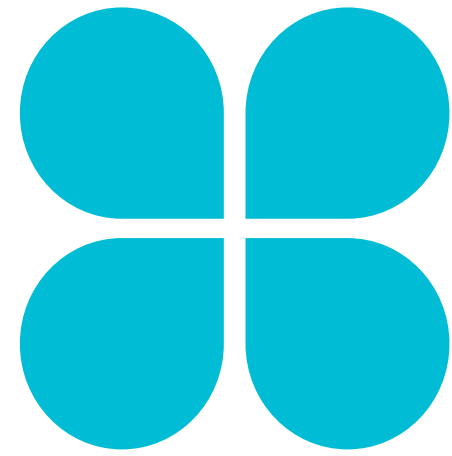
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# the top sustainable **BUSINESS TRENDS** **OF 2018**

**Joel Makower**

Chairman & Executive Editor, GreenBiz Group

“Two degrees and the SDGs.” That’s the new sustainable business mantra. It rhymes. You can almost dance to it.

The double-barrel impact of the Paris climate agreement and the [United Nations Sustainable Development Goals](#), both enacted in 2015, is finally being felt as companies begin to align their sustainability goals and, ultimately, their operations with these global commitments. And even though the United States government remains on the sidelines of both efforts, the private sector — allied with states, cities and other nations — is marching forward. If not in lockstep, at least in the same general direction.

Indeed, company commitments and achievements continue, unbuffeted by the political winds. Leadership companies such as Walmart and Apple continue to raise the bar — a commitment to [remove a billion tons](#) of greenhouse gases from the atmosphere, in the case of the retail titan, and a pledge to make mobile phones [entirely from recycled materials](#), for the iconic tech company. Newer and smaller firms are making moves, too, ramping up renewable energy purchases and taking on other green initiatives once seen as purely the domain of the world’s biggest brands.





Perhaps most important, the inauguration of President Donald Trump and the subsequent rollback of America’s environmental regulations and international commitments galvanized companies to extend or redouble their efforts. [“We Are Still In”](#) morphed from a meme to a movement, no longer just a slogan expressing companies’ unrelenting efforts to address climate change, but now a gesture of defiance — a rare instance of the private sector coming together to take on a sitting American president. With more than 2,500 signatories — including 1,700 companies, 200 U.S. cities, nine states, 200 colleges and universities and scores of faith-based institutions — “We Are Still In” has emerged as the largest climate campaign in the United States.

That’s the good news. The more challenging part of the story remains the scale, scope and speed of change. And while the administration’s environmental agenda is purportedly pro-business, the corporate crowd seems less enthralled with ideological efforts to undo every environmental regulation and incentive program imaginable, simultaneously paving the way for fossil-fuel and other extractive companies to run amok on even the most pristine and sensitive lands.

Where is the pushback? It isn’t coming from C-suites or boardrooms. Companies say they have too many other axes to grind with Congress and the president—infrastructure, immigration, the minimum wage, health care and a general sense that the state of the world is less stable now than at any time since the Cold War. With relatively little public pressure for companies to take a bold stand on climate and related concerns, environmentalism never seems to rise to the top of the corporate agenda.

Arguably, it should, and companies’ timidity someday may be seen as short-sighted, much as the failure to recognize or rein in abuses by the financial sector in the mid-2000s led to a global recession that throttled profits and productivity, and reduced shareholder value by trillions. Climate change is being seen by many — notably bankers, insurers and others whose job it is to assess and manage risk — as a threat that, if



not existential, could lead to significant negative impacts to operations, supply chains, communities and the well-being of employees and customers.

## **FOLLOW THE MONEY**

There are encouraging signs of an awakening, driven in part by the financial sector, which is just beginning to turn the screws in a way that could force companies to take bigger actions to stem climate change and to address society's ills, from hunger to poverty to gender equity. Over the past 18 months or so, mainstream investment firms have sharpened their focus on the environmental, social and governance, or ESG, performance of publicly traded companies. In some cases, investors, lenders and ratings groups are starting to redefine "fiduciary responsibility" to include such things as a company's ESG data or vulnerability to climate risks.

The European Union is ground zero for such thinking. There's a budding movement in the EU to encourage markets to think longer-term, to encourage pension funds to act in the best interest of sustainability and to improve disclosure to help investors understand which investments are sustainable and which probably aren't. Over time, the thinking goes, ESG data could help determine a company's inclusion in leading stock indices, such as those from S&P Global or FTSE.

But the pressures are being felt in the United States, too. In a report to its clients in November, Moody's Investors Service explained how it incorporates climate change into its credit ratings for state and local bonds. The takeaway: if cities and states don't deal with risks from surging seas or intense storms, the cost of borrowing will rise.

Suffice to say, this could be a game-changer, in terms of putting climate risk and other environmental and social indicators on a par with traditional financial metrics and risk calculations. In the meantime, the message to corporate boards is implicit, if not explicit: Take stock of your company's climate and resource risks, as well as its social impacts, both operationally and in its supply chain, as well as

the places it operates. (Witness the harm done to businesses in communities [ravaged by 2017's hurricanes](#).) As Wall Street and its global brethren begin to leverage the ever-growing cache of company-specific data and algorithms — such as using artificial intelligence and satellite imagery to pinpoint which company's facilities are likely to suffer from droughts, extreme heat and sea-level rise, among other calamities — and then make investment decisions based on that data, the changing climate no longer will be seen as external to profits and productivity.

As always, myriad hopeful signs point to shifts, some seismic, in the mainstreaming of sustainable business. The growth of science-based emissions-reduction targets — initially for addressing climate change, but eventually for other environmental issues — is helping companies assess whether their commitments and achievements are sufficient to contribute to meaningful solutions. Renewable energy markets, including for efficiency and storage, are maturing, leading companies to ramp up their purchases, even in an era of stable fossil-fuel prices and shifting tax policies. Next-gen technologies, such as artificial intelligence and synthetic biology, are being deployed in the name of a more sustainable world, tackling big, seemingly intractable challenges.

All of this is happening outside the regulatory and policy arena as companies recognize that addressing the international community's collective climate and sustainable development goals is becoming table stakes for any company seeking to be seen as a leader over the next decade or two.

Indeed, "two degrees and the SDGs" may yet become the parlance of mainstream business. And perhaps, someday, we'll all dance to it.

In that light, here, in no particular order, are 10 trends we'll be watching in the year ahead.

# 01

TOP SUSTAINABLE TRENDS

## ESG Moves from the Margins to the Mainstream

**By Libby Bernick**

Global Head of Corporate Business,  
Trucost, part of S&P Dow Jones Indices

Environmental, social and governance issues are often described by businesses and investors as “nonfinancial,” suggesting they have no materially significant impact on the bottom line, either as a risk to revenue or an opportunity for business growth.

There’s a growing recognition [by companies and investors](#) that this view is mistaken — that ESG matters are fundamental to business performance and should be disclosed in financial reports. Businesses are also coming to realize that integrating ESG concerns into core business and financial decisions will generate new streams of data that can be used to enhance growth and sustainability.

Climate change is driving this. At COP23 in Bonn, Germany, world leaders discussed progress towards the Paris Agreement to limit global warming to 2 degrees Celsius by putting a price on carbon through emissions trading schemes and carbon taxes. So far, 42 national and 25 local governments have implemented carbon pricing initiatives or are planning to do so.

To assess the anticipated impact of rising carbon prices, Trucost analyzed the greenhouse emissions and financial performance of almost 100 companies operating in 16 countries in three

sectors — automobile manufacturing, chemicals manufacturing and power generation. It found that 30 percent of profits in the automobile sector could be at risk by 2050, while the chemicals sector could have 60 percent of its profit at risk and the power sector could have its profits wiped out entirely, with 150 percent of its profits at risk.

The social impacts of a company’s operations also can have serious financial effects. In 2017, shares in [Tahoe Resources](#) fell when the Canadian mining company was forced to halt production at its Escobal silver mine in Guatemala — the third largest



in the world — after the Guatemalan Supreme Court suspended its license. The court found that the government had violated the rights of indigenous people by failing to adequately consult them before issuing the license. Tahoe Resources is also facing a lawsuit in Canada over alleged violence at the mine in 2013.

On the positive side, [research by Bank of America](#) suggests that progressive ESG practices improve company performance. It found that the top 20 percent of companies in terms of ESG ratings from 2005 to 2010 experienced the lowest (32 percent) volatility in earnings per share in the subsequent five-year period. By contrast, companies with the worst environmental, social and governance records averaged 92 percent volatility.

Despite this evidence that ESG matters are a financial issue, companies are too often blind to it. [KPMG's survey of 4,900 companies worldwide](#) in 2017 found that three-quarters fail to acknowledge the financial risks of climate change. Of those that do, most provide only a narrative description of the potential implications. Just 2 percent quantify the risks in financial terms.

This soon could change as a result of the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD), set up by the Financial Stability Board, whose members include financial authorities such as the Board of Governors of the Federal Reserve System, the U.S. Securities and Exchange Commission and the U.S. Department of Treasury.

The TCFD recommends that companies and investors publish forward-looking information on the financial implications of climate change in [annual reports and financial filings](#). This could include a 2-degree-Celsius scenario analysis — an assessment of the implications of a range of pathways in the transition to a low-carbon economy, in which energy is generated largely from renewable sources.

And the TCFD is not concerned only with carbon. The recommendations clearly state that the financial performance of organizations also may be affected by other climate-related environmental impacts,

in particular water scarcity and water quality, and organizations should report on these as well.

An issue to watch in 2018 and beyond is what progress companies and investors make towards implementing the TCFD recommendations, and whether policymakers decide they have to force the pace. The [EU's High-Level Expert Group on Sustainable Finance](#) has suggested that the TCFD recommendations could be implemented by revising [legislation on non-financial reporting](#).

Stock exchanges are playing an important role in mainstreaming [ESG disclosure](#). Fifty-eight stock exchanges, representing over 70 percent of listed





equity markets, have joined the [Sustainable Stock Exchange Initiative](#). Twelve exchanges incorporate ESG reporting into their listing rules, and 15 provide formal guidance to issuers. A further 23 stock exchanges have committed to introducing new ESG reporting guidance. Stock exchanges in Asian countries such as Singapore and Malaysia are being the most proactive on ESG, in contrast to those in the United States, raising the prospect of American companies competing for capital with Asian companies that have much [greater transparency on ESG](#).

These emerging requirements to disclose on the financial implications of ESG factors should be seen as an opportunity by companies and [investors to gain insight](#) into their business, revealing ways in which risks can be managed, waste and inefficiency reduced and opportunities for growth identified.

To do this, companies are looking for analytical tools that make sense of ESG data in business terms and integrate it into decision-making processes. For example, to help

assess exposure to evolving regional carbon pricing mechanisms, some companies are using Trucost's [Corporate Carbon Pricing Tool](#). The results can be used by sustainability managers to make the business case to the chief financial officer for investing in low-carbon technology. They also can be used to calculate an internal price of carbon. Some 1,400 companies already have factored an internal carbon price into business plans — [an eightfold leap in take-up](#) in the last four years.

The London-based investment manager Schroders recently launched its [Carbon Value at Risk tool](#), designed to help investors more accurately assess the risks that higher carbon prices pose to their portfolios. Schroders shows that some 20 percent of the profits generated by global companies are at risk if carbon prices rise to the levels required by the Paris Agreement. In the most exposed sectors such as construction, steel and commodity chemicals, some 80 percent of profits are at risk.

Similar tools have been developed to assess the financial implications of water scarcity and pollution, such as Trucost's [Water Risk Monetizer](#), which helps companies assess water-related risks at specific sites in potentially vulnerable

**Twelve stock exchanges  
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areas. Doing so can help make the case for investment in water stewardship projects using metrics such as revenue at risk and increased operating costs, and by creating a water “shadow price” to assess the financial return on a particular project.

For investors, the Natural Capital Declaration has created a [Corporate Bonds Water Risk Credit Tool](#), which allows users to integrate water stress into company credit analysis for water-intensive sectors including power utilities, beverages and mining.

The take-home message is that 2018 should be the year we stopped using the term nonfinancial reporting to describe ESG issues as more and more investors understand its financial implications and demand that it be integrated into decision making.

### **ORGANIZATIONS TO WATCH**

[Task Force on Climate Related Financial Disclosures](#) — provides guidance to companies and investors on the disclosure of information on the financial implications of climate change.

[Sustainable Stock Exchange Initiative](#) — U.N. effort to encourage stock exchanges to promote corporate transparency and performance on sustainability issues.

[EU High Level Expert Working Group – Green Finance](#) — expert body established to advise the European Commission on measures to integrate sustainability into the European Union’s financial policy framework.

[Carbon Pricing Leadership Coalition](#) — public-private initiative to encourage the development of effective carbon pricing policies.

[U.N. Principles for Responsible Investment – ESG Factors in Credit Risk Analysis](#) — aims to enhance the transparent and systematic integration of environmental, social and governance factors in credit risk analysis.

# 02

## TOP SUSTAINABLE TRENDS

# Science-based Targets Gain Traction

**By Cassandra Sweet**  
Senior Writer, GreenBiz Group

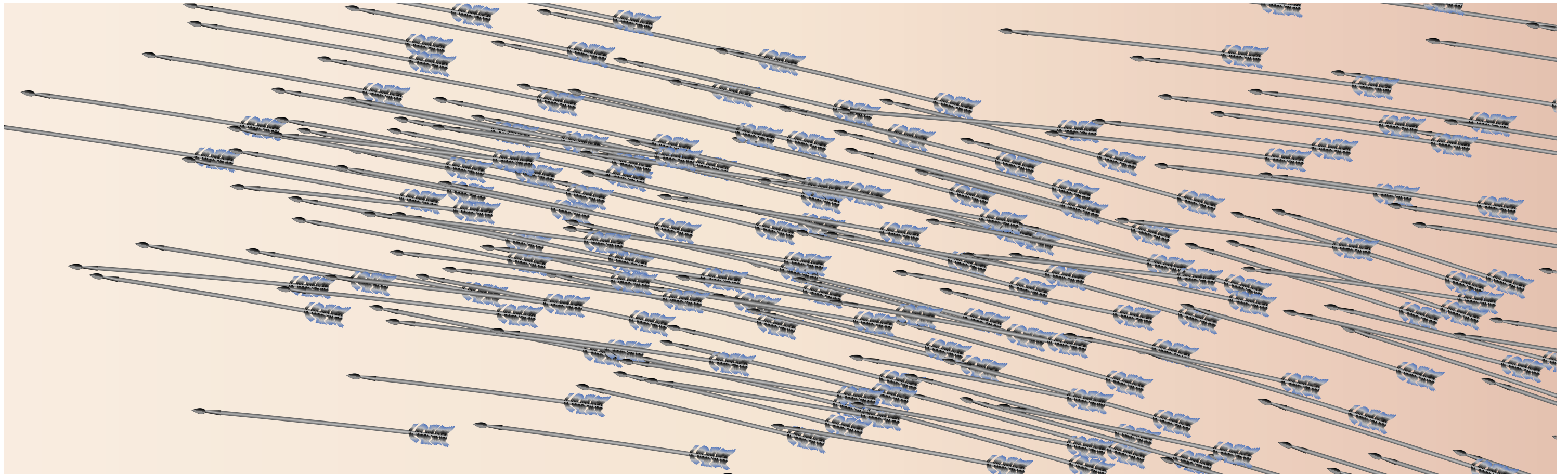
The bar for setting meaningful greenhouse-gas-reduction targets keeps getting higher. The leaders are turning to science to determine exactly how high. [Science-based emission-reduction targets](#) are those in line with the level of decarbonization required to keep global temperature increases below 2 degrees Celsius, compared to preindustrial levels, as described in the Fifth Assessment Report of the [Intergovernmental Panel on Climate Change](#). Companies set these goals with the help and approval of the [Science-Based Targets Initiative](#) (SBTI), a collaboration among CDP, World Resources Institute, the World Wide Fund for Nature (WWF) and the United Nations Global Compact.

[Mars](#), for example, set [science-based targets](#) last year that call for the company to eliminate 100 percent of the carbon dioxide emissions from its own operations by 2040. Most of those emissions are from energy usage, which Mars plans to cut through conservation and clean up by switching to renewable energy. More impactfully, Mars also plans to slash emissions from its supply chain, which includes ending deforestation in its supply chains for beef, cocoa, palm oil, paper and pulp and soy.

Many of the 40 companies that committed in 2017 to setting science-based targets are likely to complete defining them this year, and some of the 200 other firms that committed to targets in previous years

probably will, too, adding to the more than 80 corporations that have set approved targets already. The SBTI is working to streamline the process to help make science-based target-setting mainstream and established as standard business practice, so that corporations play a major role in driving down global greenhouse gas emissions.

Science-based targets currently use climate science to look at emissions generated by a company either by itself or as part of the industry in which it operates. Targets are developed based on emissions cuts the company can make at its own operations, and



cuts it can try to affect on the part of its suppliers, such as through farmers and producers of raw materials adapting sustainable land management, water use and energy usage.

Companies that set science-based targets often have aggressive renewable energy procurement goals, too, as they realize that switching from fossil-fueled electricity to clean power such as solar and wind is a practical and cost-effective way to reduce emissions.

The markets for renewable energy are growing as a result. U.S. companies signed contracts in 2017 for at least [2,090 megawatts of solar and wind power](#), through September, up 30 percent from all of last year, according to the Business Renewables Center at the Rocky Mountain Institute.

And more companies are setting increasingly aggressive renewable energy goals. Kellogg, for example, committed in 2017 to achieving 100 percent renewable electricity by 2050, after the company set science-based emissions-reduction targets in December 2015. About [115 other companies](#) also have committed to switching from fossil fuel-based electricity to 100 percent renewable power. This is helping boost U.S. clean power overall. Wind, solar, hydropower and other renewables generated about [476 terawatt-hours](#), about 18 percent, of U.S. power supplies in the first eight months of 2017, compared to 15 percent for all of last year, according to data from the Energy Department.

This year could be a turning point for the emergence of science-based targets for big polluters. A handful of oil producers, petrochemical manufacturers and miners,



including Australia-based Origin Energy and PTT Global Chemical of Thailand, have said they want to set science-based targets, and SBTI has said it wants to develop them for those sectors.

Setting targets for carbon-extraction industries is likely to be controversial, as climate scientists and activists increasingly call for limiting production of oil, gas and other carbon-heavy resources to drive down global emissions. A campaign called [Keep It In The Ground](#), started in 2015 by The Guardian newspaper, aims to limit global production of oil, natural gas and coal to existing developments, keep untapped resources in the ground and ramp down fossil-fuel production altogether. The effort has support from Greenpeace, Sierra Club and 350.org, and has inspired U.S. legislative proposals on the federal and local levels.

Can oil and gas producers set valid science-based targets? Probably not, unless they have a plan like Denmark-based [Dong Energy](#), which transformed itself from an oil and gas producer to a utility and major offshore wind developer. The company recently sold off its oil and gas business for \$1.05 billion, devised a plan to stop using coal for power generation, set science-based emission-reduction targets and changed its name to Ørsted (in honor of 19th-century scientist Hans Christian Ørsted, who discovered electromagnetism).

For companies that don't produce fossil-fuel products, the good news is that opportunities to replace fossil fuel with renewables keep expanding and, after conservation, this is the best way to cut emissions. Lower prices, more sophisticated markets and more options for buying clean power makes this easier. The challenge will be preventing certain politicians from removing state and federal incentives for renewables that are key to the transition to clean energy.

About 640 companies around the world have made climate commitments via the [We Mean Business](#) coalition's "Take Action" campaign. These U.S. and global

companies are good candidates for the next wave of corporate science-based emissions-reduction targets.

Some of the firms are already on [CDP's Climate A List](#). The 117 companies received the top grade for establishing best practices to measure and reduce their impact, and disclose this information to CDP, which in turn shares it with investors.

## ORGANIZATIONS TO WATCH

[Science Based Targets Initiative](#) — helps companies devise the targets, then approves the targets so that the company can proceed.

[CDP](#) — formerly known as Climate Disclosure Project, a London-based nonprofit that drives companies to cut their greenhouse gas emissions, by grading companies on their reported activities. The group claims to have received environmental data in 2017 from more than 6,300 firms.

[Renewable Energy Buyers Alliance](#) — a consortium of four NGOs — the World Resources Institute, BSR, World Wildlife Fund and the Rocky Mountain Institute's Business Renewables Center — that helps companies understand the benefits of using renewables, helps connect large buyers to renewable energy suppliers and helps utilities understand and serve the needs of energy buyers.

[We Mean Business](#) — another coalition sponsored by The Climate Group and CDP, along with some other groups, that encourage businesses to take action on global warming, with a goal to put the world on track to avoid dangerous climate change by 2020.

[Keep It In The Ground](#) — a [stand-alone organization](#), an [initiative started by The Guardian](#) newspaper supported by organizations such as [Greenpeace](#), the [Sierra Club](#) and 350.org, as well as [legislative proposals in the U.S. Senate](#) and [House](#), the [city of San Francisco](#) and other jurisdictions.

# 03

TOP SUSTAINABLE TRENDS

## GreenFin Funds the Sustainability Transition

**By Joel Makower**

Chairman & Executive Editor, GreenBiz Group

Global agreement to mitigate climate change? Check. A set of global goals to transition human civilization toward sustainability? Check.

Trillions of dollars to pay for it all? Not so much. At least, not yet.

Finding the capital needed to achieve the goal of 2 degrees Celsius global temperature rise, or to fund the SDGs' 17 audacious outcomes, is a task unprecedented in scale. For nations, cities, companies and others to do their part, they'll need to come up with vast sums of money to enable the transition to sustainability.

How vast? According to the International Finance

Corporation (IFC), part of the World Bank Group, the Paris Agreement could spur [nearly \\$23 trillion](#) in "climate-smart" investments between now and 2030. The funding needed to achieve the SDGs globally was [estimated by the United Nations](#) at \$6 trillion a year for 15 years.

Of course, there's overlap between the SDGs and the Paris Agreement — [Goal 13](#), for example, aims to "take urgent action to combat climate change and its impacts" — so the exact price tag isn't really known. Suffice it to say, it's a king's ransom.

Amassing and deploying such sums will tax the global economy, which in 2016 was about \$78 trillion,

according to the International Monetary Fund. But various players are undaunted. Among those is the global banking industry — giants such as Barclays, Citi, Goldman Sachs, HSBC and JPMorgan Chase — that see nearly unlimited opportunity to fund the transition. They join the world's governments, multilateral development banks, pension funds and others in a growing pool of needed capital.

Some of this green finance — GreenFin, for short — is merely a natural extension of business as usual. Banks have long financed building construction, so backing green buildings isn't much of a stretch. Funding power plants



***Last year, China launched five pilot zones to promote “green finance” and help pay for a war on pollution expected to cost about \$450 billion a year.***

is standard operating procedure for large financial institutions, so a solar or wind farm is a natural follow-on. Same with lending for municipal infrastructure, transit systems and affordable housing. Environmentally improved versions of these are largely variations on a theme.

Increasingly, a new breed of financial products and services is being deployed specifically to fund such projects. “More measures related to green finance were introduced between June 2016 and June 2017 than in any one-year period since 2000,” Jaclyn Yeo, senior research analyst at Asia Pacific Risk Center, [told Brink News](#).

Green bonds are the best-known GreenFin instrument, and probably the fastest growing. The money raised by green bonds finances projects such as renewable energy, pollution prevention and resource conservation. Introduced a decade ago by the European Investment Bank, the wider bond market started to react after a \$1 billion green bond sold within an hour of issue by IFC in 2013. The market for green bonds that year was \$11 billion. Just four years later, in 2017, it hit \$200 billion.

It’s just getting started. A 2017 [report](#) by the Organization for Economic Co-operation and

Development estimated that the green bond market could grow to \$4.7 trillion to \$5.6 trillion in outstanding bonds by 2035, with annual issuances of \$620 billion to \$720 billion.

Green bonds aren’t the only GreenFin innovation. There are social impact bonds, which aim to improve positive social outcomes that also result in public-sector savings; sustainable development bonds issued by multilateral institutions, which link returns to the performance of companies advancing global development priorities set out in the SDGs; and green municipal bonds that fund infrastructure such as energy, water and transportation systems. Late last year, HSBC issued the world’s first SDG-based bond; the \$1 billion offering was three times oversubscribed.

GreenFin is finding its way into government programs. Last year, the world’s largest carbon emitter, China, launched five pilot zones to promote “green finance” and help pay for a war on pollution expected to cost at least 3 trillion yuan (about \$450 billion) a year.

The world’s biggest banks, for their part, seem to be engaging in a financial arms race to claim GreenFin bragging rights. In 2015, Bank of America [pledged \\$125 billion](#) in low-



billion a year and investments in green buildings could reach \$3.4 trillion cumulatively in key emerging markets. Investments in water supply and sanitation could exceed \$13 trillion cumulatively by 2030, with \$2 trillion more needed for climate-smart urban waste management.

Of course, it's not that simple. There is the complexity of stranded assets, notably about 80 percent of global oil and gas reserves, according to the International Energy Agency (IEA). These would need to be written off — or, at least, put toward nonburnable uses such as polymers for packaging and building materials — to stay within the Paris Agreement limits. You simply can't do that without crashing the markets or causing a global recession, or worse.

But the upside is significant, too: Meeting the goals of the Paris Agreement could fuel a \$19 trillion surge in additional economic growth over the next 30 years, according to a [2016 report](#) by two global energy agencies. That's equivalent to the value of all companies traded on the New York Stock Exchange.

A few nonfinancial companies are stepping up with their own GreenFin initiatives. In 2016, Apple issued a [\\$1.5 billion green bond](#) — the largest by any U.S. tech company — to pay for a range of environmental initiatives, including helping fund its own new headquarters. That same year, Starbucks brewed a [\\$500 million "sustainability bond"](#) to be used for several purposes, including underwriting programs for farmers that adhere to the [Coffee and Farmer Equity practices](#).

Such initiatives can provide companies with multiple benefits. They include providing funds for sustainability initiatives, improving internal integration between a firm's finance and sustainability teams, and enhancing company reputation by highlighting its sustainability commitments. Moreover, such bonds can be seen as less risky to investors and, therefore, in higher demand.

carbon business by 2025 through lending, investing, capital raising, advisory services and developing financing solutions. Last year, JPMorgan Chase said it would [facilitate \\$200 billion](#) in "clean financing" through 2025. In November, [HSBC pledged](#) to provide \$100 billion in financing and investment by 2025 to help combat climate change. And Citi, which in 2007 committed \$50 billion over 10 years, reached that goal three years early, [upping the ante](#) to \$100 billion in 2014 for "environmental solutions that will reduce climate change impacts and benefit society."

Big as these numbers are, they're still just a fraction of what's needed to take on the immense social and environmental challenges ahead.

Globally, IFC views sustainability as a massive financing opportunity, according to a [recent report](#). Renewable energy investments could climb to \$11 trillion cumulatively by 2040, it said. By 2025, investments in off-grid solar and energy storage could reach \$23



There's a key role for the public sector in paving the way for GreenFin to flourish. One critical need is policy cohesiveness across ministries, central banks, regulators and financial sector participants, according to the [Roadmap for a Sustainable Financial System](#) published at a meeting of the G20's Green Finance Study Group in November.

It's clear that we're at the beginning of what promises to be a global redeployment of capital over the next quarter century. In December, French

President Emmanuel Macron convened a climate summit to mark the two-year anniversary of the Paris Agreement. It showcased forward-looking initiatives from the financial sector, with speakers from the People's Bank of China, the African Investors Network for Climate, the Swedish Minister for Financial Markets and the French Minister for the Ecological and Inclusive Transition.

A truly global show of force.

## ORGANIZATIONS TO WATCH

[Climate Bonds Initiative](#) — the London-based NGO aims to mobilize the \$100 trillion bond market for climate change solutions and has created the de facto standard for green bonds.

[G20 Green Finance Study Group](#) — the group of large-economy heads of state vowed to “scale up green finance” and has set out a number of steps to develop and propagate related policy measures.

[JPMorgan Chase](#) — one of several leading banks (including Bank of America, Citi and HSBC) that has made significant funding commitments to funding sustainable technologies. Last year it, committed to \$200 billion to “clean” financing by 2020.

[State Bank of India](#) — the subcontinent's largest bank announced in 2017 that it would raise \$3 billion through green bonds, one of the largest global green bond efforts, with significant potential for funding sustainable development of the world's second-largest population.

[World Bank Group](#) — the multilateral bank has taken a leadership role in GreenFin strategy, including providing more than \$10 billion a year for projects that increase resilience to climate impacts and reduce emissions.

# 04

## TOP SUSTAINABLE TRENDS

# Rethinking Carbon for the New Economy

As the world moves toward a low-carbon economy, a [fourth industrial revolution](#) is taking place where advances in digital technology, artificial intelligence and robotics are combining to fundamentally change the way we live, work and do business.

The implications of the collision between a low-carbon, big data economy are huge. Many of these new technologies require increasing amounts of electricity, which will have to be generated from super-efficient, low-carbon sources if the world is to achieve the Paris Agreement on climate change to limit global warming to 2 degrees Celsius. The

information and communications technology (ICT) sector, where proliferating connected devices are giving rise to an [internet of things](#), could see electricity use soar. At the same time, it is creating opportunities for [more efficient energy use](#). For example, the global smart grid market is projected to grow from almost [\\$21 billion in 2017 to \\$51 billion](#) by 2022.

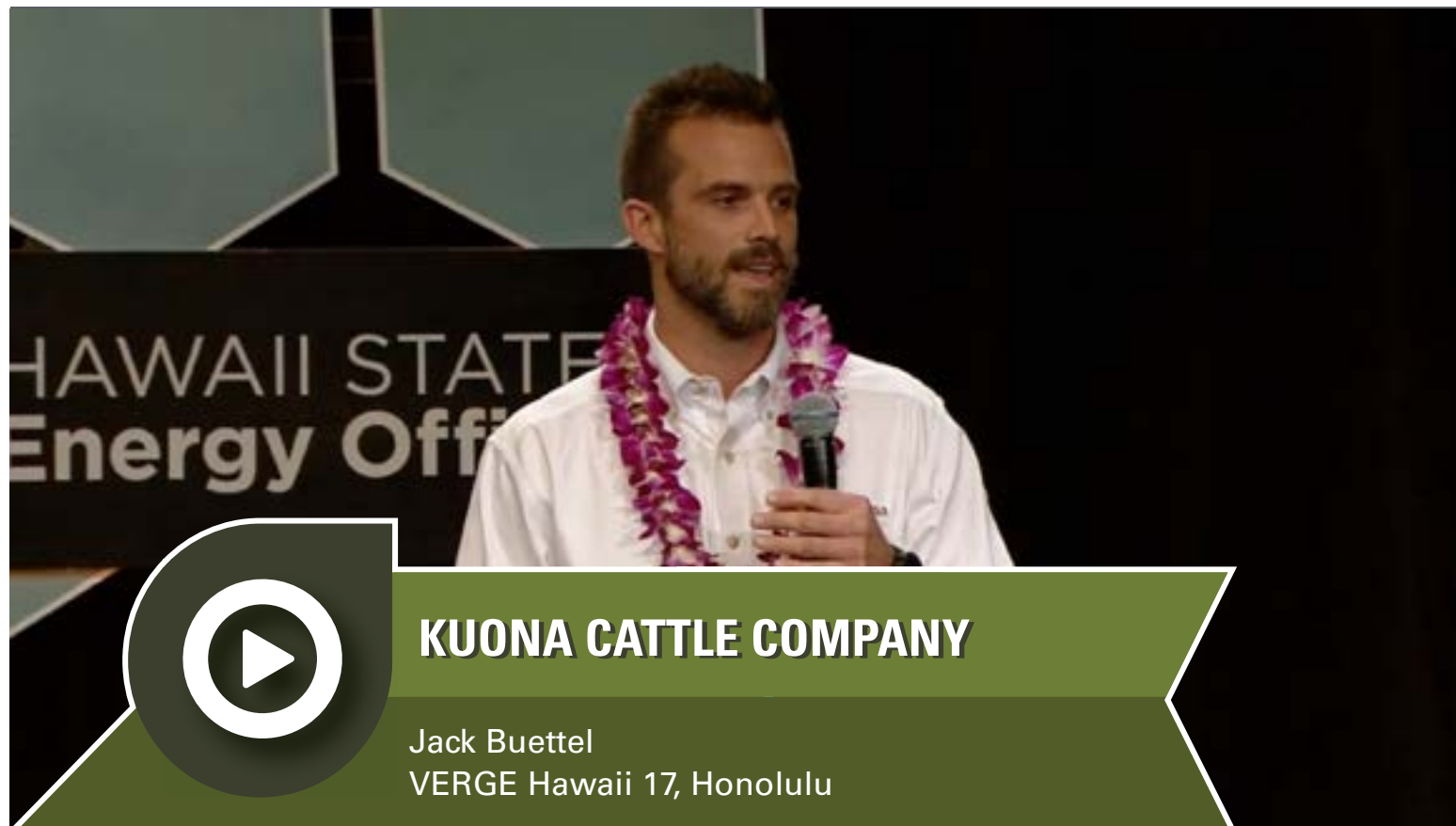
In any economic transformation, there will be winners and losers. Companies planning for growth while using carbon-intensive technologies are unlikely to find themselves on the right side of

history, while those that innovate could succeed. For example, [more than 20 of the top 50 ICT companies by revenue](#), particularly data center operators, are investing in renewable energy, primarily through power purchase agreements with electricity producers.

The automobile sector is another example of an industry at the sharp end of the fourth industrial revolution's spear. The cost and hassle of car ownership, especially in cities, combined with the emergence of ride-hailing apps and driverless cars, could mean that people increasingly opt not

**By Libby Bernick**

Global Head of Corporate Business,  
Trucost, part of S&P Dow Jones Indices



as of the end of 2016 was the U.S.-based S&P 500 Growth, while the S&P/ASX All-Australian 50 had the highest level of embedded emissions in fossil fuel reserves and the greatest percentage of revenues derived from coal-based activities, making it the most exposed to potential stranded assets.

The convergence between the low-carbon economy and fourth industrial revolution is stimulating new ways to think about carbon. Indeed, some sustainability experts, such as designer and author William McDonough, argue that airborne carbon is a valuable resource, an asset that's merely in the wrong place. McDonough suggests that [thinking about carbon in a more productive way](#) will help designers extract carbon from the atmosphere or from industrial emissions and use it to create durable products and processes that recycle and sequester carbon.

McDonough says: "Climate change is the result of breakdowns in the carbon cycle caused by us: It is a design failure. Anthropogenic greenhouse gases in the atmosphere make airborne carbon a material in the wrong place, at the wrong dose and wrong duration. It is we who have made carbon a toxin — like lead in our drinking water. In the right place, carbon is a resource and tool."

to own a car. Think tank [RethinkX](#)'s new research suggests transport-as-a-service with autonomous electric vehicles (EVs) will be two to four times cheaper than car ownership by 2021, resulting in a far faster demise of car ownership than most have predicted.

Along with radical disruptions to the oil industry, RethinkX predicts dramatic drops in air pollution and greenhouse gases alongside big gains in economic productivity as people claim back time lost while driving. [Bob Lutz](#), former vice chairman at General Motors, is among those who have predicted that the end is nigh for the traditional automobile manufacturing business model, driven by the emergence of mobility service providers such as Uber, Lyft and Google's Waymo.

Regions, not just individual companies or industry sectors, also may be better placed to succeed in the new economy. The [S&P Dow Jones Indices Carbon Scorecard](#), a barometer for the regional carbon efficiency of the markets, provides insights on the direction of travel for a new carbon economy. For example, the index with the lowest carbon footprint

***The convergence between  
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about carbon.***

The list of companies developing innovative solutions to use carbon as a resource continues to grow. Covestro, for example, manufactures a foam plastic called [cardyon](#), which contains 20 percent carbon dioxide and can be used to make products such as foam mattresses. [Carbon Clean Solutions](#) has developed a process to make it easier and cheaper to extract carbon from industrial emissions sources. Carbicrete, among others, aims to produce [carbon-negative concrete](#).

Emerging alongside these innovative early adopters are new collaborative ventures that bring people and ideas together, share knowledge and attract finance and business support to scale up new carbon thinking. Initiatives such as [Carbon Productivity](#), a consortia of companies and consultancies, aim to achieve a tenfold increase in the value we create per unit of fossil carbon used. The [New Carbon Economy Consortium](#), led by the Center for Carbon Removal and including Arizona State University, is creating a roadmap that outlines specific steps for translating research into business and policy action. Providing practical support is [Greentown Labs](#), a cleantech incubator just outside Boston offering startup carbon companies laboratory, workshop, office and event facilities as well as access to a network of investors.

The fourth industrial revolution also enables greater transparency and data flow between market participants so that financial capital can be deployed toward new low-carbon business models. For example, Kensho has developed the [New Economies Indices](#) with the idea that current industry classification schemes do not capture the drivers of future economic growth. Kensho proposes a range of new sectors that capture the ecosystem of companies that are emerging in the 21st century, such as Intelligent Infrastructure, which includes companies involved in smart grids, smart buildings and smart transport.

New technologies are likely to have applications in gathering data, allowing for faster and more precise decision-making on low-carbon technologies. Data

innovations such as Microsoft's [Smart Energy Azure Demonstration Platform](#) enables consumers to use energy at times of the day when the power generation is at its cleanest. Artificial intelligence technology platforms such as Kensho's could be used to gather real-time data on the ESG performance of all companies and seamlessly integrate with financial performance data via online platforms that investors could use to make investment decisions.

To achieve the Paris Agreement goal to limit global warming to 2 degrees Celsius, carbon emissions must peak as soon as possible and then decline rapidly. To do this we need to innovate as never before, exploring every opportunity to stop carbon entering the atmosphere, and use the carbon that is already there as a resource. As the proverb goes, "Necessity is the mother of invention."

## ORGANIZATIONS TO WATCH

[Kensho](#) — deploys scalable machine learning and analytics systems for government and financial institutions to provide solutions to social and economic analytical problems.

[Carbon Productivity](#) — supports stakeholder conversations, alongside the development of appropriate tools, to generate value for society from reducing fossil carbon.

[Center for Carbon Removal](#) — nonpartisan, nonprofit organization working to clean up carbon pollution from the air by supporting the development of natural and engineered carbon removal solutions.

[Greentown Labs](#) — provides workshop, office and event space in Somerville, Massachusetts, for cleantech entrepreneurs to build products and develop their businesses.

[Covestro](#) — international manufacturer and supplier of sustainable polymers to the electronics, automotive and construction sectors based in Leverkusen, Germany.



# 05

TOP SUSTAINABLE TRENDS

## Economic Inclusion Becomes a Sustainability Imperative

**By Anya Khalamayzer**  
Associate Editor, GreenBiz Group

In nature, diversity builds ecosystem health, productivity, longevity and resilience. So, too, in communities: Sustainable economic and social systems need to be diverse and inclusive in every respect.

Gender and ethnic diversity have been business concerns ever since the corporate social responsibility movement dawned several decades ago. Economic inclusion — ensuring that everyone has equal opportunity to participate in the economic life of their community as employers, employees, consumers and citizens — is being seen increasingly as part of the sustainability agenda.

The very first Sustainable Development Goal, set by the United Nations in 2015, is to “[end poverty in all its forms, everywhere](#),” followed closely by [gender equality](#). The green economy will be a “powerhouse,” [says Christiana Figueres](#), the former U.N. climate chief who now co-leads the Formula E advisory board — if we have “clean energy for everyone and emissions from no one.”

Companies, cities and other institutions are opening pathways to leadership and inclusion in order to serve women, people of color and marginalized members of both rural and urban communities. That takes more than just “[checking a box](#)” on diversity, says

Whitney Tome, director of the nonprofit Green 2.0, tasked with increasing diversity in the mainstream environmental movement.

Whereas “diversity is like inviting people to a party, [inclusion is asking them to dance](#),” writes business activist Verna Myers, who rose out of Baltimore’s working class to become a Harvard-trained lawyer, entrepreneur, author and cultural innovator. That means putting equity and inclusion at the forefront of company policies and products.

Sustainability membership group BSR, which has consulted to large companies for 25 years, found that social resilience is a rising corporate concern,

with [income and gender inequality](#) on par with risks such as cybersecurity and natural disasters. Businesses have a growing stake in helping shape “a social contract for the future,” says BSR President and CEO Aron Cramer.

Silicon Valley’s top firms are embracing diversity, says Van Jones, author, political commentator and founder of #YesWeCode, a national initiative that teaches information technology skills to young people from disadvantaged backgrounds. In his 2017 book, “Beyond the Messy Truth,” Jones writes that all of Silicon Valley’s top firms are [responding to the need to close their diversity chasm](#). For example, in 2017, Google partnered with Howard University to hire black computer science majors. [Since 2016](#), HP diversified its corporate boards and workforce, and brought more women to the executive level. In 2015, Salesforce CEO Marc Benioff [spent \\$3 million](#) for pay parity for men and women.

Such programs are good for business, too: Public companies ranking in the [top quartile for ethnic and racial diversity](#) are 35 percent more likely to have above-average financial returns, and those in the top quartile for gender diversity are 15 percent more likely to perform better financially.

As societal expectations increase, many companies are becoming more transparent about the results of their diversity and inclusion initiatives, even if they are still slight. For example, underrepresented ethnicities comprised 3 percent of Pinterest’s staff in 2015 [yet rose to 7 percent](#) in 2016, the year it hired Head of Diversity and Inclusion Candice Morgan. In November, Glass Lewis, an institutional investor adviser, warned corporate boards without women that it will urge investors to [vote against them in 2019](#). And in 2018, the EU will require large, listed companies to [include diversity information](#) in their annual reports.

More recently, corporations have backed diversity and inclusion policies that boost their resilience: Microsoft [publicly supported](#) extending the Deferred Action for Childhood Arrivals program from cuts proposed by the Trump administration for

sound business reasons: the powerful immigrant contributions to the company’s workforce. And after the 2016 U.S. presidential election, hotelier chain Marriott International’s CEO Arne Sorenson penned an [open LinkedIn letter](#) urging Trump to minimize divisiveness around sexual orientation, gender, race, religion, disability and ethnicity.

The specter of climate change is also spurring companies to action.





Around the world, people of color, rural communities [and women](#) feel the worst effects of climate change and pollution, including the risk of becoming climate refugees — having to migrate to other countries to escape flooding, droughts or other climate-born disasters. A recent partnership between IKEA and the United Nations High Commissioner for Refugees helped provide solar panels and biodigesters to refugee camps in the Middle East, literally empowering communities living on the edge.

Renewable energy is at the heart of other economic inclusion initiatives. For example, innovative “pay as you save” (PAYS) financing, [pioneered by Holmes Hummel](#), uses a tariff structure to fund energy improvements for low-income homeowners and renters without requiring upfront costs or a credit check. In one Appalachian community in southern Arkansas, PAYS programs provide energy efficiency and renewable power to low-income rural residents at no upfront cost.

Low-income communities often find themselves on the front line of sustainability crises in a climate-unstable world. Hurricanes typically hit low-income communities hardest, as witnessed in 2017’s onslaught of storms. The imbalance can be felt years later: While four out of five white residents believe that New Orleans has mostly recovered from Hurricane Katrina in 2005, nearly three of five blacks [say it has not](#). In 2017, New Orleans appointed a chief resilience officer in part to help bridge that divide.

One job of city resilience officers is to include members of marginalized communities in urban planning sessions, decreasing the risk that even environmentally responsible development [causes gentrification](#) that displaces low-income residents. The green-building community recognizes this. Under new CEO Mahesh Ramanujam, the United States Green Business Council [committed 20 percent of its growth by 2020](#) to underserved communities.

“Architects and designers could learn new techniques from the ingenuity and genius of black and brown communities,” [says Mike Ford](#). Known as the “Hip Hop Architect,” he is the founder of Brandnu Design, which focuses on community engagement, “pre-development” strategies and capital campaigns for new urban developments.

Louis Stewart, the first chief innovation officer of Sacramento, California, sees [equity and urban mobility](#) as essential ways to attract talent and ensure sustainable economic growth. For one, ride-sharing can transport low-income people to jobs in high-rent areas, or could nix expensive parking lots, [easing housing costs](#) in cities such as Houston.

Urban resilience can grow from small seeds: Allowing low-income students to participate in a gardening program [moved the graduation rate](#) in a South Bronx school from 17 percent to 100 percent.

Then there are growth spurts. Late last year, JPMorgan Chase invested \$900,000 in sustainable infrastructure projects in Detroit. The funds will help



***Low-income communities***

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use the vacant space between commercial properties for green infrastructure that can mitigate stormwater drainage fees and turn vacant land into commercial spaces that support minority small business owners.

“Sustainable infrastructure is critical to the efficient and continuous operation of small businesses and to revitalizing commercial activity throughout Detroit,” says Matt Arnold, the bank’s global head of Sustainable Finance.

You can’t have a healthy economy in an unhealthy community. It’s in companies’ interest to help ensure everyone’s well-being.

### **ORGANIZATIONS TO WATCH**

[Salesforce](#) — the software leader, which employs [30 percent women globally](#) and about 35 percent minorities in the United States, recently jumped from a rank of 23rd to eighth in Forbes’ “Best Places to Work” list, in part due to domestic partner benefits and onsite childcare.

[Google](#) — is on a learning curve; even as it faced controversy after an employee’s gender-biased memo went viral, it holds team trainings to address unconscious bias and hired Diversity Officer Danielle Brown.

[U.S. Green Building Council](#) — the membership group, founded in 1993 to promote sustainability in construction, design and operation, announced a commitment to 20 percent growth by 2020 for underserved communities.

[#YesWeCode](#) — created by author and attorney Van Jones and inspired by a conversation with musician Prince, it seeks to help 100,000 youth from underrepresented backgrounds enter the lucrative work in technology.

[Groundswell](#) — aims to bring economic equity to the energy sector, partnering with underserved communities in Washington, D.C., Baltimore and elsewhere to bring affordable solar power to businesses.

# 06

TOP SUSTAINABLE TRENDS

## Energy Storage Charges Forward

**By Heather Clancy**  
Editorial Director, GreenBiz Group

Use it or lose it. Few products in the world have a shorter shelf life than electricity. That's why pretty much everyone involved in the power sector — from utilities to buyers to startups to state regulators — is putting more energy than ever behind ways to extend it.

That's fueling [a boom in projects](#) and investments centered on advanced battery chemistries and alternative energy storage approaches, such as hydrogen fuel cells and thermal options that use hot water or ice to conserve power. The holy grail over time is to create a network of resources that can be used in concert with solar and wind farms. The idea is to balance those intermittent renewable resources, help their production output become more predictable and

make it easier to integrate distributed power plants into the grid.

But energy storage also promises tangible benefits in the short term, especially for demand-response applications that help utilities and businesses manage through “peak” periods when the strain on the electric grid could threaten reliable operations.

That powerful combination could inspire the deployment of 125 gigawatts in storage capacity worldwide between now and 2030, according to [projections](#) — a \$103 billion investment. Notes Bloomberg New Energy Finance Analyst Yayoi Sekine: “The industry has just begun. With so

much investment going into battery technology, falling costs and with significant addition of wind and solar capacity in all markets, energy storage will play a crucial role in the energy transformation.”

You don't have to be a clean power advocate to appreciate the return on investment. Even Department of Energy Secretary [Rick Perry](#) is talking up [the potential](#). And an astonishing mix of equipment providers are introducing systems, even big diesel and gas generator companies such as [Caterpillar](#) and military contractors such as [Lockheed Martin](#).

By the end of 2017, at least 1,700 installations were in progress, an increase of more than 300 in just six



months. Some are utility-scale endeavors like the [30-megawatt plant](#) built by San Diego Gas & Electric that was billed as the world's largest lithium-ion battery farm — until Elon Musk's Tesla managed to steal its thunder in late 2017 with a [100-MW project](#) meant to supplement wind power on the Australian grid. A more modest example is the [Glacier Battery Storage project](#) in Washington state, a 2 megawatt system backing up one of Puget Sound Energy's substations.

Other projects have a [commercial bent](#) and are meant to support industrial facilities or offices. An example is the approach [Hawaiian Electric](#) is using with fleet storage devices from Stem, a company that pairs artificial intelligence with energy storage, at Albertsons and Whole Foods grocery stores. The behind-the-meter technology — meant to serve specific buildings rather than the grid at large — helps manage power spikes.

In the United States, which will account for roughly a quarter of the industry's growth over the next 13 years, [state-level incentives](#) became far more common in 2017 in the absence of limited and waning financial support at the federal level. A handful of states have passed installation targets, and more than 20 states have at least 20 megawatts of activity in [their pipelines](#), with or without official regulations in place. California's program is the oldest, adopted in 2010. It originally mandated the installation of 1.3 gigawatts by 2020, but regulators in 2016 tacked on a requirement for an additional 500 MWs in behind-the-meter storage capacity. Another new California policy, adopted in late 2017 and more potentially disruptive, could even see energy storage used to cover the grid capacity of existing natural gas plants.

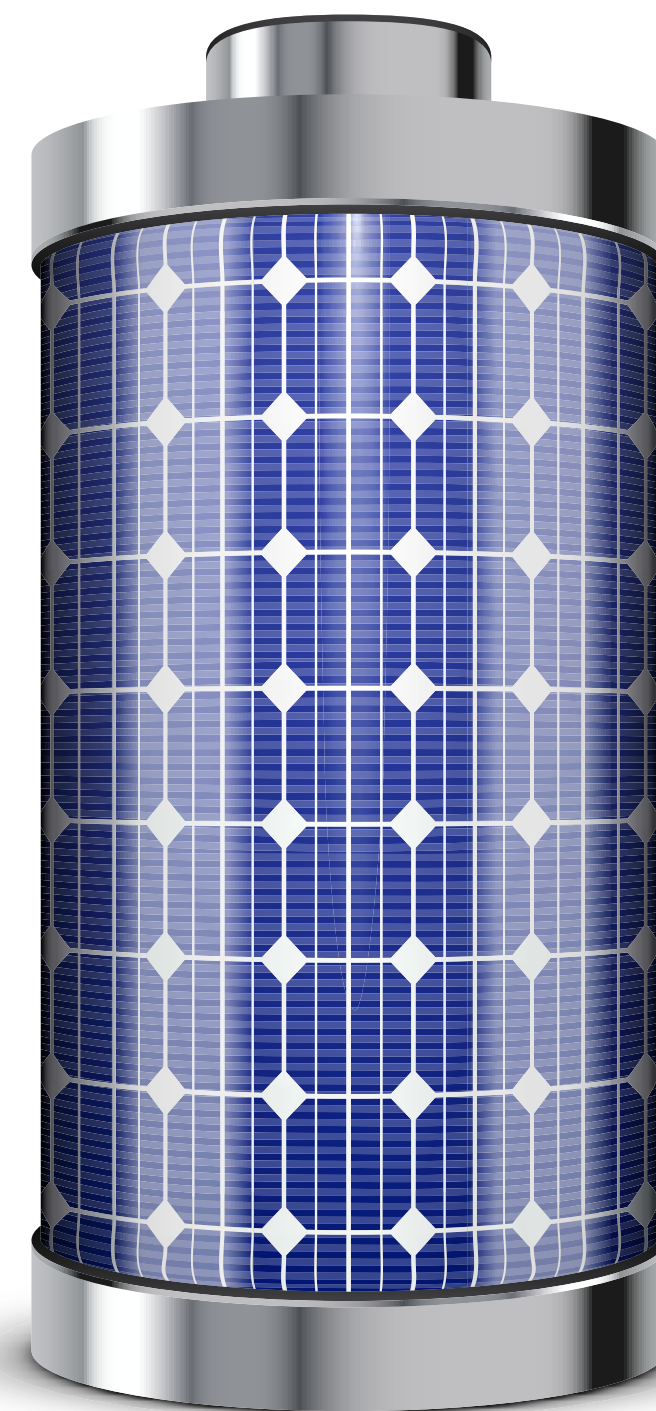
There's also an appreciable amount of activity happening in the Northeast, where outages tied to extreme weather events are more frequent and where many

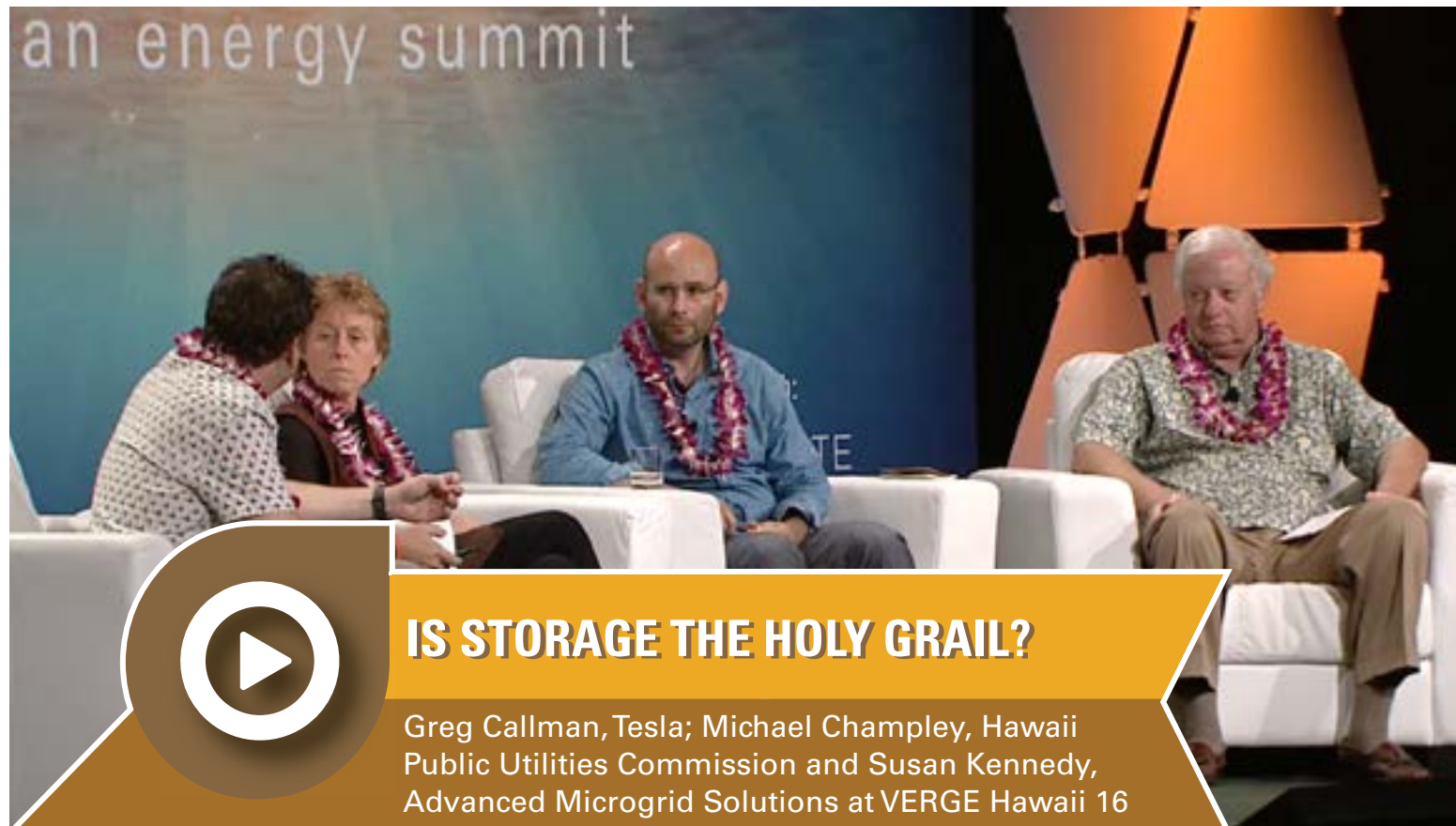
legacy coal and nuclear power plants are reaching the end of their life or facing an uncertain recertification. Massachusetts has mandated enough storage to provide at least 200 megawatt-hours of energy. [New York](#) is still finalizing its targets hours to support its burgeoning wind power industry, but it's also vying to become a [manufacturing force](#) with the state's first lithium-ion "gigafactory" set to come online by late 2019.

Right now, many people tend to equate energy storage with advances in batteries. The [battery](#) supporting Tesla's forthcoming semi-truck, as just one example, will deliver more range at a lower cost than anyone predicted. [Millions of dollars are being thrown at startups](#) — \$480 million in the first half of 2016 went to companies researching lithium advances, zinc-air innovations and flow science using various electrochemical combinations. The systems they're testing are meant for both electric vehicles and stationary systems that support buildings or community distribution systems. The [Pena Station microgrid](#) in Denver, for example, uses a 1-megawatt system to support the solar resources.

[An analysis by Lux Research](#) suggests that lithium-ion will be most cost-effective for applications requiring from 75 kilowatts to 100 megawatts of capacity, with backup ranges of 15 minutes to eight hours. The capital costs for the technology could fall as much as 36 percent over the next five years, more quickly than expected, according to [research by investment firm Lazard](#). McKinsey has estimated that [costs for stationary applications](#) could reach \$200 per kilowatt-hour in 2020 (half the price in 2015), and reach \$160/kWh by 2025.

But [other approaches](#) are worth watching, some of which have been around for years. One of the biggest differentiators among these technologies is how quickly they can collect and release power.





leader in this space is CALMAC, which uses ice tanks to take pressure off the electricity needed to run heating, ventilation and air-conditioning equipment. The company, which has sold its systems to more than 4,000 companies including Goldman Sachs, Google, Walmart and McDonald's, was [acquired](#) by HVAC giant Ingersoll Rand in late 2016.

And don't forget the potential capacity of [electric vehicle batteries](#). High-profile automakers including Tesla and Mercedes-Benz are working on vehicle-to-grid pilots, and many utilities believe that grid-connected EVs could become a powerful source of electricity during peak hours in cities. Some, such as Italy's Enel, are [experimenting](#) with charging networks and energy management software to enable that application.

Little wonder that demand for lithium-ion batteries for EVs and stationary energy storage uses could outstrip sales for consumer electronics supplies by the end of this year. The next challenge could be building batteries fast enough to keep up with demand.

### COMPANIES TO WATCH

[Fluence](#) — a joint venture of energy storage powerhouses AES Energy Storage and Siemens created to support grid-scale and commercial installations.

[Ingersoll Rand](#) — the company's Trane division acquired one of better known thermal storage companies, CALMAC, for an undisclosed sum in late 2016.

[Nuvve](#) — a startup focused on helping turn electric vehicle charging networks into two-way battery resources for the electric grid.

[Sonnen](#) — although the German company's technology is sold mainly as a residential option, it has sold thousands of systems, and utilities such as Green Mountain Power in Vermont are piloting community-scale applications.

[Tesla](#) — the automaker is talking up its Powerwall products for commercial uses such as peak demand shaving and emergency backup; the latter scenario is resonating for islands such as Puerto Rico, which may use microgrids to replace its hurricane-ravaged electricity system.

[Capacitors](#) or [flywheels](#), for example, might make sense for applications that require access to electricity quickly in the absence of another fuel source. The former is commonly used to support hybrid buses (to help them start more quickly after braking or idling) and wind turbines (where they are used for blade adjustments). The latter transforms power into kinetic energy (à la regenerative braking), releasing it back to the grid when there are hiccups by changing the speed of the rotation.

For a grid-level boost, some utilities have relied on pumped storage using multi-level reservoirs of water and principles of hydroelectricity for literally decades. When demand for power is low, water is pumped up into a holding facility; when usage peaks, the water can be released through turbines to peak the production. [One of the world's largest installations](#) is owned by Dominion Energy in Virginia: It can generate up to 3,000 megawatts as the water is released through six generators.

When it comes to commercial installations, keep your eyes on [thermal storage technologies](#), which help reduce the energy required to heat or cool buildings. One



# 07

TOP SUSTAINABLE TRENDS

## Cities Mobilize to Avert “Peak Delivery” Congestion

By John Davies

VP & Senior Analyst, GreenBiz Group

Cities across the world are congested enough. But the growing wave of online and app-based commerce could reach a tipping point. That’s bad news for local economies and the companies that operate within them.

Online sales in the United States will [grow](#) from an estimated \$409 billion to over \$603 billion in 2021. With those sales come deliveries. The United States alone accounted for an annual 13 billion parcel shipments — just over 40 packages a year for every man, woman and child in America — and that number likely will double in the next three to four years.

That double-parked delivery van is a branded problem hiding in plain sight. In Manhattan alone, UPS and FedEx pay millions every year in parking fees, and commuters curse the congestion. Hidden from view are app-based delivery services from Amazon and Uber that add more to the congestion as they [deploy passenger vehicles](#) with even fewer opportunities to consolidate multiple deliveries.

Until now, cities mostly have conducted in-depth studies focused on public transit, bike lanes and walkability. The continued increase in online and app-based deliveries points to the need for an urban logistics plan if cities want to avoid getting choked with more pollution and congestion.

One solution highlighted by [McKinsey](#) at the GreenBiz [VERGE 17](#) conference is the construction of Urban Consolidation Centers, which are located outside city centers and receive orders from numerous suppliers and retailers. Goods are consolidated to fill trucks to their maximum capacity for transport and staging in the city.

Getting into the city will pose another challenge as urban areas establish low-emissions zones either to ban certain types of vehicles or to regulate them with congestion fees. Cities such as [Paris](#) are planning to ban diesel cars entirely by 2024 and all petrol-fueled cars by 2030. This will spur the [electrification of fleets](#) as companies commission all-electric delivery

vans from startups such as [Workhorse](#) and [Chanje](#). Additional efficiencies will come as companies such as [Starsky Robotics](#) roll out technology that lets a trained driver use remote control to steer the truck from a highway exit to its final destination.

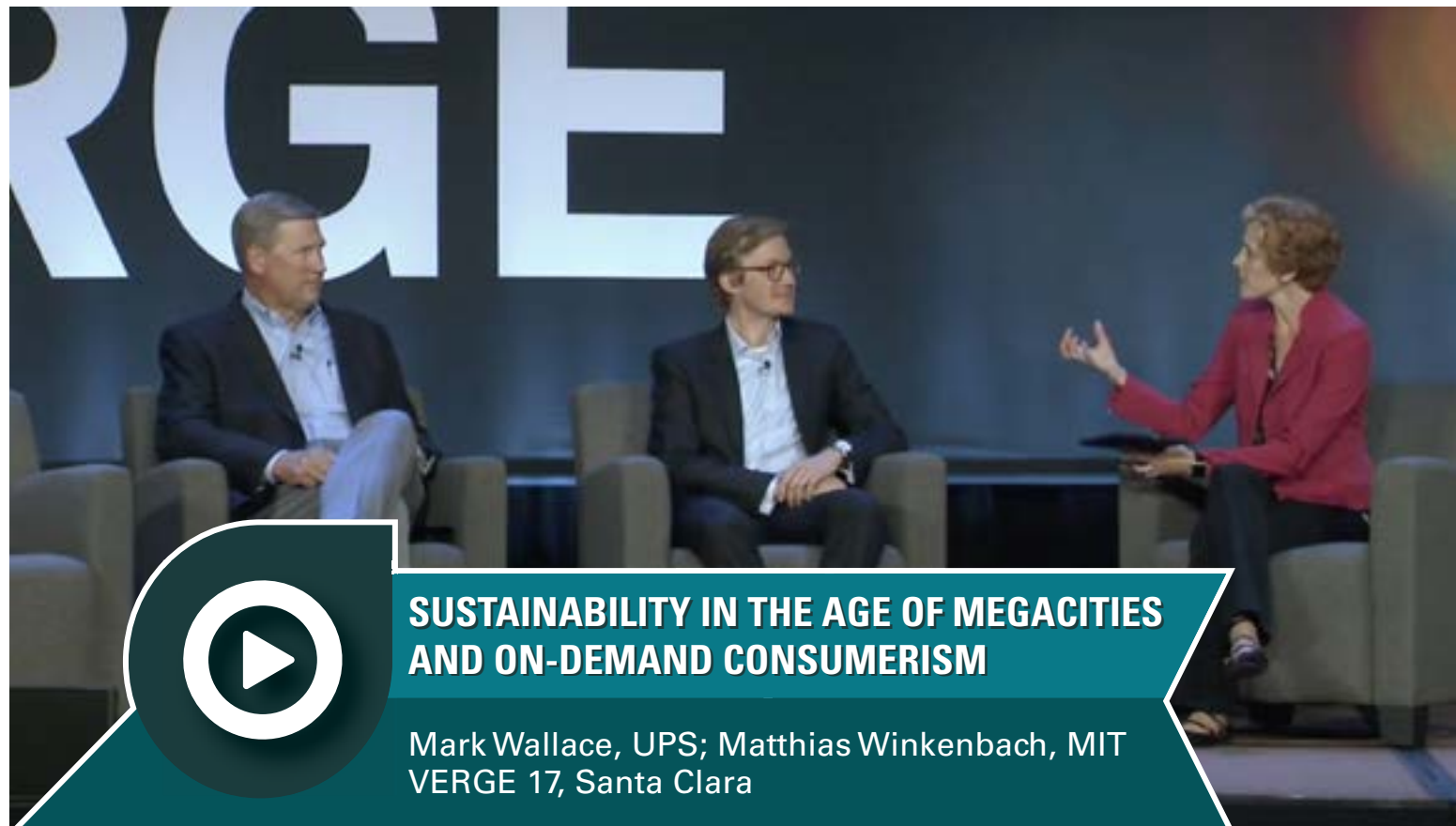
Once a truck is staged, a package still needs to get to its final address. In the German city of Hamburg, UPS sends out electric vehicles that act as micro depots and then uses walkers, conventional tricycles and eBikes to make deliveries throughout the city center and in pedestrian-only zones. In the United States, [five states](#) are looking to [Starship Technologies'](#) robots to make those doorstep deliveries.

The streets aren't the only place where multi-modal delivery systems will operate. Drones as a stand-alone solution might not be deployable at a large scale, but [drones taking off from delivery vans](#) might solve a lot of problems in urban delivery. Japan's [Chiba City](#) plans to eliminate delivery vans entirely as large drones bring packages from a portside warehouse, dropping them off at a staging area where smaller drones deliver packages to balconies on high-rise condominiums.

Getting to the last mile is not the only challenge being addressed by technology. Automated delivery lockers — some in building [lobbies](#) and some driven by autonomous vehicles — can be opened by a smartphone app. Volvo and other automobile manufacturers are experimenting with [in-car delivery services](#), where a single-use digital key provides access for deliveries in the trunk of a car. Amazon and Walmart are even asking permission to [enter your home](#).

For all of this to work, we'll need better data. The city of Seattle has partnered with the University of Washington's Urban Freight Lab to collect data that will help them tackle [the final 50 feet](#) from a city-owned curb to someone's front door. MIT's Megacities Logistics Lab has created [open-source online](#)





## SUSTAINABILITY IN THE AGE OF MEGACITIES AND ON-DEMAND CONSUMERISM

Mark Wallace, UPS; Matthias Winkenbach, MIT  
VERGE 17, Santa Clara

[maps](#) to provide details of urban supply chains. Cities may begin to require app-based services such as Uber and Lyft to expose their now-private data. That, combined with both mobile and stationary sensors in urban areas, will help planners identify opportunities and monitor the impact of pilot programs.

The critical factor to keep urban growth from gridlock will be city leaders embracing multi-stakeholder collaboration. [New York City](#) and [Seattle](#) realized they couldn't go it alone when they developed comprehensive mobility plans that incorporated logistics planning. This is reinforced by business leaders in [research](#) conducted by GreenBiz, where 72 percent of those surveyed [acknowledged that businesses should work](#) closely with city officials in identifying and addressing urban environmental and social challenges.

Ever growing urban centers are at a crossroads. To avoid making decisions or passing laws that result in unintended consequences, city officials need to take the lead in

engaging and educating stakeholders on the tradeoffs involved in moving people in addition to the goods and services they require for a healthy, safe and equitable environment.

Not to mention enjoying the wonder of same-day delivery.

### ORGANIZATIONS TO WATCH

[University of Washington's Urban Freight Lab](#) and the [MIT Megacities Logistics Lab](#) — partnering with city planners and logistics firms to collect data that will help make more informed planning decisions.

[Workhorse](#), [Chanje](#) — lead the way as startups hope to unseat traditional vehicle manufacturers in electrifying delivery fleets.

[Starsky Robotics](#) — running autonomous trucks on highways with remote operation for first and last mile.

[Amazon](#) and [Walmart](#) — their original business models were based on efficient and innovative logistics. and they show no signs of slowing down.

[Starship Technologies](#) — will consumers be able to resist pizza deliveries from R2D2's cousin?

***The critical factor to keep***

***urban growth from gridlock will***

***be city leaders embracing***

***multi-stakeholder collaboration.***

# 08

## TOP SUSTAINABLE TRENDS

# Artificial Intelligence Gets Smarter

**By Heather Clancy**  
Editorial Director, GreenBiz Group

Stephen Hawking fears it. Elon Musk begrudges it. Mark Zuckerberg embraces it. There is no shortage of smart people willing to offer their sometimes dire, sometimes optimistic opinions about how humankind's future will be reshaped by computers and software using some sort of artificial intelligence (AI).

If there's one thing upon which the naysayers and yeasayers agree, it's that AI is [already more real](#) than many people realize. A [whopping 70 percent](#) of the companies surveyed this year by Forrester Research plan to use some form of AI by the end of this year. It's tough to think of a tech giant that isn't making AI research a priority: Alphabet (through

DeepMind and Google), Amazon, Apple, Facebook, IBM and Microsoft are throwing literally millions of dollars at this opportunity.

You already use AI every day, whether you realize it or not. Consider the chatty personal assistant in your smartphone. The AI built into your handheld gadget is programmed to learn more about your habits — and the nuances of your individual speech patterns — over time. Those fraud alerts you receive from credit card companies, or shopping hints from e-commerce sites? They are made possible by software trained to observe your activity over time — in the form of online browsing and bona fide transactions — and to make predictions behind the

scenes based on knowledge it gathers about your behavior. Many companies are investing big in AI software and skills: Market researcher IDC projects [global spending](#) related to this technology at \$46 billion by 2020, compared with an estimated \$12.5 billion in 2017.

Set aside, for a moment at least, the unease many people feel about the rapid pace at which AI is advancing. Concerns about disruptions and job losses across human workforces as certain tasks become automated, the unknown question of who will make sure AI is used in [an ethical manner](#) — and how to account for diverse perspectives based on gender, race and socioeconomic factors — all



deserve serious consideration. Still, it is vividly clear that the transformative potential of this technology for the sustainability movement is unlimited.

The staid United Nations even has adopted [a rather hopeful position](#). “If we are smarter and focused on win-win type of results, AI could help proficiently distribute the world’s existing resources like food and energy,” notes U.N. Deputy Secretary-General Amina Mohammed.

In the not-so-distant future, [AI will play an intrinsic role](#) in enabling and scaling sustainability solutions that today we only can dream about because the task of analyzing the data manually is too complicated.

We’re talking about wicked systemic issues such as automating pathways to more sustainable products

and building designs; creating complex systems that detect sources of environmental pollution more quickly and precisely; and resources that can surface potential issues across a [corporate supply chain](#) or across [sensitive natural ecosystems](#). AI software coupled with radar, ultrasound, cameras, LiDAR and other sensors and analytics also will be crucial for the success of self-driving vehicles. That’s the reason Tesla founder [Musk is backing OpenAI](#), a research institute dedicated to promoting AI technologies and policies that benefit society.

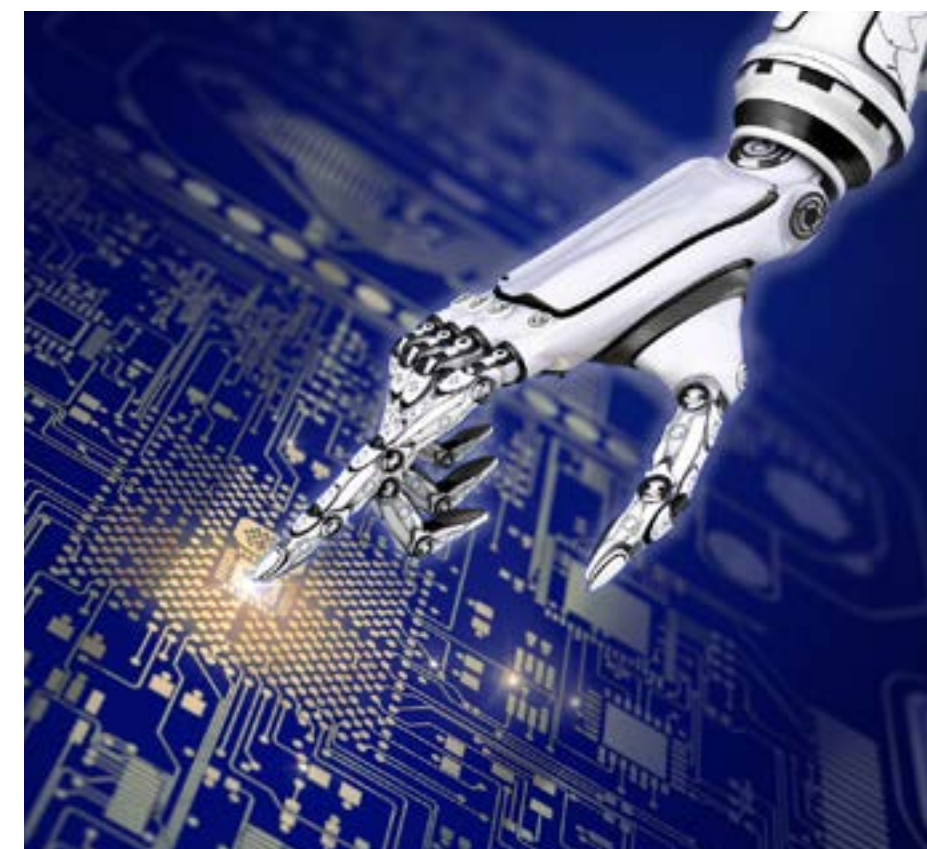
Musk may be leery of AI, but he’s preparing for its broader infiltration. “I think by the time we are reactive in AI regulation, it’s too late,” [he says](#).

The central [promise of AI](#) — a concept alive since the 1950s, but that has become more accessible alongside quantum leaps in low-cost computer processing power — is its capability to become smarter over time, to collect and consider millions or even billions of data points and types, then to act on that information in some active or predictive manner. It uses human guidance as a reference point but usually works on problems in the absence of human intervention.

But how do computers gain this knowledge? That’s where [techniques](#) such as machine learning come into play. As a computer gathers more and more data, its decision-making algorithms become more sophisticated — this is the behind-the-scenes brain

that enables tasks such as near-real-time shopping recommendations or credit-card fraud warnings. Although the results aren’t always perfect, they would be all but impossible to support using human labor.

Machine learning is already widely used for applications that recognize speech and images, so it’s easy to envision how it could play a role in cataloging endangered species, such as modeling how planetary ecosystems might react to catastrophic changes in the climate. An example of the latter is the [EarthCube project](#), managed by the National Science Foundation, which is essentially a three-dimensional, digital representation of Earth’s





***Machine learning could play a role in cataloging endangered species, such as modeling how planetary ecosystems might react to catastrophic changes in the climate.***

ecosystems. By changing the inputs, scientists more easily can simulate the effects of changes in atmospheric carbon dioxide.

AI is also emerging as a useful tool that companies can use to automate their response to conditions that could signal that, say, energy consumption or greenhouse gas emissions are reaching levels deemed unacceptable by management. [Google](#) uses its parent company's DeepMind [neural network](#) algorithms — software that can mimic the cognitive processes of a human brain — to manage the power it needs for cooling computer servers and other data center equipment. [Xcel Energy](#) has used nascent AI approaches for more than a decade to manage emissions from coal-fired power plants. More recently, the utility has begun harnessing the technology to more thoroughly [forecast the best places](#) to add renewable energy sources such as solar and wind power.

You can also expect AI to help define new paths for urban development. One top-of-mind example is the [partnership](#) between Microsoft and the Chesapeake Conservancy, an ambitious effort to create better geospatial maps across 100,000 square miles in the region. The tech colossus is using the data to “train” a future system that could be capable of visualizing land cover across the United States down to a single-meter resolution.

Numerous projects in China deserve attention — 600 cities there have declared an intention to invest in “smart” technology, including the country's eastern capital of Hangzhou. The “City Brain” project initiated by Alibaba and Foxconn collects copious amounts of data about the city's more than 9 million residents, and it already has contributed to noticeable improvements in urban traffic flow, according to [early reports](#).

IBM, which has identified AI as a core pillar of its future, used Beijing as the proving ground for its [Green Horizons](#) program, a framework for sustainable

urban development. Among the first applications is a sophisticated system for tracking China's notorious air pollution using data from satellites, weather stations, environmental sensors, traffic cameras and industrial facilities. The environmental bureau receives detailed information up to 72 hours in advance, which allows it to recommend actions that could reduce the impact such as adjusting traffic flows throughout a region or decreasing industrial production.

All of this is just scratching the surface of what's possible looking into the near-term and long-term future.

"Computers can, in theory, emulate human intelligence, and exceed it," [notes physicist Hawking](#). "Success in creating effective AI could be the biggest event in the history of our civilization. Or the worst. We just don't know. So we cannot know if we will be infinitely helped by AI, or ignored by it and sidelined, or conceivably destroyed by it."

The question: Is your team ready to help define the lesson plan?

## COMPANIES TO WATCH

[Autodesk](#) — the well-known computer aided design pioneer is exploring the potential of AI to imagine and suggest alternatives that otherwise might not be considered.

[DeepMind](#) — bought three years ago by Alphabet for an undisclosed sum, the British company's software is capable of playing professional level Go (a complex Chinese board game) and is also being applied to identifying breakthroughs in health care and materials science.

[IBM](#) — the company's Green Horizons initiative focuses on air quality management, grid integration for solar and wind resources, and energy optimization.

[Microsoft](#) — its AI for Earth initiative is allocating \$2 million in grants and tech support to organizations applying machine learning to water conservation, agriculture, biodiversity and climate change.

[OpenAI](#) — is on a mission to ensure that AI benefits humanity, with more than \$1 billion in early funding from the likes of Elon Musk, entrepreneurs Peter Thiel and Reid Hoffman, and computer scientist Alan Kay.



# 09

TOP SUSTAINABLE TRENDS

## Enter the Electrification of Everything

The expert consensus is broad: The most direct path toward a clean energy future is to replace technologies that still run on combustion — including gasoline vehicles and natural gas heating and cooling — with alternatives that run on electricity, such as electric vehicles and heat pumps, all tapping into renewable or low-carbon power sources.

Call it the First Law of Decarbonization: Everything that can be electrified, will be.

The challenges are vast but not insurmountable. How do we upgrade the power grid and make electric vehicle charging systems ubiquitous? How do we

ensure affordable energy across the full range of social demographics and geographies? How do we develop local and regional strategies that transcend existing policy frameworks and business models? And how do we do all this in short order?

The good news is that we're seeing great technological progress. By 2040, a dollar will buy 2.3 times as much solar energy as it does today, [according to Bloomberg New Energy Finance \(BNEF\)](#), and offshore wind prices will decrease by 71 percent. Since 2010, the price of lithium-ion batteries dropped by 73 percent. Within the next eight years,

electric vehicles (EVs) will be as cheap as gasoline vehicles, with sales projected to surpass those of internal combustion engines by 2038. At the same time, says BNEF, the global energy storage market will double six times by 2030. Add in the internet of things, cloud computing and artificial intelligence, and we're on a path to widespread electrification and decarbonization that could happen faster than most people realize.

What will it take? Let's start with transportation.

Currently, just 2 million EVs are on the road globally (out of just over a billion cars globally), and barriers

**By Paul Carp**

Research Director, GreenBiz Group

**& Elaine Hsieh**

Program Director, VERGE, GreenBiz Group





to growth still remain, such as long charging times and low gas prices providing less incentive for both consumers and automakers to switch.

Still, [China](#) has moved to ban cars that run on fossil fuels. The world's largest car market is also the leader in EV production and demand. That's motivating automakers such as [Volkswagen](#) and [General Motors](#) to invest heavily in EVs in China and elsewhere.

The momentum is building across corporate fleets as well with the launch last year of [EV100](#) — a global initiative by [major multinational corporations](#) to leverage their buying power to “make electric transport the new normal by 2030.” EV100 members, including IKEA, Unilever and HP, are committed to integrating EVs into their owned or leased fleets and installing charging stations for customers and employees. By setting out their future EV purchasing requirements on an ambitious timescale, these companies can drive manufacturers to make electric cars more rapidly affordable.

This shift also has paved the way to pair EVs with autonomous capabilities. With few moving parts to operate, it's relatively easy to make EVs drive themselves, and the cost for the underlying [LiDAR](#) technology has plunged — from \$150,000 per car in 2012 to \$250 in 2016 — enhancing the value proposition for automated fleet investments as well.

Meanwhile, there is a renewed focus on electrifying commercially viable transportation — buses, trucks, trains, even airplanes.

Transit agencies around the world are transitioning to electric buses. In 2017, mayors of 12 major cities — from London to Los Angeles, Mexico City to Milan — signed the [C40 Fossil-Fuel-Free Streets Declaration](#), pledging to add only fully electric buses to their public transportation by 2025. Electric bus manufacturers, including BYD and Proterra, and even Local Motors' electric and autonomous people mover [Olli](#), are ramping up to fulfill this demand.



Medium- and heavy-duty electric trucks are another growing market. The delivery and logistics sector that provides “last-mile” transportation of goods and services in and around cities is becoming electrified. With U.S. urban delivery routes averaging 70 miles a day, medium-duty trucks are seen as a potentially quicker, more scalable clean transportation solution than getting more consumer EVs on the road. Some of these eventually will become autonomous.

Heavy-duty truck electrification is yet another growing area. Almost every truck manufacturer — including Peterbilt, Kenworth and Volvo — is developing battery, fuel-cell electric or hybrid vehicles. [Tesla](#) created significant buzz late last year around its Semi electric tractor-trailer, and big buyers such as Walmart and J.B. Hunt Transport Services climbed on board to [place preorders](#), even though production won’t start until at least 2019.

What about planes and trains? A campaign called [Solutionary Rail](#) is gathering unlikely allies from urban and rural communities to electrify America’s railroads

and open corridors. And a more nascent effort aims to electrify air travel for short distances, perhaps within a decade. Last fall, U.K.-based easyJet said it had linked up with U.S. firm Wright Electric to build battery-powered aircraft for flights of under two hours. That would cover the journeys of about a fifth of passengers flown by the airline. Meanwhile, in December, Airbus, Rolls Royce and Siemens said they were collaborating on hybrid-electric planes, with a lift-off expected by 2020.

Also looking up: the decarbonization of residential and commercial buildings. With natural-gas furnaces and water heaters no longer thought to provide a cheaper and cleaner alternative to electrically heated sources, the concept of [all-electric buildings](#) is surging, promising new value streams to building occupants, owners and communities.

Imagine a fleet of buildings — say, at a corporate campus or university — dynamically connected to the grid. The electric heating system is up to four times

more efficient than natural gas heating. Dirty diesel generators are replaced with fast-responding energy storage and the system's advanced controls optimize when to use onsite solar and when to tap into the grid. This technology exists today though its viability depends on building usage, local utility rates, weather and other factors.

Retrofitting existing buildings will take more than technology alone; there are huge legacy systems and equipment to replace. Fuel-based heating and cooling systems vary greatly, including legacy [district steam](#) systems across Europe and older North American cities that capture and recycle thermal energy generated by power plants or waste treatment facilities. In homes, electric heat pumps have limitations in more extreme weather across the Midwest and East Coast.

The electric transition will require new policies at the local and state and provincial levels. Two forward-thinking California policymakers [wrote](#) that electrifying central heating and water heating systems across the state could cut the price of all-electric homes by \$4,500.

So, what will it take to get from here to ubiquitous electrification? As Hank Paulson, a co-author of the [latest "Risky Business" report](#), states, "We can reduce climate risks with existing clean technologies. We don't need an energy miracle." The technologies that enable electrification will continue to improve in price and performance, as we've seen with batteries and EVs, while business and policy leaders will continue to see the ongoing benefits of decarbonization.

But getting there requires an integrated way of planning, developing and connecting existing building and transportation systems to a clean power grid.

## ORGANIZATIONS TO WATCH

[Chanje](#) — California-based EV startup with unconventional electric cargo vans focused on last-mile deliveries. Rental giant Ryder is a major customer.

[BYD](#) — China-based EV company, the world's largest, is backed by billionaire Warren Buffett and recently expanded its electric truck effort in North America with its first plant in Canada, where it builds garbage trucks and long-range semis.

[Proterra](#) — zero-emission electric buses that reduce fleet operating costs and eliminate dependency on fossil-fuels. It recently broke a world record for range —1,100 miles on a single charge.

[Renewable Thermal Collaborative](#) — recently launched through the Renewable Energy Buyers Alliance, this collaborative, including Cargill, GM, Kimberly-Clark, P&G and Mars, centers on the use of renewable energy for heating and cooling.

[Tiko](#) — the Swiss-based solar and energy storage home-energy management system has connected tens of thousands of European homes with advanced technology to provide savings to customers and grid services to utilities.

***Retrofitting existing buildings will  
take more than technology alone;  
there are huge legacy systems  
and equipment to replace.***

# 10

TOP SUSTAINABLE TRENDS

## Synthetic Biology Hacks the Code for Sustainability

**By Joel Makower**

Chairman & Executive Editor, GreenBiz Group

Biology, the scientific study of life at every level, shows how organisms — from single cells to human bodies — stay diverse and productive over time. We study biology in part to better understand our bodies, our resources and the potential threats to our environment. Oversimplified, biology + chemistry + physics makes all life possible.

Now, add to that equation: engineering.

That's the mashup behind synthetic biology, a relatively new scientific field. Its roots trace to the early 1960s, but it's been only since the 1990s, with the advent of the genomics revolution and the rise of systems biology, that scientists developed

a rigorous engineering discipline to create, control and program cellular behavior.

Today, synthetic biology — “synbio,” for short — is rapidly growing, with great promise for addressing a wide range of sustainability issues, including how we power and feed our world, and how we design and create the materials we use to make things. It stands to revolutionize agriculture, energy production, water filtration and a variety of resource-intensive industrial processes.

“The big issues facing humanity can be solved with biology,” [says](#) Craig Venter, legendary biotechnologist and entrepreneur and founder of the company

[Synthetic Genomics](#). “We need to feed 9 to 10 billion people and provide energy and clean, potable water. We’re currently destroying our environment at an increasing pace. Biology stands to become the No. 1 sustainable energy source in history.”

It’s also become a significant source of controversy, particularly among environmentalists, who view synthetic biology as essentially “playing God” with life’s genetic instructions, potentially causing great harm to nature’s biological and ecological systems. References to “Jurassic Park” permeate some of the more critical literature on the field. In 2010, a [U.S. Presidential Commission for the](#)



***Much of synthetic biology's greatest potential goes right to the heart of sustainability's biggest challenges.***

[Study of Bioethical Issues](#) heralded synbio as a significant breakthrough, but offered 18 recommendations aimed at creating “an ongoing process of prudent vigilance that carefully monitors, identifies and mitigates potential and realized harms over time.”

Not that the U.S. government is standing on the sidelines. DARPA, the Defense Department R&D lab that helped create everything from the internet to Siri, has ramped up its synbio funding, including for designing and manufacturing DNA. Meanwhile, federal agencies are angling for which, if any, office needs to oversee this technology. The U.S. Food and Drug Administration, Department of Agriculture and Environmental Protection Agency might all lay claim to a product made using synthetic biology, depending on the method of production and its intended use. Similar conversations are happening in governments around the world.

Much of synbio's greatest potential goes right to the heart of sustainability's biggest challenges. Let's start with food. Hacking the biological code is making it possible to produce [milk without cows](#), eggs without chickens and a [variety of meats](#) without animals of any kind.

A number of startups have staked a claim on plant-based protein using synbio processes. Some, such as [Impossible Foods](#) and [Beyond Meat](#), are already on supermarket shelves and restaurant menus, at least in some places, touting burgers [so real that they “bleed.”](#) They use a genetically modified yeast concoction to produce heme, which is responsible for meat's characteristic taste and aroma. Creating heme in the lab uses a process similar to brewing beer.

Genetically modifying yeast is at the heart of several such innovations, as it is easy to manipulate, quick to grow and difficult to contaminate with microbes. That means removing some public health concerns associated with meat production, such as pathogens and salmonella.

[Perfect Day Foods](#) is producing milk and other dairy products using a specially designed yeast the company has dubbed Buttercup. [Clara Foods](#) is whipping up chicken-free egg whites. [Sugarlogix](#) is in the early stages of brewing something a bit different: breast milk. Still another startup, [NotCompany](#), based in Chile, aims to disrupt the food industry with software called “Giuseppe,” which combines AI and machine learning to discover what's in



food — nutrition and sustainability, but also mouthfeel, flavor and color — and recreate it in a lab with a vegan twist. In a related, non-edible realm, [Modern Meadow](#) is harnessing design, biology and engineering to produce biofabricated sustainable leather.

It's not just startups. Big chemistry has been all over synbio for years. For example, DuPont, together with Goodyear Tire & Rubber, is developing a reliable, high-efficiency, fermentation-based process for the Biolsoprene monomer — a substitute for rubber — and synthetic biology has played an important role. Big companies are also investing in synbio startups: Exxon, BP and Novartis are backing Synthetic Genomics, for example, and [Amyris Biotechnologies](#), which tweaked yeast to spit out a substance that makes fuels, plastics, detergents and fragrances, has partners such as Shell and Mercedes as well as Al Gore and Bill Gates.

For these innovators and investors, a big prize awaits success: About 160 million steers, pigs, sheep and chicken were slaughtered in the United States in 2016, and 100 billion eggs were produced. Because livestock production is second only to energy production

as a major source of greenhouse gas emissions — not to mention its impact on water pollution and land use — there's a big environmental benefit from these products.

Similarly, synbio has a role to play in upending energy production, particularly for petroleum-based alternatives that decompose and recycle carbon biomass more efficiently to produce fuels, chemicals and plastics.

Waste-gas-to-fuel startup [LanzaTech](#) is genomically manipulating clostridia, a bacterium that produces energy via anaerobic digestion. The company has partnered with steel mills in Asia to capture emissions from steelmaking, then bubble the gases through fermentation tanks to feed engineered microbes, creating low-cost ethanol and other chemicals. It's become one of the [companies to watch](#) in the emerging circular economy.

[Agrivida](#) uses synthetic biology to insert a gene that will trigger an enzyme to break down the cell walls of corn stover and other tough biomass materials in order to produce biofuels. Similarly, researchers at the University of Minnesota engineered a “synthetic biopathway” that can more efficiently and cost-effectively turn ag waste into a variety of useful products, from chicken feed to Spandex.

***Synbio has a role to play in upending energy production, particularly for alternatives to petroleum-based fuels to produce fuels, chemicals and plastics.***

Synbio's holy grail is to design microbes that efficiently gobble up carbon dioxide, carbon monoxide and methane to produce chemicals, turning emissions from industrial processes into revenue streams.

Despite the high expectations, serious questions remain. What are the unintended consequences of synthetic biology? Will consumers accept foods and other goods made with altered genes? After all, synthetic biology builds upon genetic engineering, which after 30 years is still encountering consumer resistance in some parts of the world.

Case in point: The sustainably minded detergent brand Ecover faced blowback in 2014, when it said it would use oil produced by engineered algae instead of from palm oil, which has been linked to deforestation, habitat degradation, climate change, animal cruelty and indigenous rights abuses in countries where it is produced. One critic [referred to the novel material](#) as "extreme genetic engineering." Ecover ultimately decided not to make the switch.

Still, investors are eyeing synthetic biology innovators, and a small but growing number of venture funds and accelerators are focusing on bringing these companies and products to market. While the numbers are small compared with other tech sectors, funding for synbio startups has tripled over the past five years, to \$4 billion, [according to research firm CB Insights](#); in 2016, investments surpassed \$1 billion for the first year. Other big-idea organizations — XPRIZE Foundation, Singularity University and Google's X facility among them — see the potential for disruptive breakthroughs in a wide range of fields that stand to improve human and environmental well-being — the very heart of sustainability.

## **ORGANIZATIONS TO WATCH**

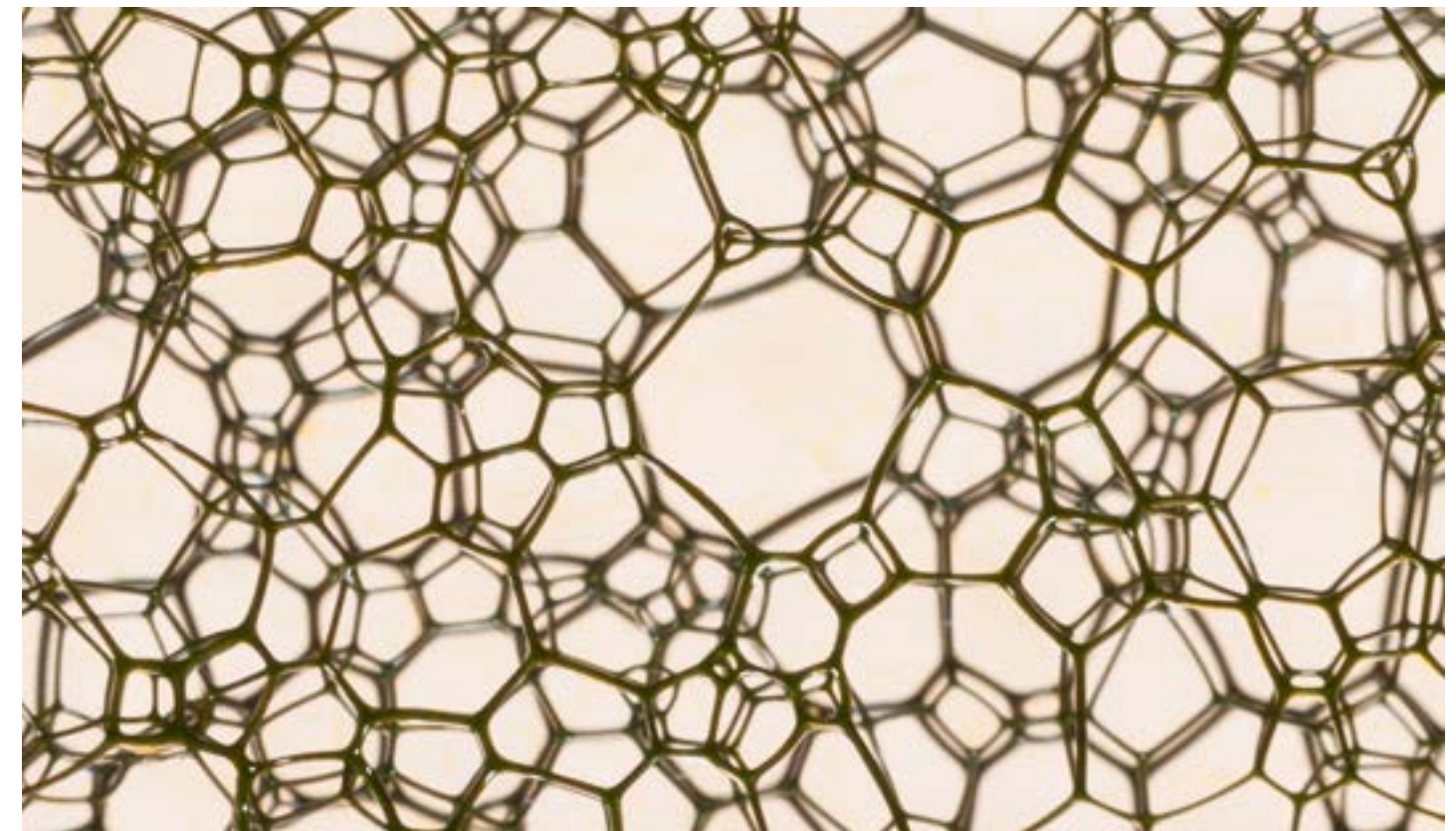
[Impossible Foods](#) — is among the darlings of the plant-based meat startups, transforming wheat and potato protein into a juicy beef alternative.

[LanzaTech](#) — its novel gas-to-liquid technology has opened up vast new sources for making low-carbon chemicals and fuels that displace petroleum without the environmental concerns associated with crop- and land-based bioproducts.

[Synbio LEAP](#) — the Synthetic Biology Leadership Excellence Accelerator Program (LEAP) aims to catalyze a next generation of leaders in biotechnology. Its fellowship program brings together emerging leaders across sectors.

[Gingko Bioworks](#) — last year it announced a [joint venture](#) with Bayer to minimize agriculture's environmental impact by developing a plant microbiome that makes its own nitrogen fertilizer, reducing greenhouse gas emissions and water pollution.

[Synthetic Genomics](#) — founded by synbio pioneer Venter, it designs and builds biological systems to address global sustainability problems.





## BIG AMBITIONS - WITH A SIDE OF SCIENCE - ARE RAISING THE BAR ON GOAL SETTING

**Bold leadership and sound science are driving these four actions into 2018.**

**Jon Dettling**

Quantis Global Director, Services + Innovation

I'm often asked, "How good do we really need to be to deal with our major sustainability challenges?" This comes from leaders urgently shifting how goals are being set. Bold leaders are looking to science for clearer answers and liking what they're finding there. However, the change they are driving isn't the willingness to listen to science, it's embracing the bold ambition to follow what science is telling us.

### **LEADERS GET BOLD**

Meeting goals is meaningless if targets aren't set in the right place. Corporate sustainability goals missed the mark in the past by setting achievable objectives, without inquiring if they're going far enough, fast enough. Today, leaders are switching from setting sustainability goals to setting goals to be sustainable. The business stakes are too high to follow a slow or uncertain path.

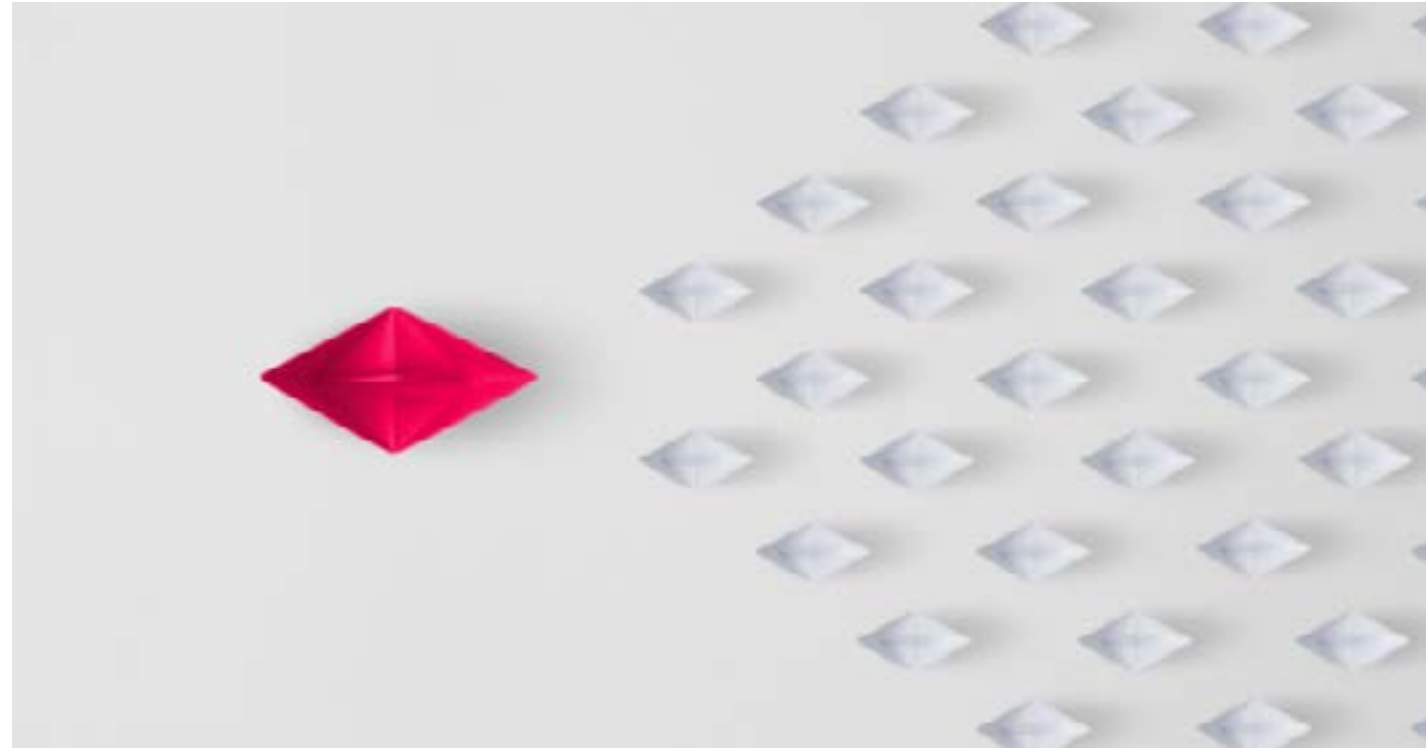
Over the last year, we've witnessed a sharp shift toward commitments to do what we need to do, rather than only what we think can do. Hundreds of companies are taking a bolder, longer-term, "business-un-usual" approach of committing to more ambitious, visionary and purpose-filled sustainability targets.

### **SCIENCE FINALLY GETS SEXY**

Science is finally making headlines, and more businesses are acting on its message that our current progress is not enough. [More than 10,000 scientists recently declared](#) we're either treading water or nose-diving on critical environmental indicators. Finally, many leading companies are pulling out of this nose dive.

This much-needed revolution is evidenced most clearly on carbon, where more than 320 companies have committed to the Science Based Targets initiative, a radical departure from typical goal-setting. Companies are taking a long-term





view of up to several decades, often committing to changes (that span the full value chain) that they don't yet know how to achieve.

Corporates are asked to commit to a target date beyond even their successor's tenure, which requires changing how they and their value chain partners do business. That hundreds of leaders are signing on is evidence for the need to understand the critical role the private sector needs to play. What comes next? Expect to see four actions emerging:

### **1. Ambitious goals going far beyond carbon**

Companies making ambitious, long-term carbon targets quickly see the benefit of anchoring goals to why they're necessary. Urgent global challenges of water and land use will follow a similar trajectory. We're seeing this accelerate through strong interest in our work on linking deforestation goals to carbon accounting, and on framing goals on achieving water balance.

### **2. Supply chain collaborations go big**

For most companies, the entire value chain outweighs the carbon footprint of their own operations. Scope 3 carbon accounting offers shared accountability, where several companies recognize their influence over the same emissions. Focusing on big changes will lead to collaborative solutions and shared accountability.

Expect to see even more collaborative goal setting. Walmart's Project Gigaton, for example, promises to work with suppliers to deliver a gigaton in total carbon reductions. We're working with WRI, The Gold Standard and others to clarify accounting principles for value-chain interventions to identify or create public references.

### **3. Leaders go for the relay**

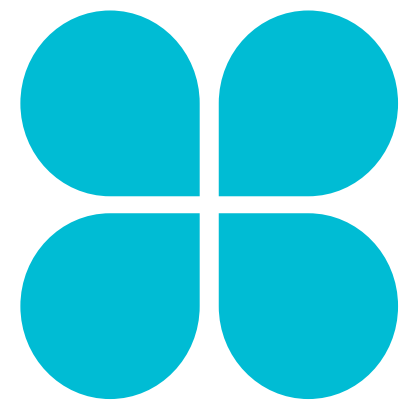
Success on issues such as carbon won't be determined by when the first runners pass the finish line, but by how far back the rest of the pack remains. Several hundred companies can't solve the problem alone; their commitments must become imperative for all companies. More leaders will align their business goals with science-based sustainability, leading others, in relay fashion.

### **4. Goals go for purpose**

"Purpose" has grown as a buzzword amid questions about how the companies we invest in, work for and buy from align with our values. Backing up goals with action demonstrates serious commitment.

The new generation of goals shows that sustainability is not just an issue to manage. Instead, a company doing its part to solve the big challenges is part of its reason for being. These goals stop talking about being a smaller part of the problem and instead commit to solutions.

Expect to see all this and more in 2018.



## KEY PLAYERS

# To Watch

[Amazon](#) and [Walmart](#) — their original business models were based on efficient and innovative logistics, and they show no signs of slowing down.

[Autodesk](#) — the well-known computer aided design pioneer is exploring the potential of AI to imagine and suggest alternatives that otherwise might not be considered.

[BYD](#) — China-based EV company, the world's largest, is backed by billionaire Warren Buffett and recently expanded its electric truck effort in North America with its first plant in Canada, where it builds garbage trucks and long-range semis.

[Carbon Pricing Leadership Coalition](#) — public-private initiative to encourage the development of effective carbon pricing policies.

[Carbon Productivity](#) — supports stakeholder conversations, alongside the development of appropriate tools, to generate value for society from reducing fossil carbon.

[CDP](#) — formerly known as Climate Disclosure Project, a London-based nonprofit that drives companies to cut their greenhouse-gas emissions, by grading companies on their reported activities. The group claims to have received environmental data in 2017 from more than 6,300 firms.

[Center for Carbon Removal](#) — nonpartisan, nonprofit organization working to clean up carbon pollution from the air by supporting the development of natural and engineered carbon removal solutions.

[Chanje](#) — California-based EV startup with unconventional electric cargo vans focused on last-mile deliveries. Rental giant Ryder is a major customer.

[Climate Bond Initiative](#) — the London-based NGO aims to mobilize the \$100 trillion bond market for climate change solutions and has created the de facto standard for green bonds.

[Covestro](#) — international manufacturer and supplier of sustainable polymers to the electronics, automotive and construction sectors based in Leverkusen, Germany.

[DeepMind](#) — bought three years ago by Alphabet for an undisclosed sum, the British company's software is capable of playing professional level Go (a complex Chinese board game) and is also being applied to identifying breakthroughs in health care and materials science.

[EU High Level Expert Working Group – Green Finance](#) — expert body established to advise the European Commission on measures to integrate sustainability into the European Union's financial policy framework.

[Fluence](#) — a joint venture of energy storage powerhouses AES Energy Storage and Siemens created to support grid-scale and commercial installations.

[G20 Green Finance Study Group](#) — the group of large-economy heads of state vowed to “scale up green finance” and has set out a number of steps to develop and propagate related policy measures.

[Gingko Bioworks](#) — last year it announced a joint venture with Bayer to minimize agriculture’s environmental impact by developing a plant microbiome that makes its own nitrogen fertilizer, reducing greenhouse gas emissions and water pollution.

[Google](#) — is on a learning curve; even as it faced controversy after an employee’s gender-biased memo went viral, it holds team trainings to address unconscious bias and hired Diversity Officer Danielle Brown.

[Greentown Labs](#) — provides workshop, office and event space in Somerville, Massachusetts, for cleantech entrepreneurs to build products and develop their businesses.

[Groundswell](#) — aims to bring economic equity to the energy sector, partnering with underserved communities in Washington, D.C., Baltimore and elsewhere to bring affordable solar power to businesses.

[IBM](#) — the company’s Green Horizons initiative focuses on air quality management, grid integration for solar and wind resources, and energy optimization.

[Impossible Foods](#) — is among the darlings of the plant-based meat startups, transforming wheat and potato protein into a juicy beef alternative.

[Ingersoll Rand](#) — the company’s Trane division acquired one of better known thermal storage companies, CALMAC, for an undisclosed sum in late 2016.

[JP Morgan Chase](#) — one of several leading banks (including Bank of America, Citi and HSBC) that has made significant funding commitments to funding sustainable technologies. Last year it, committed to \$200 billion to “clean” financing by 2020.

[Keep It In The Ground](#) — a stand-alone organization, an initiative started by The Guardian newspaper supported by organizations such as Greenpeace, the Sierra Club and 350.org, as well as legislative proposals in the U.S. Senate and House, the city of San Francisco and other jurisdictions.

[Kensho](#) — deploys scalable machine learning and analytics systems for government and financial institutions to provide solutions to social and economic analytical problems.

[LanzaTech](#) — its novel gas-to-liquid technology has opened up vast new sources for making low-carbon chemicals and fuels that displace petroleum without the environmental concerns associated with crop- and land-based bioproducts.

[Microsoft](#) — its AI for Earth initiative is allocating \$2 million in grants and tech support to organizations applying machine learning to water conservation, agriculture, biodiversity and climate change.

[Nuvve](#) — a startup focused on helping turn electric vehicle charging networks into two-way battery resources for the electric grid.

[OpenAI](#) — is on a mission to ensure that AI benefits humanity, with more than \$1 billion in early funding from the likes of Elon Musk, entrepreneurs Peter Thiel and Reid Hoffman, and computer scientist Alan Kay.

[Proterra](#) — Zero-emission electric buses that reduce fleet operating costs and eliminate dependency on fossil-fuels. It recently broke a world record for range — 1,100 miles on a single charge.

[Renewable Energy Buyers Alliance](#) — a consortium of four NGOs — the World Resources Institute, BSR, World Wildlife Fund and the Rocky Mountain Institute’s Business Renewables Center — that helps companies understand the benefits of using renewables, helps connect large buyers to renewable energy suppliers and helps utilities understand and serve the needs of energy buyers.

[Renewable Thermal Collaborative](#) — recently launched through the Renewable Energy Buyers Alliance, this collaborative, including Cargill, GM, Kimberly-Clark, P&G and Mars, centers on the use of renewable energy for heating and cooling.

[Salesforce](#) — the software leader, which employs 30 percent women globally and about 35 percent minorities in the United States, recently jumped from a rank of 23rd to eighth in Forbes’ “Best Places to Work” list, in part due to domestic partner benefits and onsite childcare.

[Science Based Targets Initiative](#) — helps companies devise the targets, then approves the targets so that the company can proceed.

[Sonnen](#) — although the German company’s technology is sold mainly as a residential option, it has sold thousands of systems, and utilities such as Green Mountain Power in Vermont are piloting community-scale applications.

[Starship Technologies](#) — will consumers be able to resist pizza deliveries from R2D2’s cousin?

[Starsky Robotics](#) — running autonomous trucks on highways with remote operation for first and last mile.

[State Bank of India](#) — the subcontinent’s largest bank announced in 2017 that it would raise \$3 billion through green bonds, one of the largest global green bond efforts, with significant potential for funding sustainable development of the world’s second-largest population.

[Sustainable Stock Exchange Initiative](#) — U.N. initiative to encourage stock exchanges to promote corporate transparency and performance on sustainability issues.

[Synbio LEAP](#) — the Synthetic Biology Leadership Excellence Accelerator Program (LEAP) aims to catalyze a next generation of leaders in biotechnology. Its fellowship program brings together emerging leaders across sectors.

[Synthetic Genomics](#) — founded by synbio pioneer Venter, it designs and builds biological systems to address global sustainability problems.

[Task Force on Climate Related Financial Disclosures](#) — provides guidance to companies and investors on the disclosure of information on the financial implications of climate change.

[Tesla](#) — the automaker is talking up its Powerwall products for commercial uses such as peak demand shaving and emergency backup; the latter scenario is resonating for islands such as Puerto Rico, which may use microgrids to replace its hurricane-ravaged electricity system.

[Tiko](#) — the Swiss-based solar and energy storage home-energy management system has connected tens of thousands of European homes with advanced technology to provide savings to customers and grid services to utilities.

[U.N. PRI – ESG Factors in Credit Risk Analysis](#) — aims to enhance the transparent and systematic integration of environmental, social and governance factors in credit risk analysis.

[University of Washington’s Urban Freight Lab](#) and the [MIT Megacities Logistics Lab](#) — partnering with city planners and logistics firms to collect data that will help make more informed planning decisions.

[U.S. Green Building Council](#) — the membership group, founded in 1993 to promote sustainability in construction, design and operation, announced a commitment to 20 percent growth by 2020 for underserved communities.

[We Mean Business](#) — another coalition sponsored by The Climate Group and CDP, along with some other groups, that encourage businesses to take action on global warming, with a goal to put the world on track to avoid dangerous climate change by 2020.

[Workhorse](#) — leads the way as startups hope to unseat traditional vehicle manufacturers in electrifying delivery fleets.

[World Bank Group](#) — the multilateral bank has taken a leadership role in GreenFin strategy, including providing more than \$10 billion a year for projects that increase resilience to climate impacts and reduce emissions.

[#YesWeCode](#) — created by author and attorney Van Jones and inspired by a conversation with musician Prince, it seeks to help 100,000 youth from underrepresented backgrounds enter the lucrative work in technology.

# VERGE **HAWAII**

asia pacific clean energy summit

**JUNE 12-14, 2018 | HONOLULU, HI**  
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VERGE Hawaii convenes more than 800 leaders — from government, military, utilities, solutions providers and the world's largest companies — to have candid, action-oriented conversations that address the greatest challenges and opportunities in transitioning to 100% renewable energy, in Hawaii and worldwide.

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# S&P Dow Jones Indices

A Division of **S&P Global**

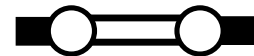


# Getting Ahead of Climate Change

## The Corporate Carbon Pricing Tool

Carbon regulation is increasing and business as usual is not an option. The Corporate Carbon Pricing Tool, developed by Trucost, part of S&P Dow Jones Indices, was created to help companies and their investors assess exposure to evolving regional carbon pricing mechanisms and understand the investment case for green capital allocation.

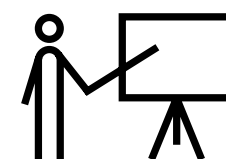
### Benefits include:



**Set a range** of internal carbon prices aligned to regional policy trends, informed by robust quantitative analytics, across the enterprise or for each business unit.



**Understand** current and future financial implications of carbon regulation risk on operating costs and margins.



**Inform** the business case for low carbon investment based on projected changes in regional carbon pricing over time.



**Prioritize** low-carbon innovation in regions of your business where it matters most.



**Conduct** a 2° scenario analysis to stress test the business against rising carbon prices in key markets and respond to investor expectations.



**Benchmark** carbon regulation risk exposure against key competitors.

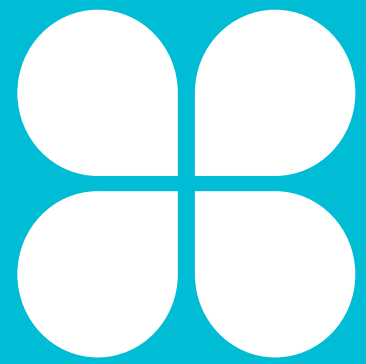
Explore the Corporate Carbon Pricing Tool: [trucost.com/corporate-advisory/carbon-pricing-tool/](https://trucost.com/corporate-advisory/carbon-pricing-tool/)

# the INDEX

## State of Green Business

Welcome to the annual State of Green Business Index, a review of trends in sustainability performance over the last five years for the largest 500 companies in the United States, as well as the largest 1,200 companies globally. Produced in collaboration with the ESG analysis firm Trucost, the 2018 assessment includes more than 30 corporate sustainability performance indicators.

- 56** highlights of **KEY FINDINGS**
- 57** the **BIG PICTURE**
- 60** corporate **PERFORMANCE**
- 64** risk **MANAGEMENT**
- 69** customer **PREFERENCE**
- 72** investment in greener **BUSINESS MODELS**



# highlights of KEY FINDINGS

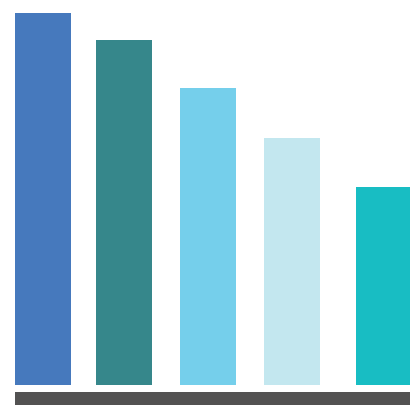
For the first time in five years, the natural capital costs of the top 1,200 global companies exceeds

**\$4.1**  
TRILLION



Natural capital costs exceed net income by

**2X**



Companies' GHG emissions fell by

**1%**

reaching the lowest level since 2012

**33%**

more companies since 2012 disclose carbon emissions from their value chain



SOURCE: Trucost, 2017

**10%**

more companies set carbon and water targets over the past five years



Current carbon targets contribute just

**20%**

of the reductions needed by the top 1,200 global companies to align with the Paris Agreement 2 degrees Celsius goal

**10**

more stock exchanges set environmental listing requirements

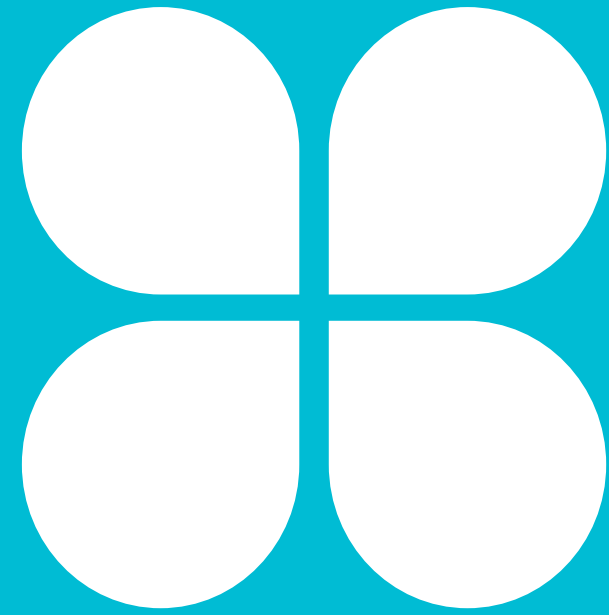
**68**

stock exchanges in total have environmental listing requirements

**40K**

companies are listed in these stock exchanges





# the BIG PICTURE

***In 2016, the cost of natural capital impacts by companies increased for the first time since the peak in 2013.***

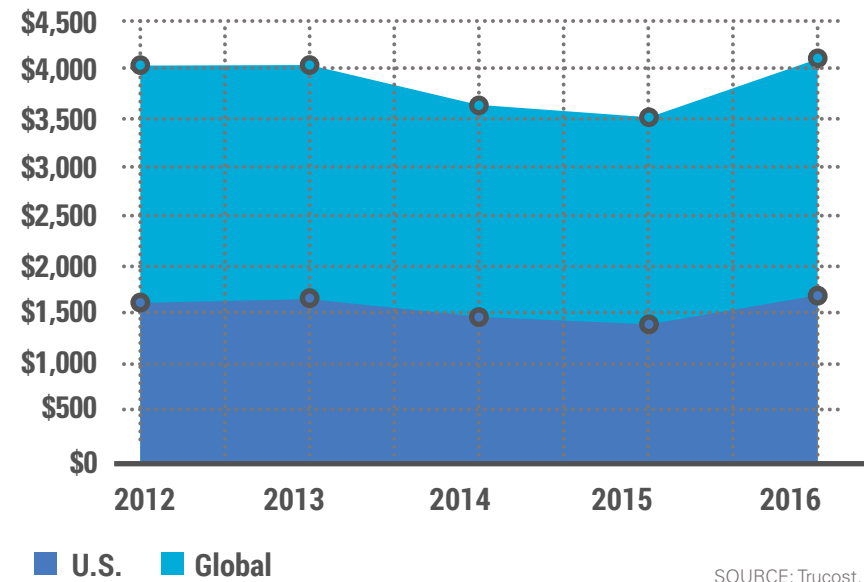
Each year in the State of Green Business Index, we assess what progress, if any, is being made by publicly traded companies in improving their environmental sustainability.

In this section, the assessment provides an overview of key trends in corporate environmental performance.

Companies use natural resources and generate pollution as a result of their business activities. Every year, Trucost estimates the costs associated with these impacts by the top companies in the United States and the world. In 2016, the cost of natural capital impacts by companies increased for the first time since the peak in 2013. The total cost in 2016 was approximately 24 percent higher than 2015, driven by increased production in agricultural supply chains and therefore greater environmental impacts, in particular water pollution from fertilizer and pesticide use. If companies had to internalize all of the natural capital costs associated with their business, for example as a result

## COMPANIES' NATURAL CAPITAL COST EXCEEDS \$4.1 TRILLION FOR FIRST TIME

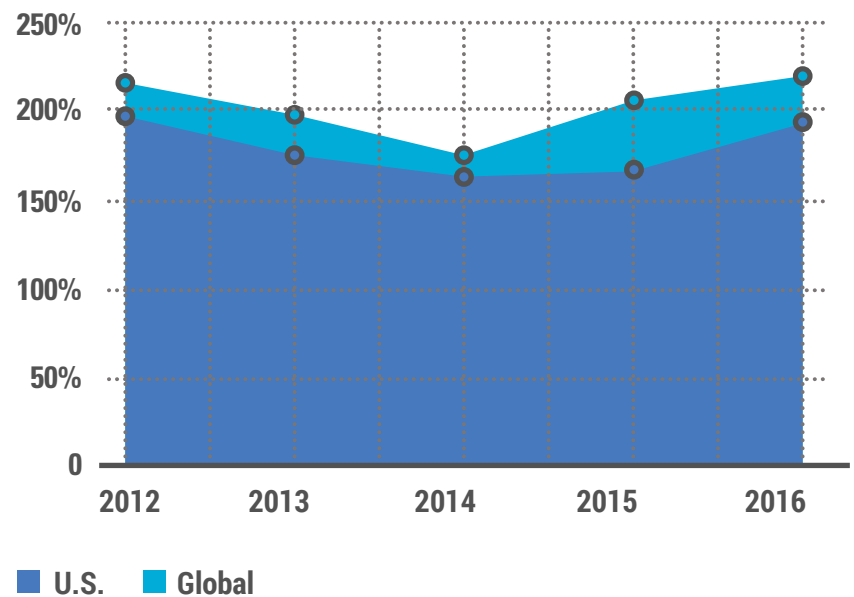
Total Natural Capital Cost (Billion USD)



SOURCE: Trucost, 2017

## COMPANIES' ENVIRONMENTAL COSTS ARE MUCH HIGHER THAN THEIR NET INCOME

Total Natural Capital Cost as Percent of Net Income



SOURCE: Trucost, 2017

**“Natural capital” refers to the limited stock of the Earth’s natural resources upon which people and businesses depend for prosperity, security and well-being.** It includes things such as clean air and water, land, soil, biodiversity and geological resources. The total value of natural capital to society globally has been estimated to be up to \$72 trillion per year according to the United Nations Environment Programme.

Natural capital costs and environmental impact data, as measured by Trucost, combine hundreds of environmental indicators related to the resources consumed to create goods or services sold, as well as the pollution and waste impacts related to the production of those goods and services, both within a company’s own operations and throughout its value chain. A full description of Trucost’s methodology is available on page 75.

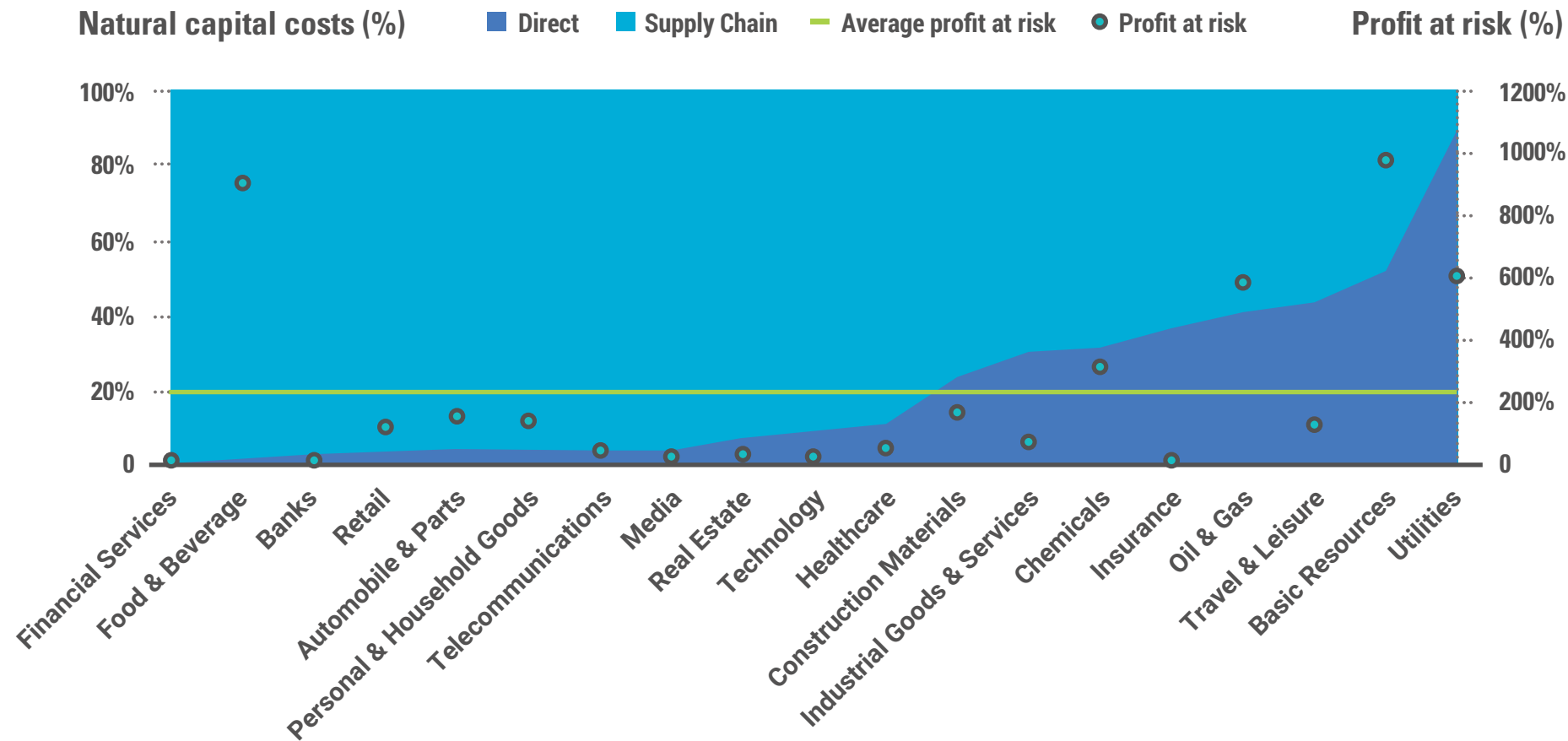
of increased regulations or new carbon taxes, their profit would be greatly at risk. The natural capital cost generated by the largest 1,200 companies in the world is nearly two times higher than their net income.

For most of the sectors, much of this cost is embedded in their supply chain. On average, 79 percent of company impacts are in their supply chain. For this reason, measuring impacts from goods and services purchased by companies is essential in understanding their natural capital costs and exposure to environmental regulation and policy risks.

Among all types of environmental impacts, the largest contributors are fertilizer-related nutrient and organic pollutants (33 percent) and greenhouse gas emissions (31 percent), followed by water use (18 percent) and heavy metal pollution (7 percent). Nutrient and organic pollutants were the greatest type of impact in 2016 because of the impact of fertilizer and pesticide use in agriculture supply chains where production

## MAJORITY OF CORPORATE NATURAL CAPITAL COSTS COME FROM SUPPLY CHAIN FOR MOST SECTORS

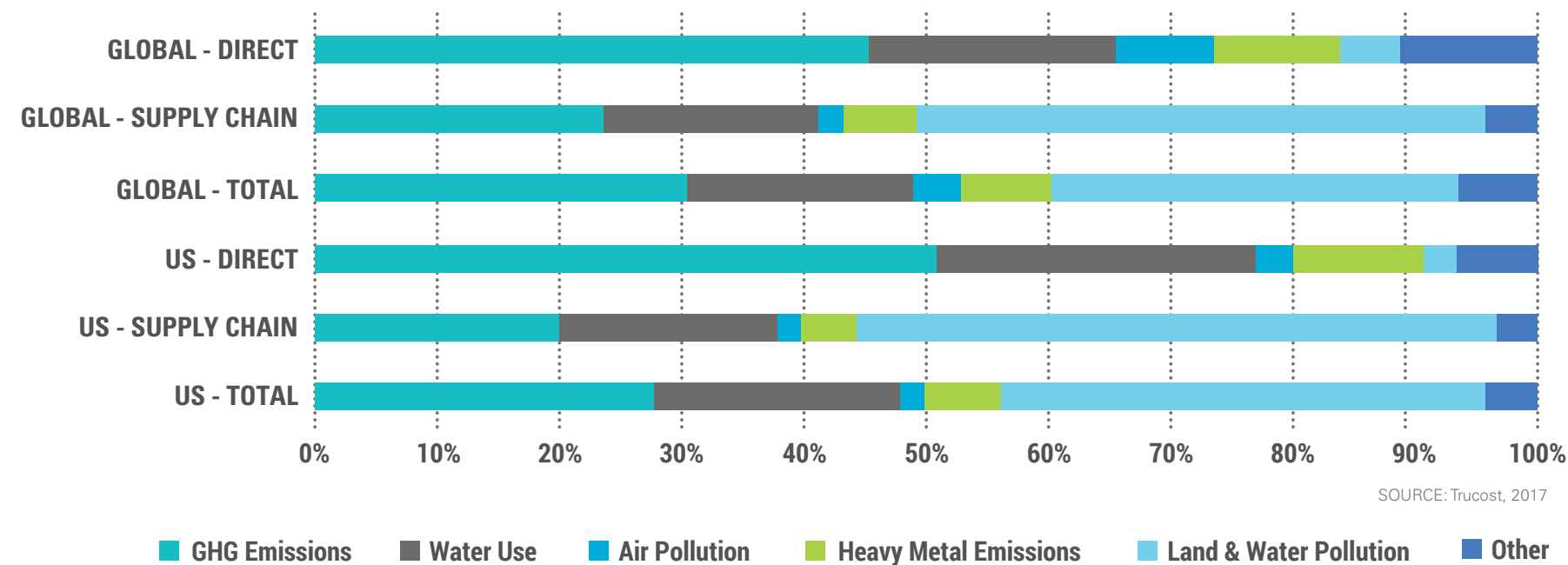
SOURCE: Trucost, 2017



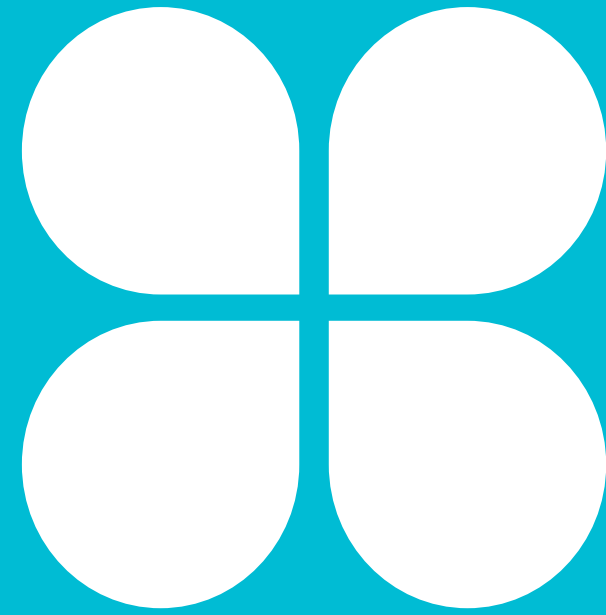
increased. These four main types of environmental impact jointly account for 90 percent of the total cost of the 1,200 companies assessed.

While these indicators illustrate that natural capital costs and exposure to business risk continue to be significant for companies, measuring and valuing the key types and sources of impacts could help businesses to prioritize ongoing improvement in their environmental performance.

## THE LARGEST NATURAL CAPITAL IMPACTS BY COMPANIES COME FROM LAND & WATER POLLUTION AND GHG EMISSIONS



SOURCE: Trucost, 2017



# corporate PERFORMANCE

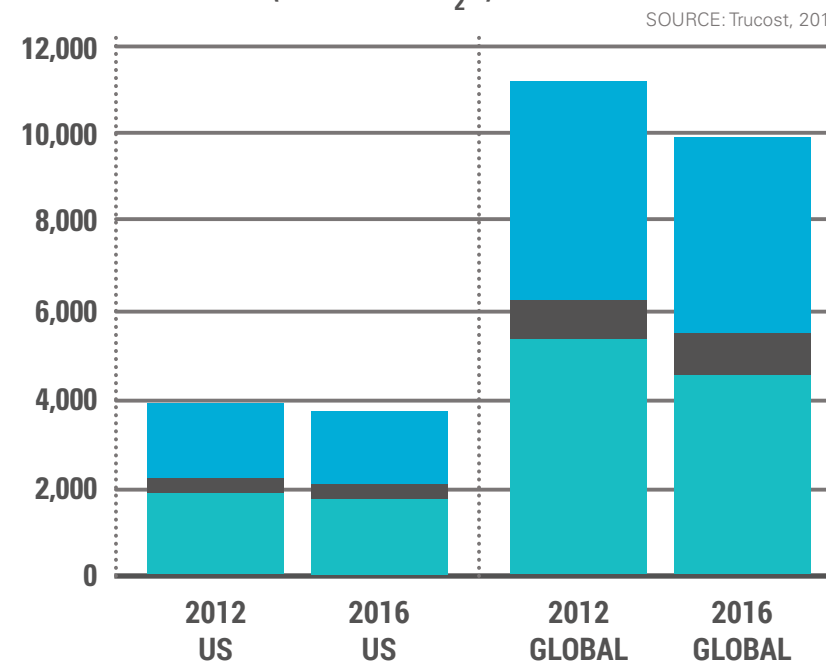
In this section, we provide more details on corporate GHG emissions, water, waste, and energy use. Many of the measures show improvement over the past five years because businesses have reduced the amount of resources used per dollar of revenue generated.

Corporate GHG emissions continue to decrease, reaching the lowest level in the past five years. The 1,200 largest companies in the world emitted 12 percent less GHG emissions in 2016 than they did in 2012, while the 500 largest U.S. companies emitted 4 percent less. This is mainly a result of lower GHG intensity in fuel use by companies' direct operations (Scope 1).

The energy mix continues to shift towards lower carbon fuels. Renewable energy by U.S. utilities increased by

## COMPANIES' GHG EMISSIONS HIT THEIR LOWEST LEVEL

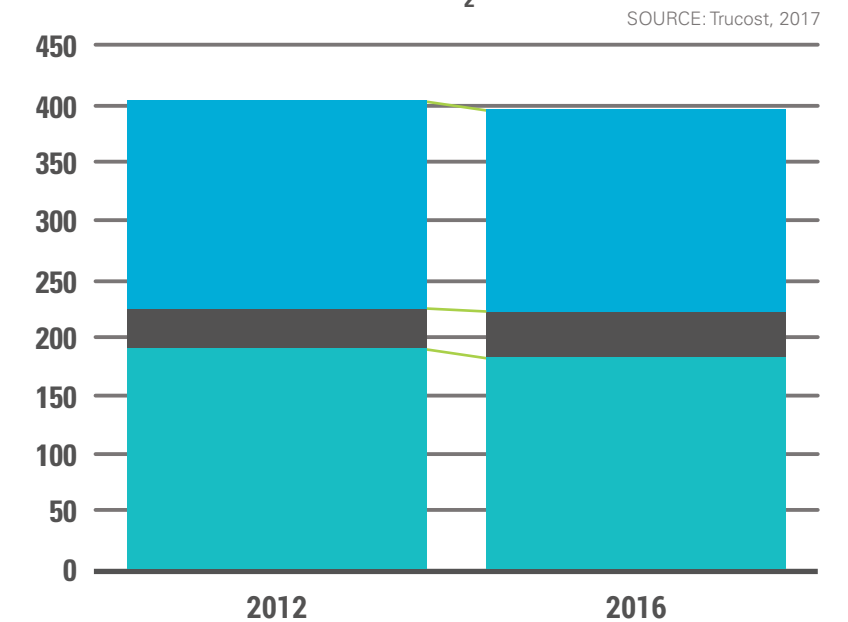
GHG Emissions (million tCO<sub>2</sub>e)



- **Scope 1** (refers to emissions generated during operation, such as fuel use for vehicles or onsite power generation.)
- **Scope 2** (refers to emissions from purchased energy.)
- **Scope 3** (refers to supply-chain emissions.)

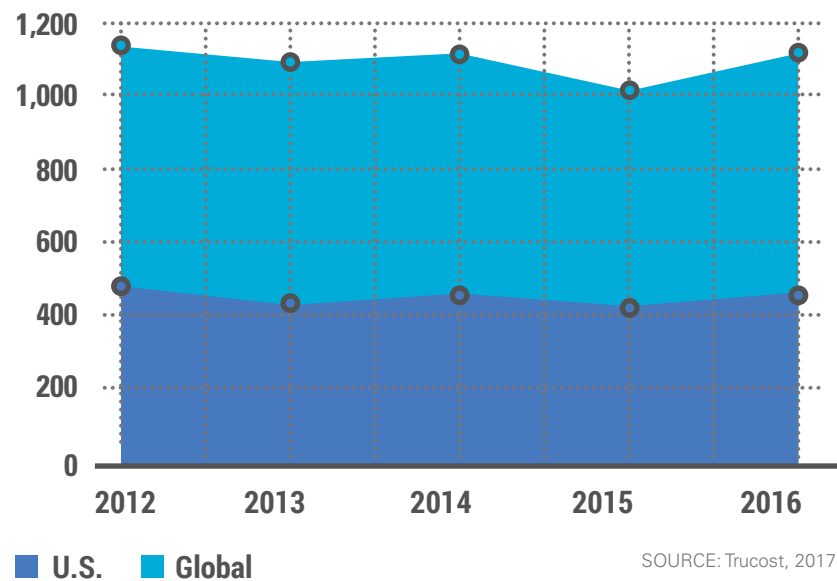
## COMPANIES SHIFT TOWARD LESS GHG-INTENSIVE FUEL USE

GHG Emissions (million tCO<sub>2</sub>e)



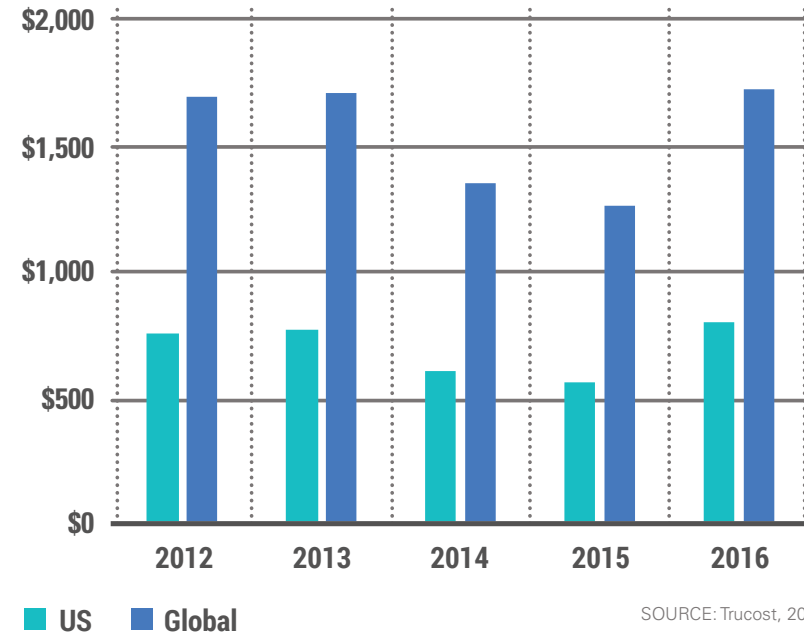
## COMPANIES' WATER USE DOES NOT SHOW ANY SIGNIFICANT DECREASE OVER THE YEARS

Total Water Use (billion cubic meters)



## WATER POLLUTION BY COMPANIES INCREASED IN 2016

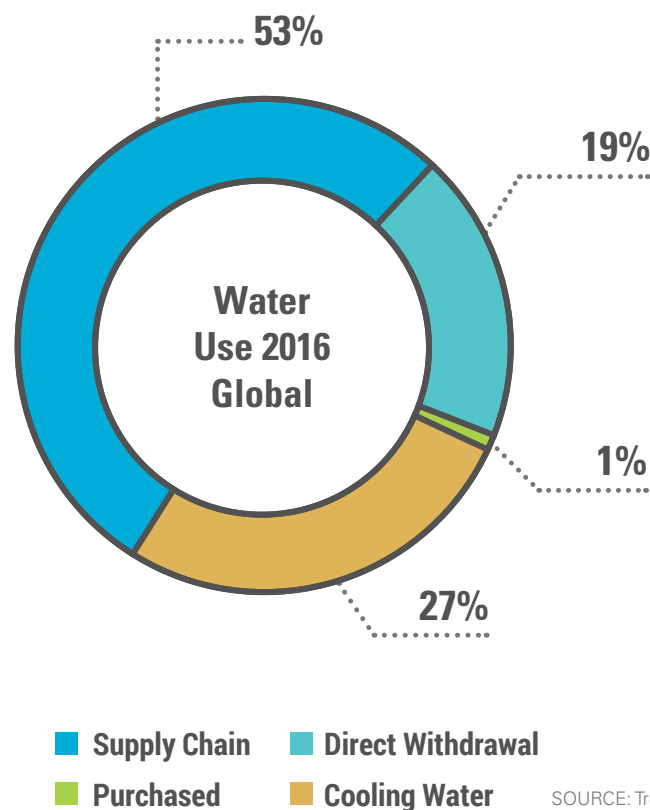
Total Environmental Cost (Billion USD)



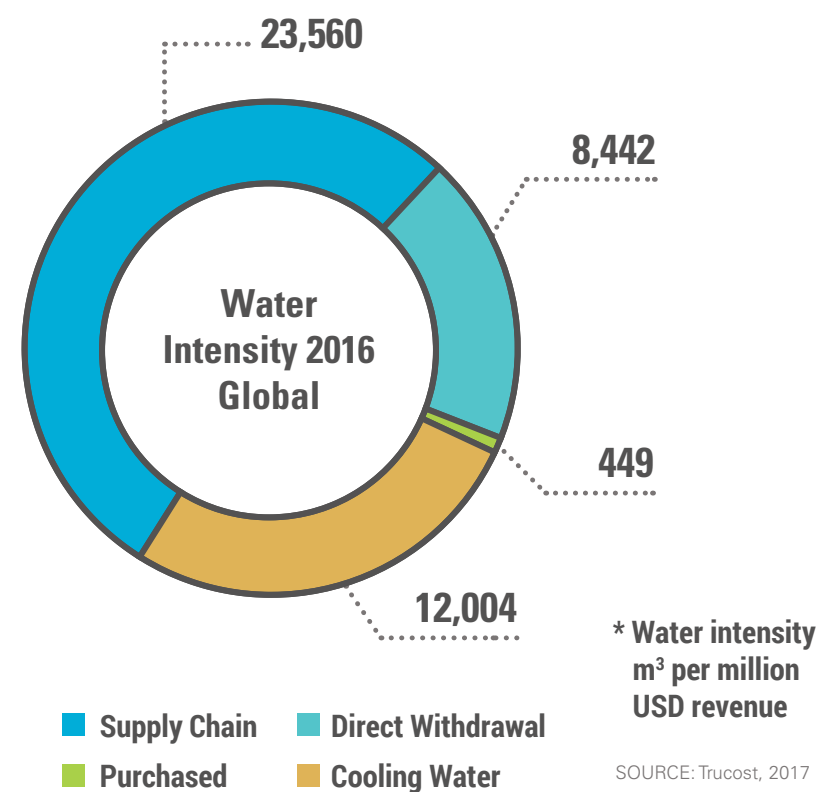
1 percent in total, while the share of coal power generation reduced by 5 percent. The green transition of the energy mix is not only taking place through a switch to renewables, but also through the use of natural gas for power generation, which accounts for 6 percent more of the U.S. energy mix compared to 2012.

Water use by companies has been relatively stable since 2012 – only showing a reduction of 4 percent and 2 percent for the largest companies in the United States and the world, respectively. The supply chain accounts for the largest share of companies' water use (53 percent), and it also has the highest water intensity. This indicates that most of the water risk for companies is likely to be beyond their operations and direct control, which highlights the

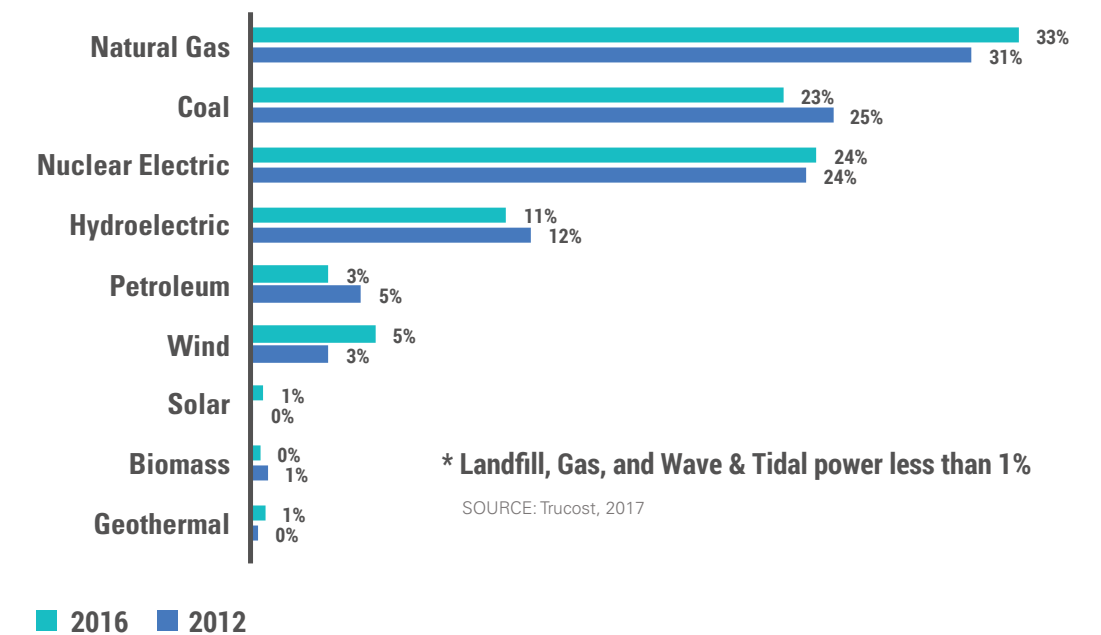
## OVER HALF OF COMPANIES' WATER USE COMES FROM SUPPLY CHAINS



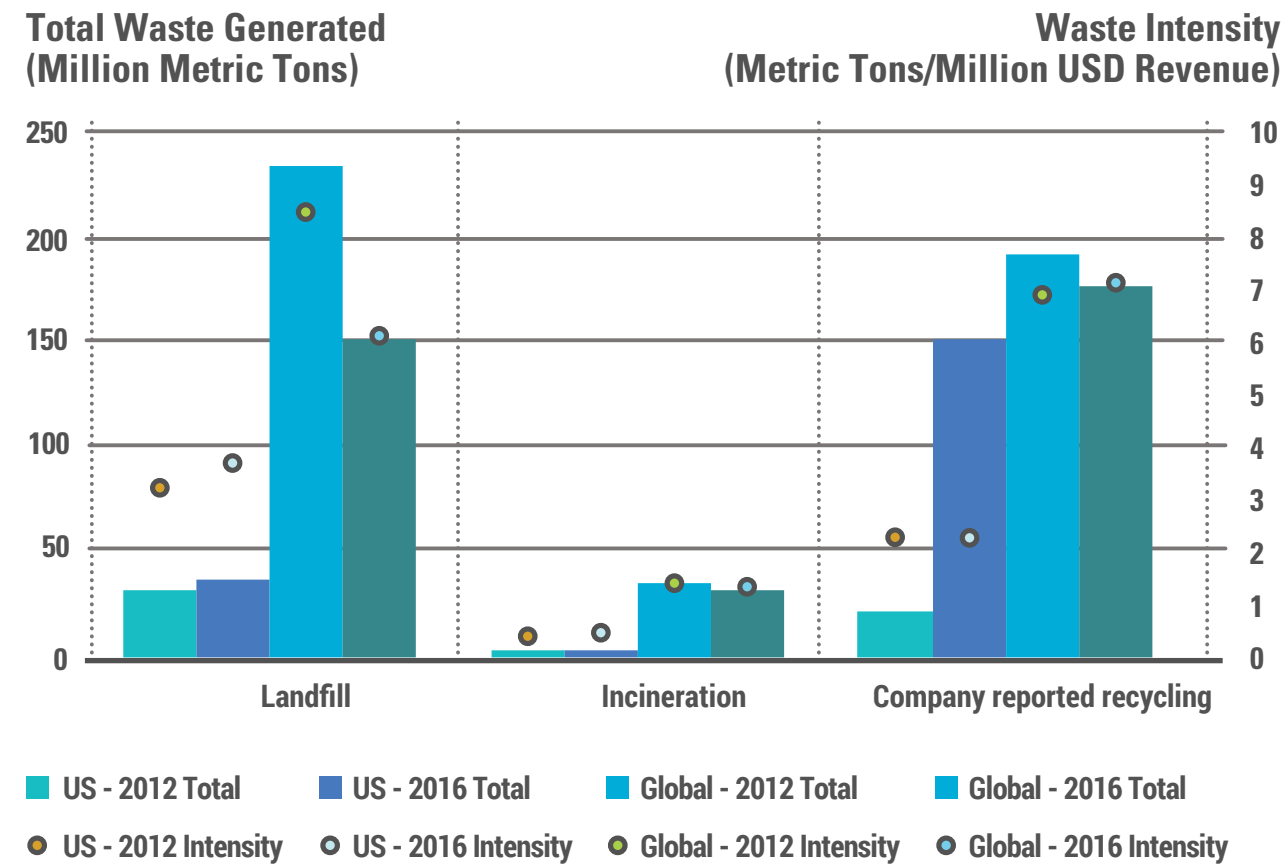
## COMPANIES' SUPPLY CHAINS USE THE MOST WATER PER REVENUE



## COAL CONTINUES TO BE REPLACED BY NATURAL GAS AND RENEWABLES FOR POWER GENERATION

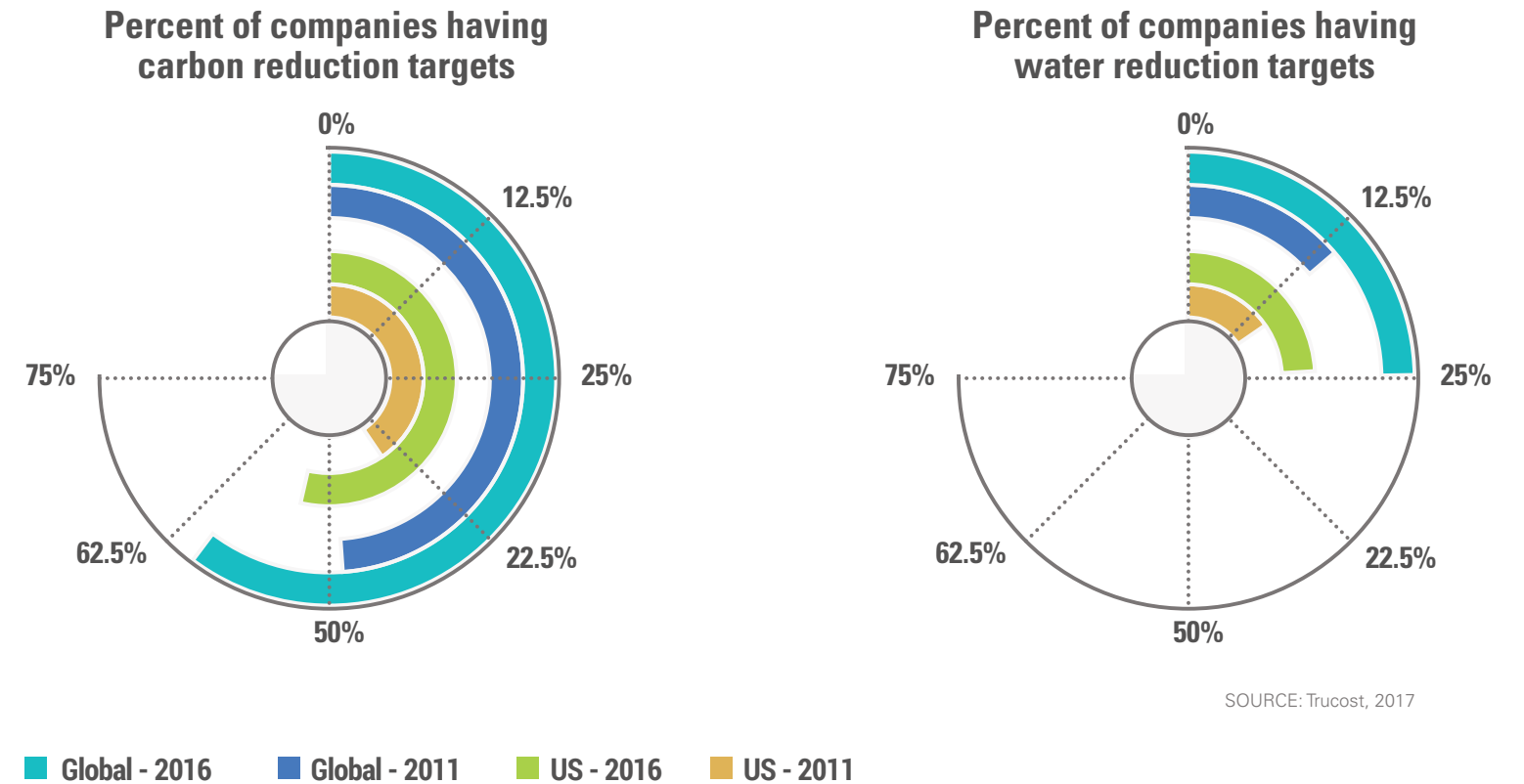


## WASTE GENERATED BY COMPANIES FALLS GLOBALLY BUT RISES IN UNITED STATES



SOURCE: Trucost, 2017

## MORE COMPANIES SET CARBON AND WATER REDUCTION TARGETS



SOURCE: Trucost, 2017

importance of corporate programs focused on managing supplier-related water risks.

Alongside the small reduction in overall water use, water quality impacts associated with business activities have increased. The total environmental costs from water pollution are 6 percent and 2 percent higher for the largest companies in the United States and the world, respectively.

The amount of waste generated decreased by 22 percent compared to 2012 for the 1,200 largest companies in the world, at the same time waste generation increased by 13 percent for the largest companies in the United States. This is because of greater waste intensity and economic growth. The largest improvement

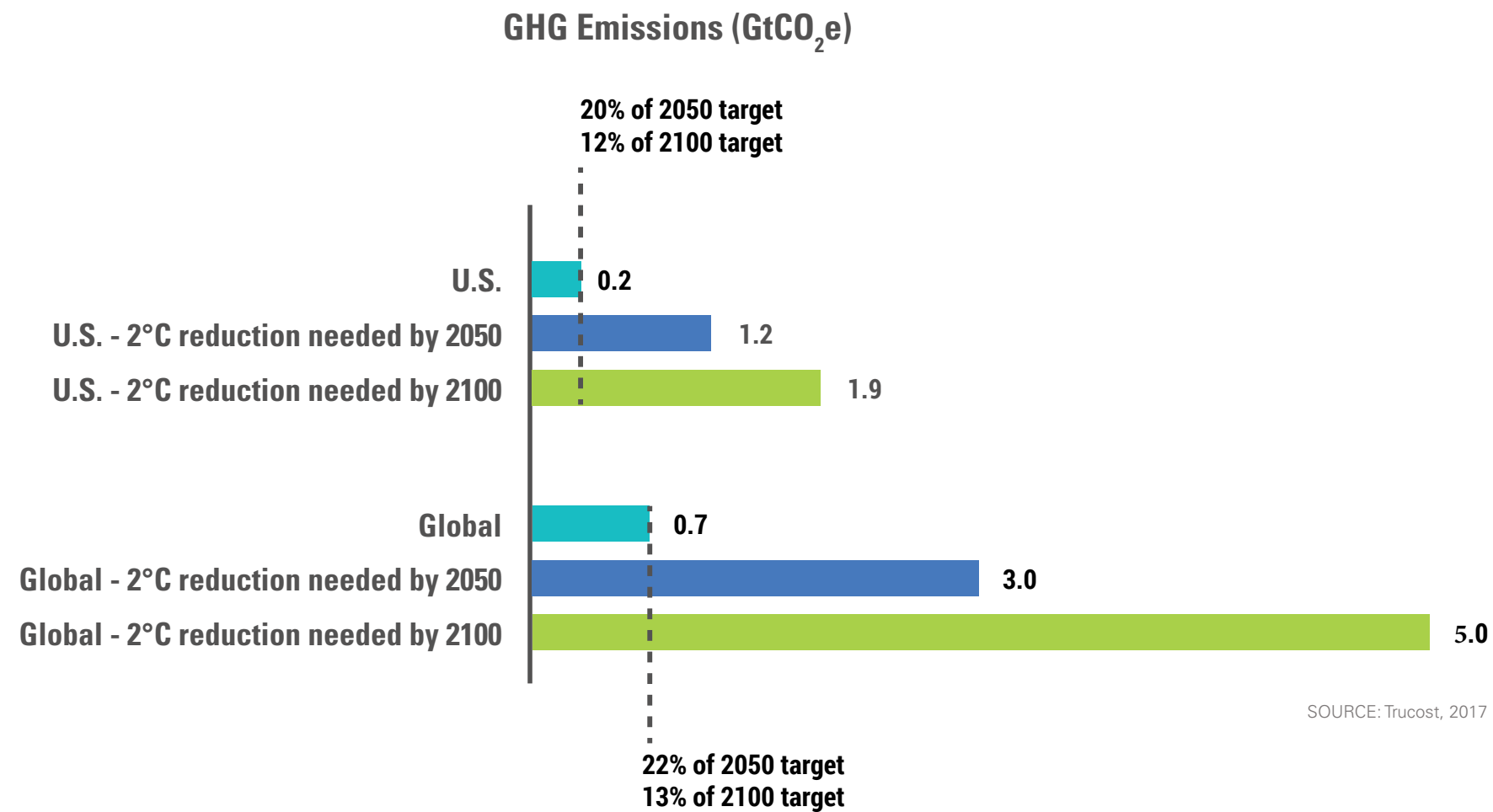
is the 35 percent reduction in waste going to landfill by global companies in 2016.

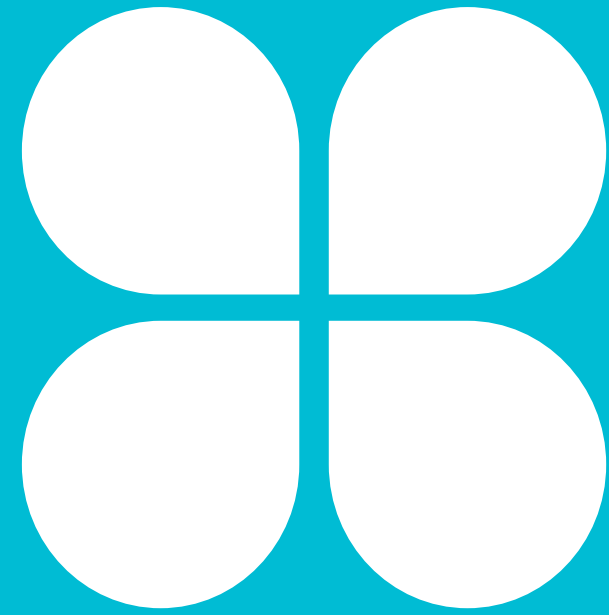
Companies also show a growing commitment to further reduce environmental impacts and publicly disclose reduction targets. The share of global and U.S. companies having GHG and water reduction targets grew by roughly 10 percent over the last five years. In 2016, about 60 percent of global companies set a GHG reduction target, while 25 percent of global companies set a water reduction target.

While the efforts made by companies to date are growing, the commitments are far short of the GHG reductions required using science-based or context-based target setting approaches. Given that top global and U.S. companies accounted for 10 percent and 4 percent of global emissions in 2016, Trucost estimates the

proportional reduction that these companies need to achieve by 2050 and 2100 to achieve the 2 degrees Celsius target specified in the Paris Agreement are 3 and 5 metric gigatons of carbon dioxide equivalent (GtCO<sub>2</sub>e) for global companies and 1.2 and 1.9 GtCO<sub>2</sub>e for U.S. companies. The GHG reduction targets set by top global and U.S. companies in 2016 (0.7 and 0.2 GtCO<sub>2</sub>e) account for only 22 percent and 20 percent of their share of reduction needed by 2050. The targets currently in place are even smaller compared to the reduction needed by 2100, accounting for roughly 13 percent and 12 percent by global and U.S. companies, respectively.

## CARBON REDUCTION TARGETS SET BY COMPANIES FALL SHORT OF THEIR CONTRIBUTION TO 2 DEGREE TARGET





risk

# MANAGEMENT

***Companies are becoming increasingly aware of the potential implications that environmental impacts could have for their business.***

Overall, most of the indicators show steadily improving trends for corporate environmental risk management through more in-depth understanding of risks throughout the value chain, better disclosure, and impact reduction projects.

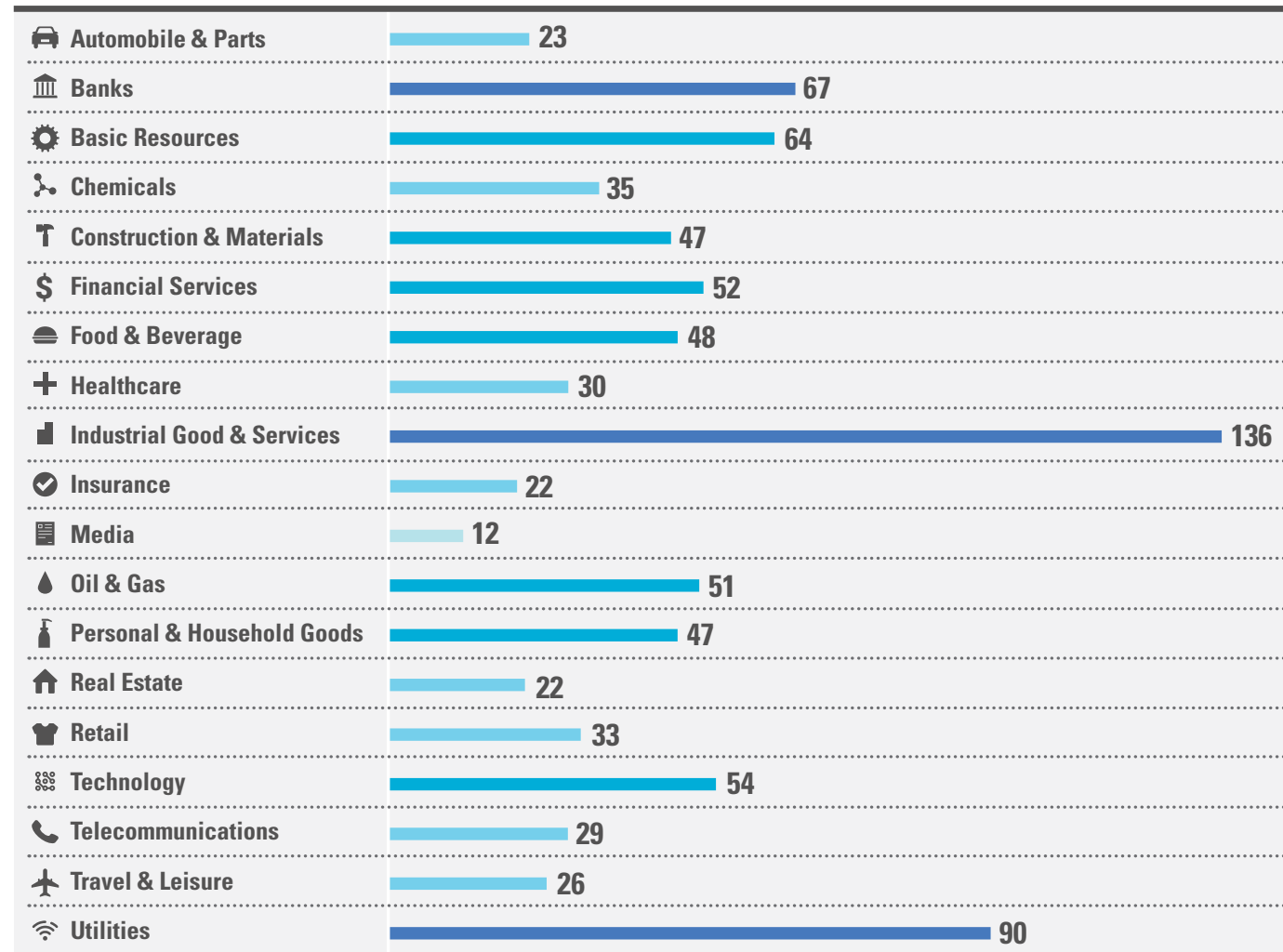
Companies are becoming increasingly aware of the potential implications that environmental impacts could have for their business. In this section, we review what companies are actively doing to monitor and mitigate environmental risks.

More companies are interested in exploring the value of natural capital through various initiatives, such as participating in natural capital alliances or setting an internal carbon price. Compared to 2012, the number of companies taking part in natural capital initiatives increased over threefold, reaching nearly 900 companies in 2016 (chart, page 51). At the same time, disclosure of natural capital costs remained relatively stable over the years. The top companies in the United States and the world only disclosed 37 percent and 47 percent, respectively, of their total environmental cost in 2016.



## MORE COMPANIES ENGAGE IN NATURAL CAPITAL ACTIVITIES

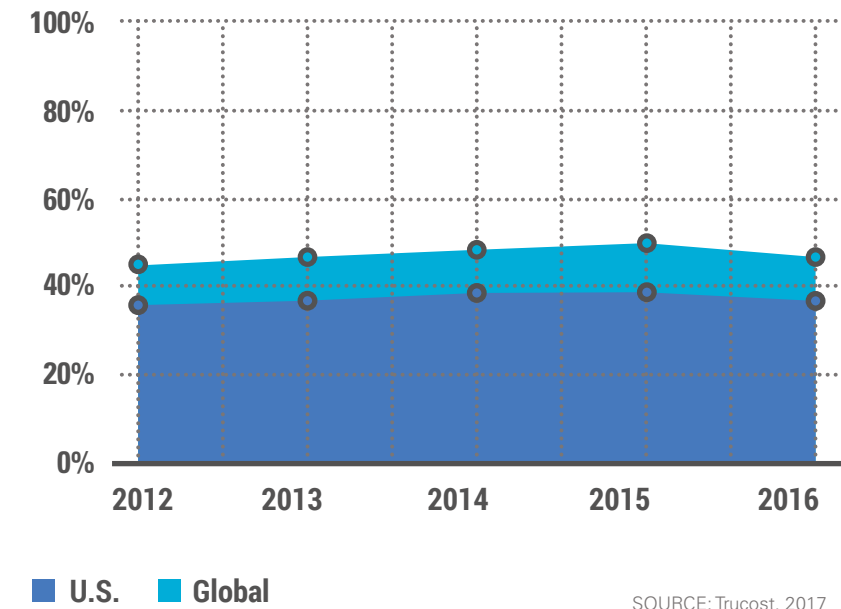
SOURCE: Trucost, 2017



Number of companies by sector: 0 20 40 60 80 100 120

## DISCLOSURE OF NATURAL CAPITAL COSTS REMAINS STABLE

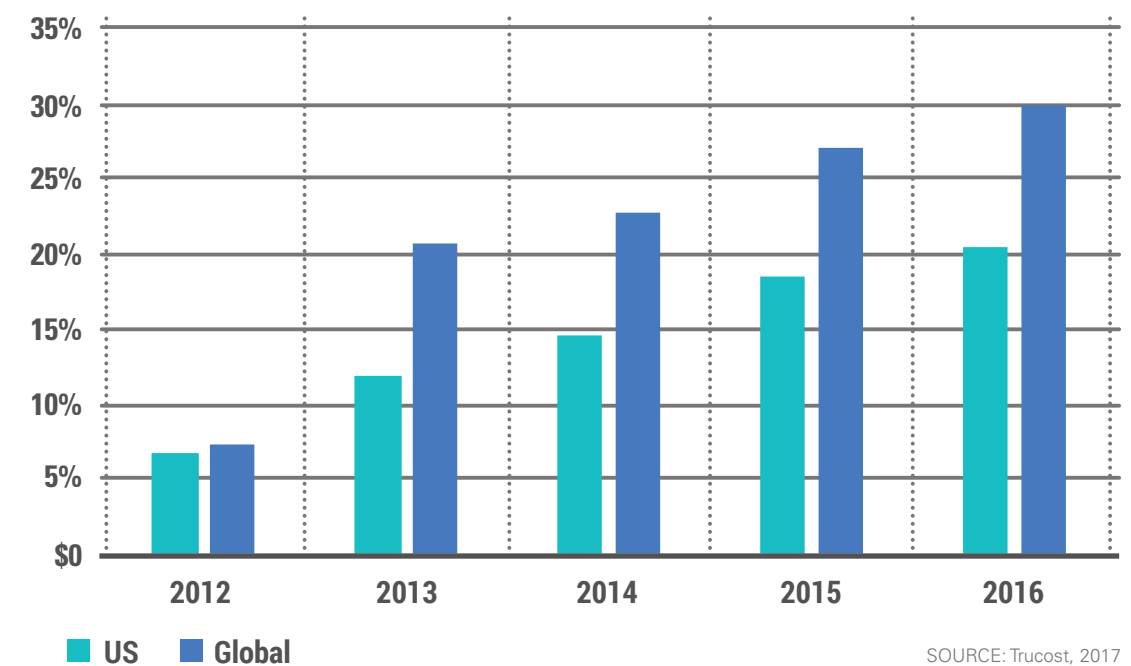
Percentage of companies disclosing



SOURCE: Trucost, 2017

## MORE COMPANIES REPORT EMISSIONS FROM THEIR PRODUCTS

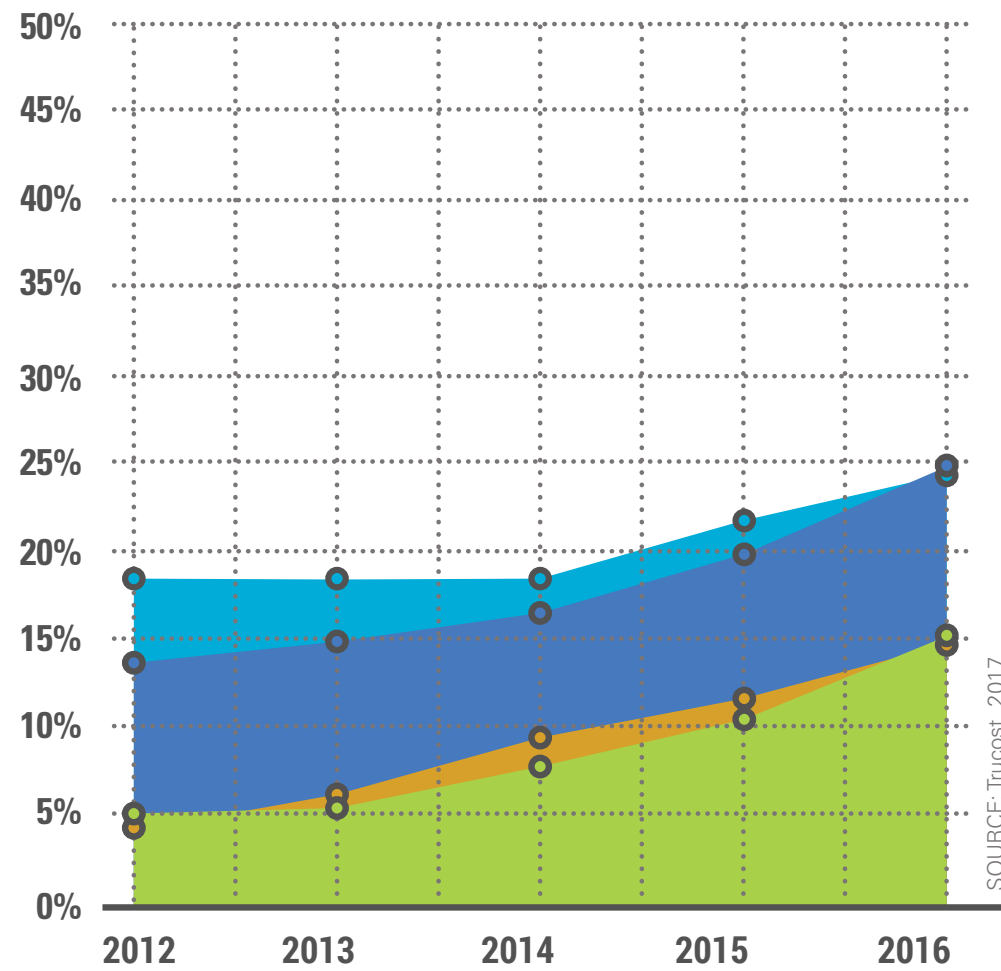
Percentage of companies reporting Scope 3 emissions from sold products



SOURCE: Trucost, 2017

## REPORTING ON WATER-RELATED RISKS CONTINUES TO GROW

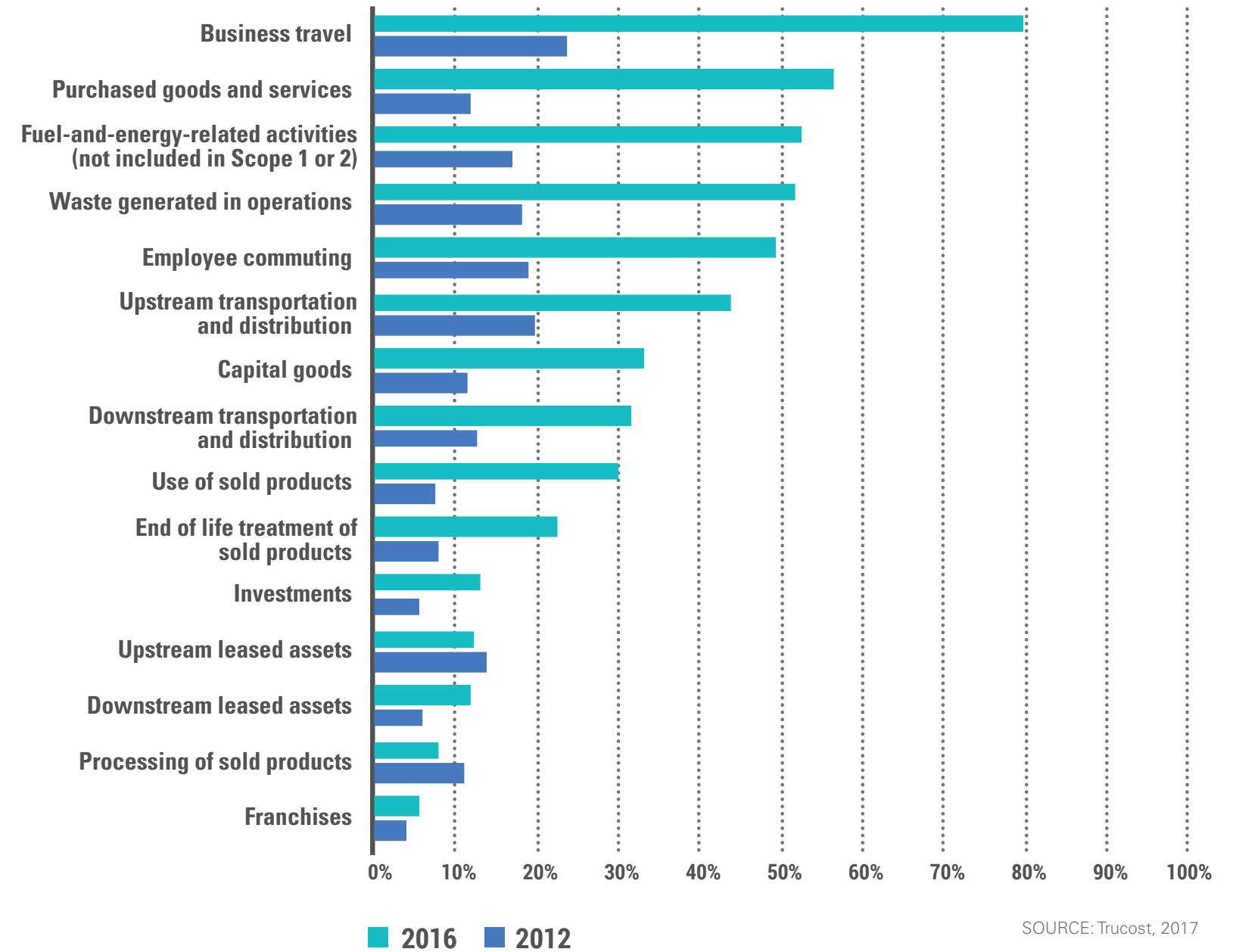
Percentage of companies reporting



- Reporting on general water risk - US
- Reporting on general water risk - Global
- Reporting on awareness of supply chain water risk - US
- Reporting on awareness of supply chain water risk - Global

SOURCE: Trucost, 2017

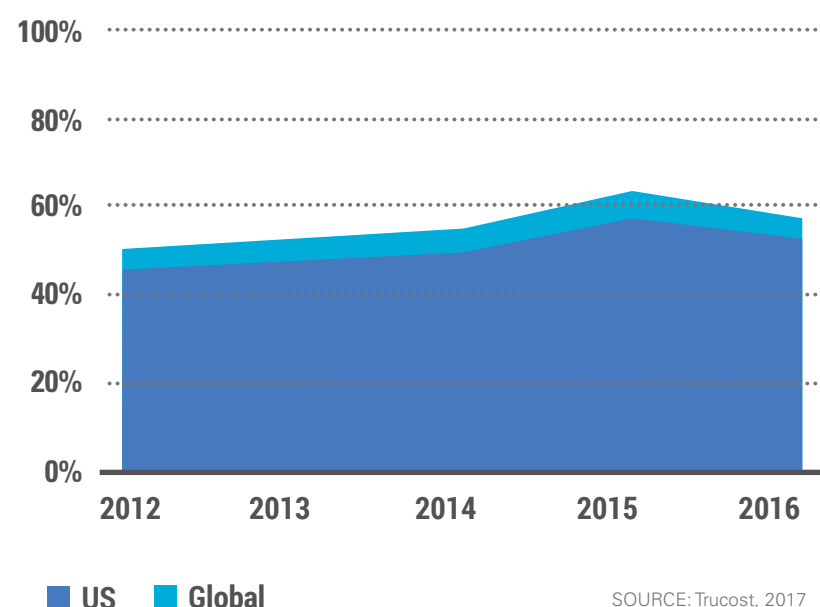
## COMPANIES INCREASE THE SCOPE OF EMISSIONS DISCLOSURE ACROSS VALUE CHAIN



SOURCE: Trucost, 2017

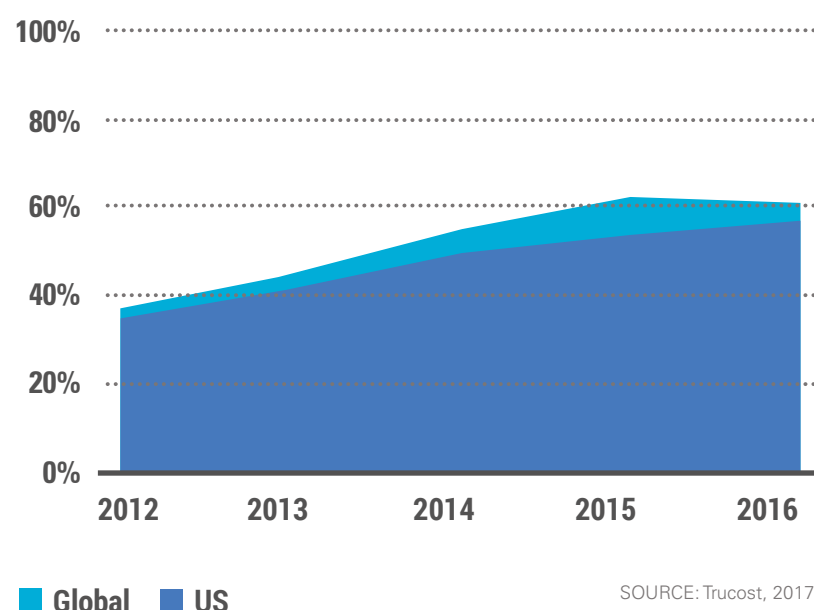
## DISCLOSURE OF NATURAL CAPITAL INVESTMENT INCREASES COMPARED TO 2012

Percentage of companies reporting



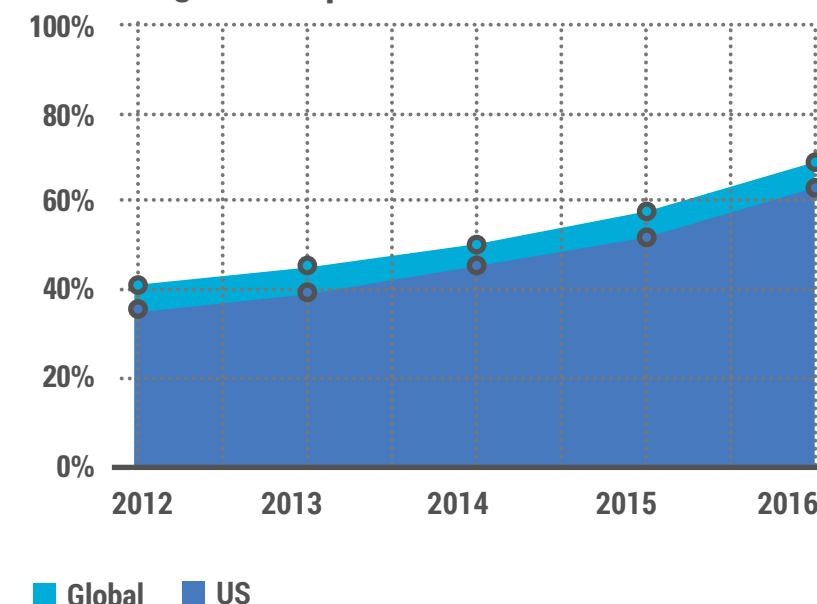
## MORE COMPANIES REPORT NATURAL CAPITAL PROFITS OR SAVINGS

Percentage of companies reporting



## OVER HALF OF THE COMPANIES ENGAGE IN REDUCING GHG EMISSIONS

Percentage of companies



Companies have also expanded the scope of impacts they assess and disclose beyond their direct operations. For example, on average 33 percent more companies disclosed GHG emissions in some part of their value chain from 2012 to 2016. GHG emissions from business travel is the most commonly assessed category by companies, followed by purchased goods and services. More companies reported GHG emissions related to their sold products, increasing to 30 percent for global companies in 2016.

A similar trend also applies to water risks. About 6 percent and 11 percent more U.S. and global companies, respectively, reported their general water risks, while roughly 10 percent more U.S. and global companies disclosed awareness on supply chain risks in 2016.

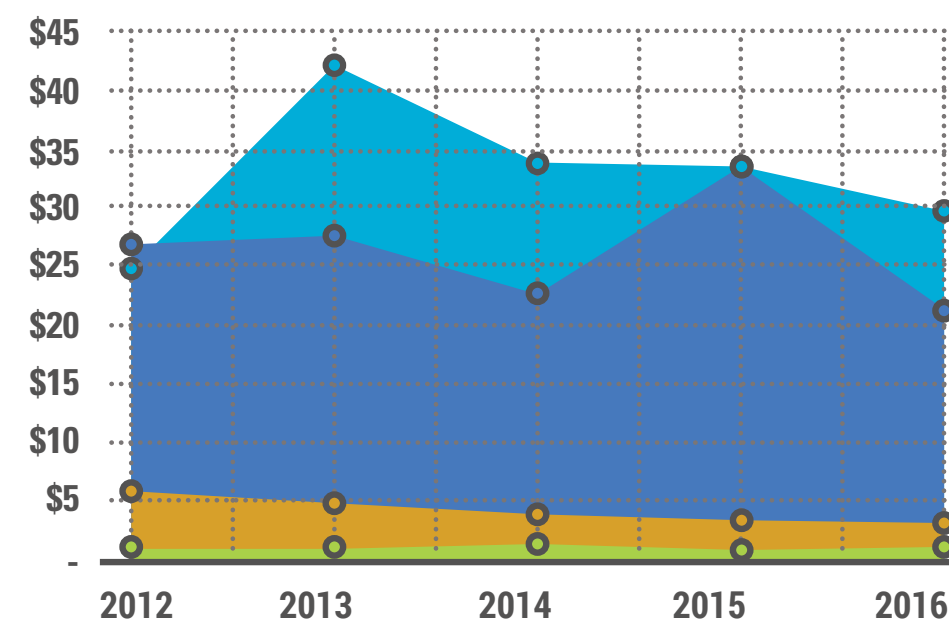
In addition to broader disclosure, companies remain proactive on investments to reduce their environmental impacts. About 50 percent and 60 percent of top U.S. and global companies reported research and development investments towards reducing natural capital impacts, which is 7 percent higher than 2012 for both U.S. and global companies, respectively. Based on their mitigation effort, roughly 60 percent of companies reported natural capital profit or savings in 2016. Approximately 60 percent of companies have at least one GHG reduction project in place, an increase from 45 percent back in 2012).

The cost of curbing GHG emissions has dropped slightly. The low cost of Renewable Energy Certificates (REC) implies that companies could reduce their emissions by switching to renewable energy – for example, the cost of compliance RECs is

fell by 20 percent between 2012 and 2016. Carbon prices, including mandatory, voluntary and internal carbon prices, have remained relatively low overall in the past five years, ranging between \$1 and \$42 per metric ton. In order to achieve the Paris Agreement goal to limit global warming to 2 degrees Celsius, the carbon price will need to reach \$120 per metric ton by 2030, according to a 2017 Trucost analysis of data from the IEA and the International Renewable Energy Agency. Along with the growing momentum in climate policy, companies are likely to face significantly higher carbon prices in the future.

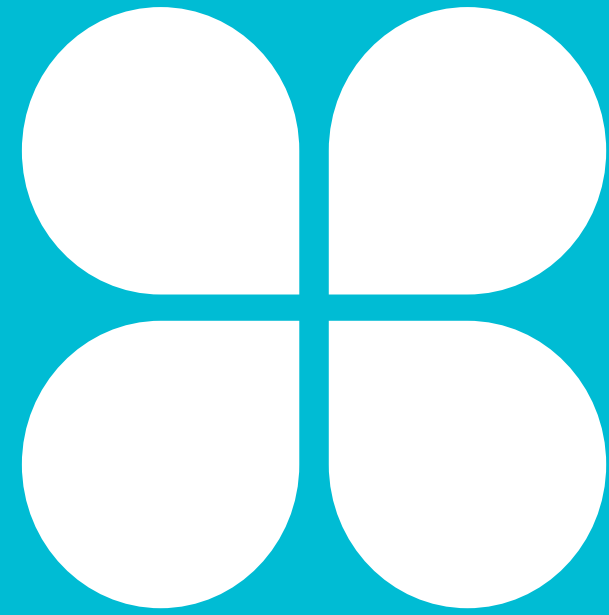
## COST OF CARBON REMAINS LOW COMPARED TO PRICE NEEDED TO ACHIEVE 2 DEGREE TARGET

**Average cost of carbon per tCO<sub>2</sub>e (USD)**



SOURCE: Trucost, 2017

- Average internal carbon price
- Third-party verified carbon offsets
- RECs (voluntary - US)
- RECs (compliance - US)



# customer PREFERENCE

***More suppliers are being asked by customers to measure and manage carbon and water risks as part of a supplier engagement program.***

Companies are increasingly responding to customer and market demand for greener products and business models.

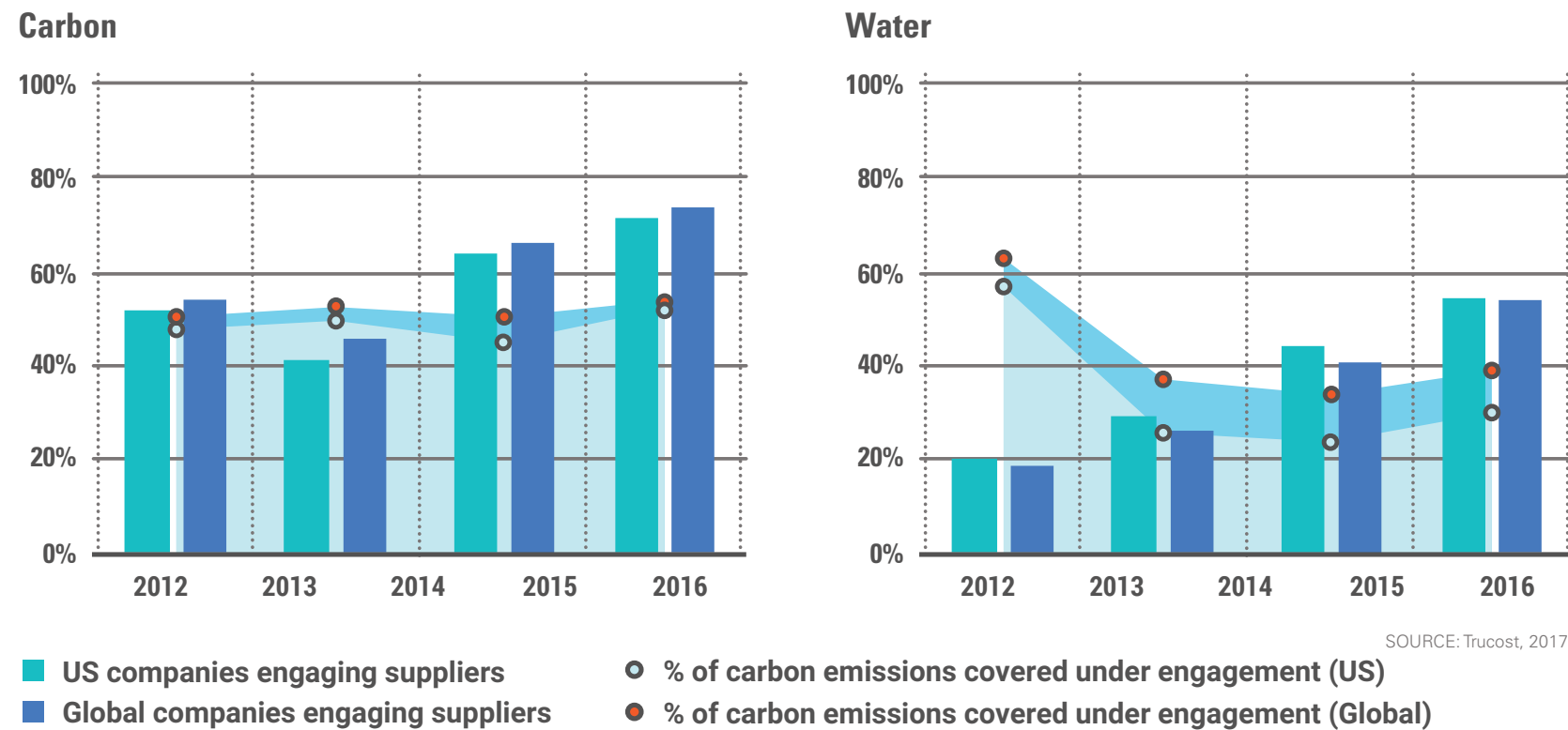
For example, more suppliers are being asked by their customers to measure and manage carbon and water risks, as part of a supplier engagement program. Over 70 percent and 50 percent of companies now engage with their suppliers to assess environmental performance for carbon and water, respectively. These engagement activities on average cover 50 percent of the companies' total supply chain GHG emissions and 40 percent of their supply chain water footprint. The increase in supplier engagement on water (35 percent) is much higher than those for GHG emissions (20 percent), indicating that companies may face greater demand for water disclosure from their corporate customers in the future. While environmental disclosure often serves as a means to maintain a "social license to operate" for companies in the supply chain, about 2 percent of corporate clients provide additional incentives to encourage suppliers to improve environmental performance.

Another example of sustainable procurement is the rise of companies purchasing renewable energy. The amount of renewable energy bought by global companies grew from slightly over 1GW in 2012 to over 5GW in 2015, according to [Bloomberg New Energy Finance](#). Utilities are becoming more open to innovation in sustainable product offerings such as green tariffs and power purchase agreements to meet growing demand from companies.

Consumers also have influence over a company's perception of environmental-related risks and opportunities. These influences are often due to reputational risks caused by companies' environmental impacts, demand for environmentally friendly products and services, awareness of corporate sustainability and disclosure, and so on. Considering all these drivers, companies see carbon-related risks and opportunities as much more significant than those related to water. About 75 percent of global companies consider consumers as one of the key drivers of risks and opportunities related to carbon emissions from their products and services. While over 40 percent of companies see consumer-driven opportunities for water, only 5 percent of companies see consumers as the driver for managing water risks. This is most likely because water risks tend to be driven by physical factors such as drought.

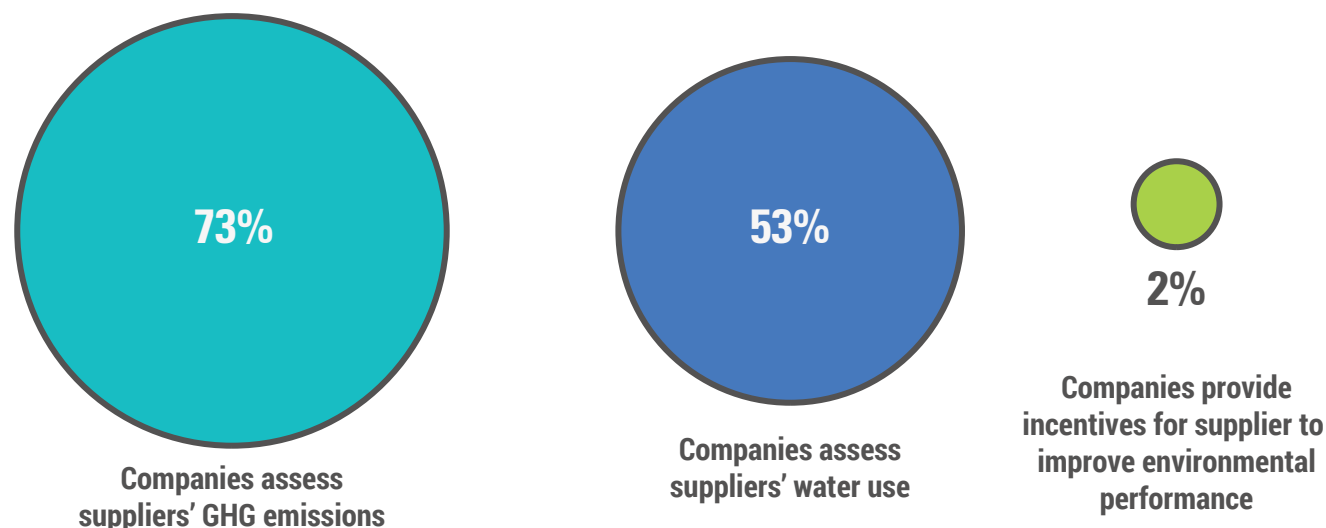
Companies offering resource-intensive products may be particularly sensitive to consumer-driven environmental risks. For example, about 70 percent of companies in the forestry and paper sector have set a target for sustainable procurement, indicating strong business-to-business demand for sustainability in the industry. For end-use consumer-related risks, forestry and paper companies see potential reputational damage as the most significant driver, followed by changes in consumer behavior.

## MAJORITY OF COMPANIES ENGAGE SUPPLIERS TO ASSESS ENVIRONMENTAL PERFORMANCE



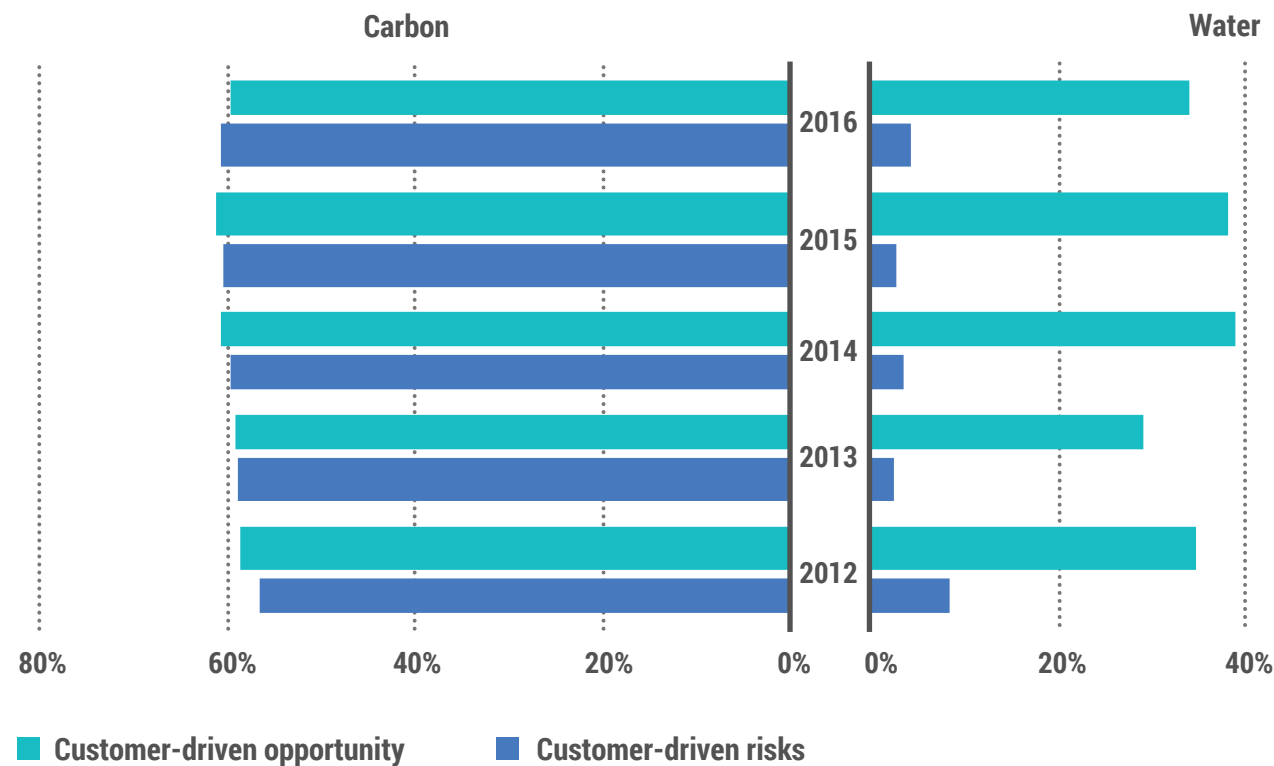
## PERFORMANCE ASSESSMENT IS THE MOST COMMON TYPE OF SUPPLIER ENGAGEMENT

Percentage of companies providing supplier incentives to improve environmental performance



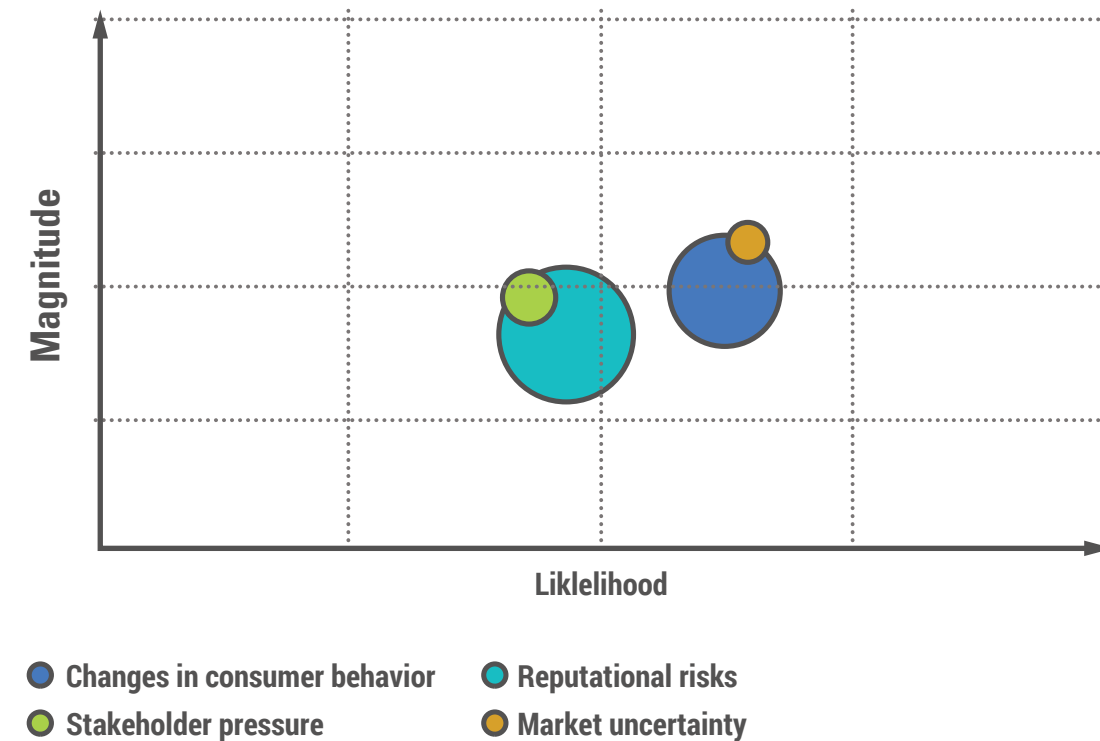
## HOW COMPANIES SEE CUSTOMER INTEREST IN CARBON- AND WATER-RELATED ISSUES

Percentage of companies seeing customers as the key driver for carbon/water risks and opportunities

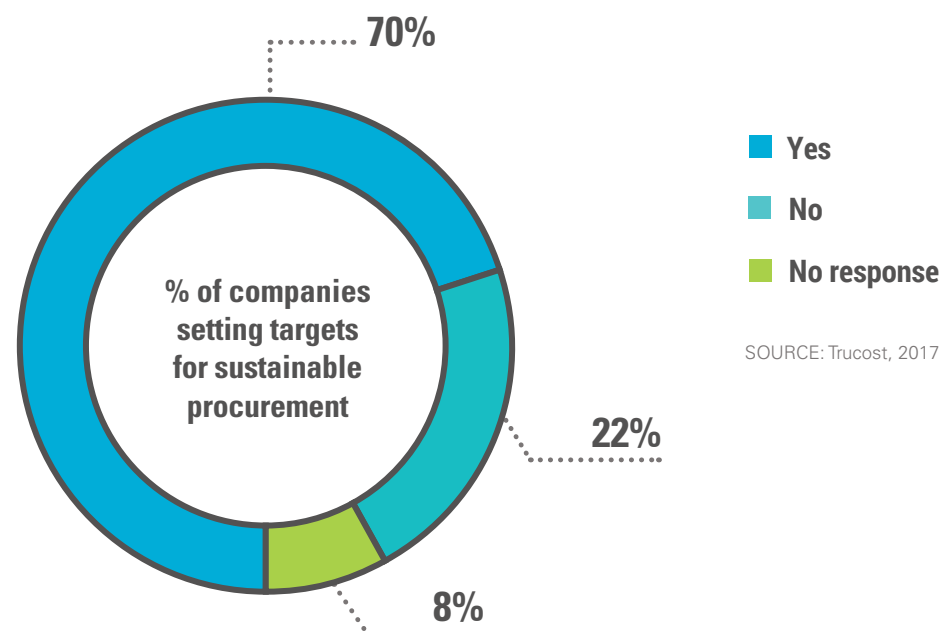


## REPUTATIONAL DAMAGE IS THE MOST SIGNIFICANT RISK DRIVER FOR FORESTRY & PAPER COMPANIES

Number of companies recognizing environmental risks driven by consumers, by likelihood and magnitude of risk

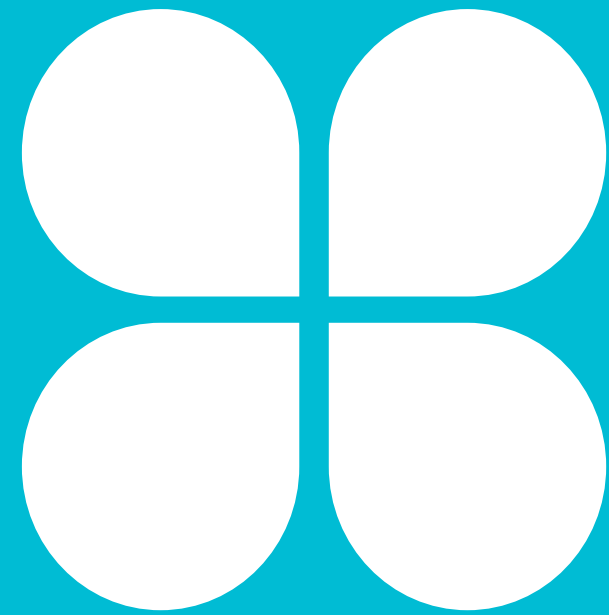


## MOST FORESTRY & PAPER COMPANIES HAVE TARGETS FOR SUSTAINABLE SOURCING



In fact, a shift in consumer preference towards sustainable purchases is becoming more prominent. About 66 percent of consumers around the world are willing to pay a premium for sustainable goods, compared to 55 percent, [according to the Nielsen Global Sustainability Report](#). More consumers tend to buy sustainable goods when they have direct benefits on health and wellbeing, such as natural ingredients or organic production practices, [according to Euromonitor](#).

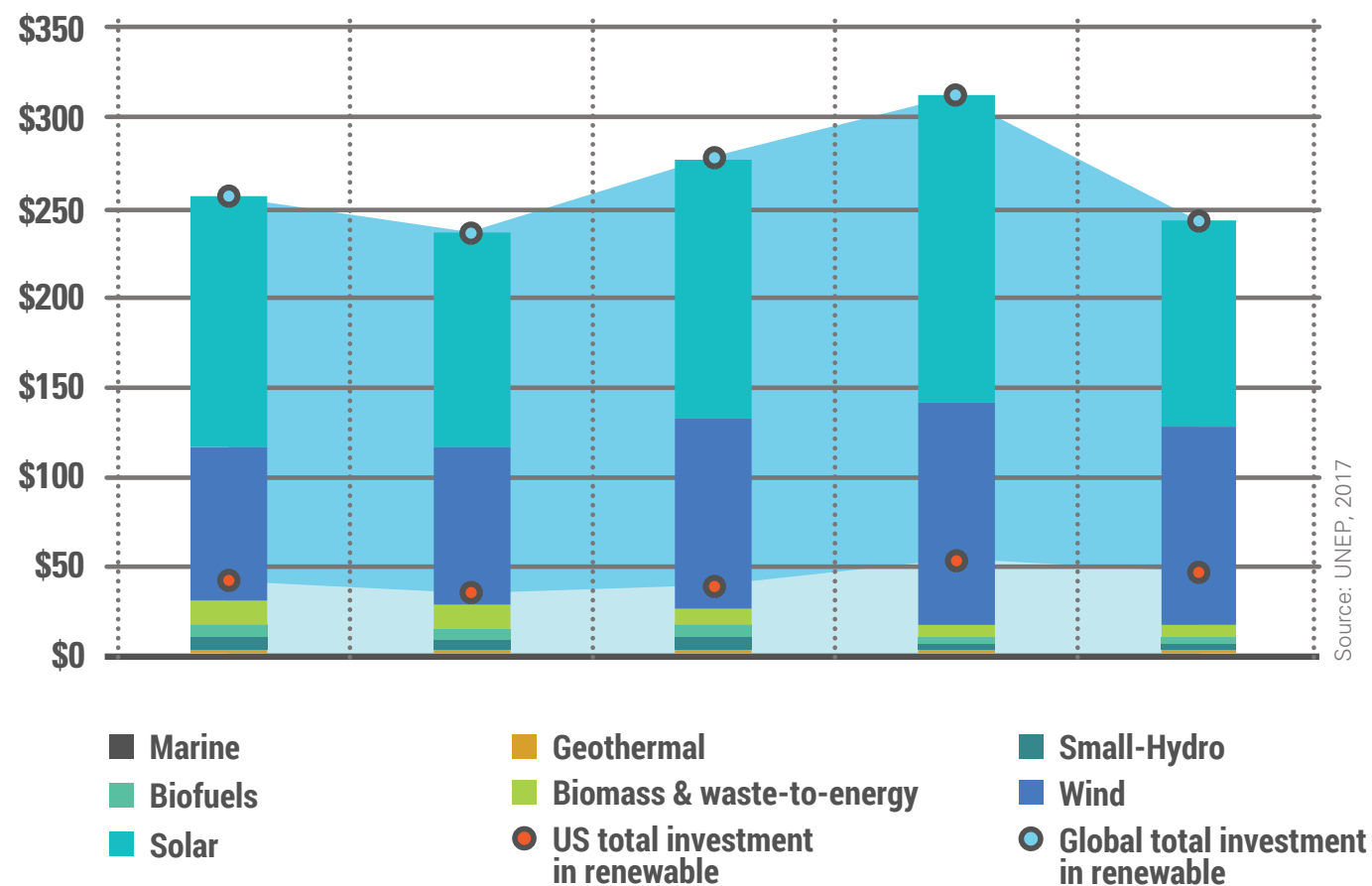
In general, Trucost found that business-to-business relationships are a prominent driver for companies to improve environmental disclosure and performance, given the rise of supplier engagement in both GHG and water. Companies perceive end-use consumers as a bigger driver of risks as well as opportunities related to GHG emissions, compared to water. With the shift in consumer preference towards sustainable goods, companies may expect opportunities for greener products and services to grow in future.



# investment in greener BUSINESS MODELS

## INVESTMENT INTO RENEWABLES HAS COOLED OFF

Total Investment (Billions USD)

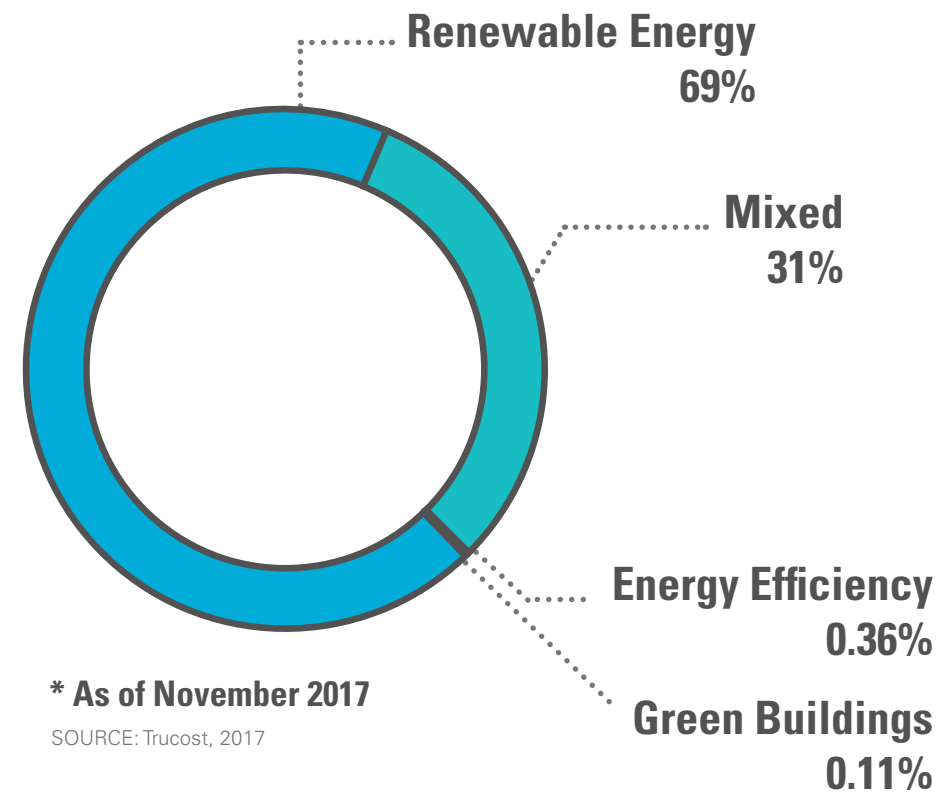


In 2016, total investment in renewable energy decreased by 23 percent globally and 10 percent in the United States, [according to the UN Environment Programme and Bloomberg New Energy Finance](#). Solar and wind energy continues to receive the most investment, whereas wind energy has experienced the largest growth of investment from 2012. The drop in renewable investment is due to the lower capital cost of renewable technologies, underlying slowdown in key markets such as China and Japan, according to a Trucost analysis of data from the Climate Bonds Initiative.

Corporate green bonds issued as of November, 2017 have the potential to save nearly 570 million tCO<sub>2</sub>e of GHG emissions. Yet, the GHG savings year to date is 7 percent lower than 2016 due to fewer corporate green bonds being issued at the time of this analysis being conducted, despite the overall larger green bond issuance in 2017. The majority of GHG savings from corporate green bonds issued in 2017 comes from financing renewable energy projects (69 percent), followed by mixed project types or other projects such as water conservation.

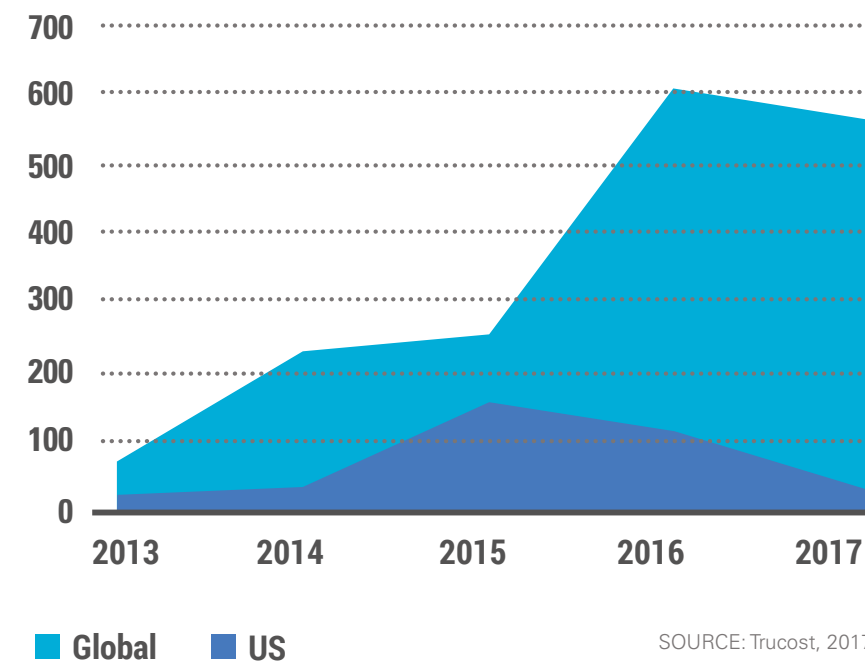


## SOURCE OF GHG SAVINGS BY CORPORATE GREEN BONDS\*



## GHG EMISSIONS SAVINGS FROM CORPORATE GREEN BONDS

Millions of tCO<sub>2</sub>e avoided by corporate bonds

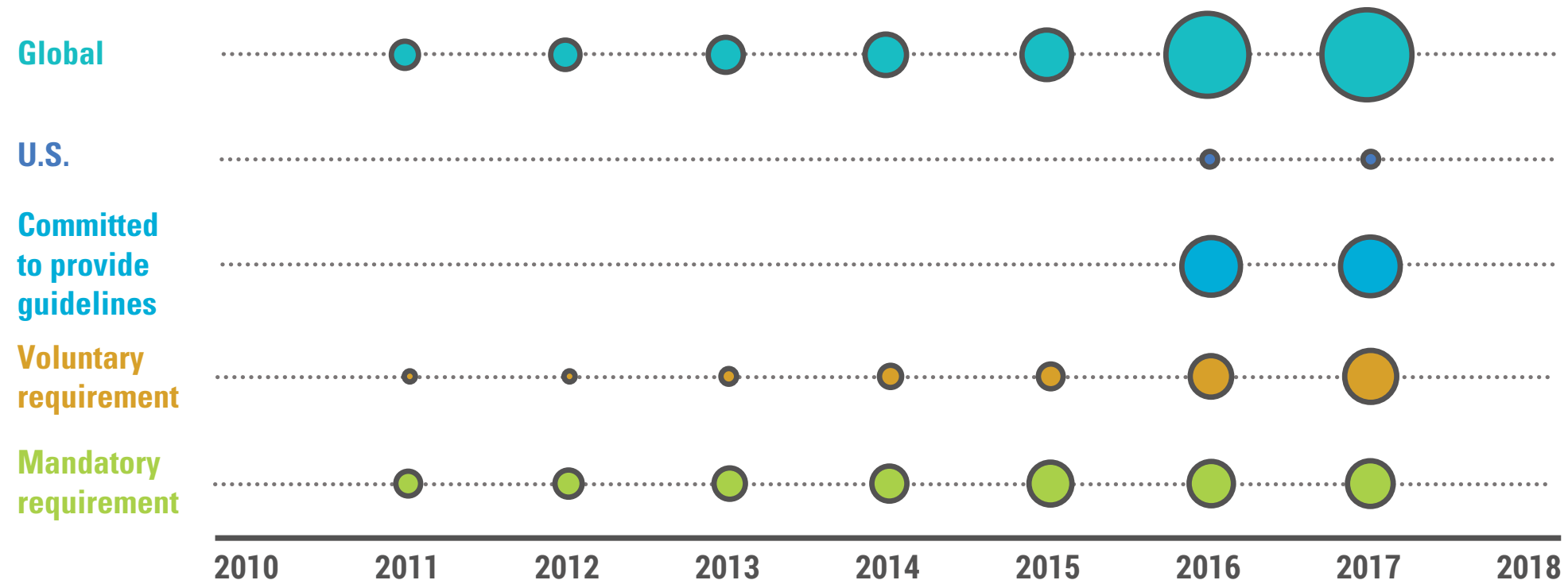


Sustainable initiatives by stock exchanges around the world continued to grow in 2017. Ten more stock exchanges have established an environmental listing requirement, of which eight introduced a voluntary requirement, according to a 2017 Trucost analysis.

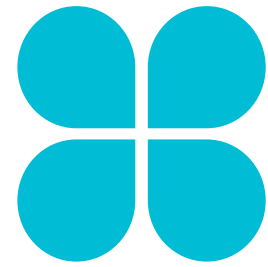
The discussion on assessing climate risks and opportunities using scenario analysis is also rising rapidly among investors, NGOs and regulators. Initiatives such as the Task Force on Climate-related Financial Disclosures (TCFD), which aims to help investors, lenders and insurance underwriters appropriately assess and price climate-related risks and opportunities, reflect the importance of transparent risk assessment to companies' access to capital in the future.

# INCREASE IN STOCK EXCHANGES SETTING ENVIRONMENTAL LISTING REQUIREMENTS IN 2016

Number of stock exchanges with environmental listing requirements



SOURCE: Trucost, 2017



# METHODOLOGY

The State of Green Business Index, derives from Trucost databases and models which use quantitative, scientific frameworks to assess the environmental and financial performance of the global economy. Trucost's approach accounts for environmental impacts in companies' operations as well as supply chains, looking holistically at a wide range of environmental measures including greenhouse gas emissions, air pollution, water use and pollution, waste and land use.

For the 2018 State of Green Business, Trucost aggregated corporate environmental performance data for both the S&P 500 index of U.S. companies and the S&P Global 1200, covering about 70 percent of global market capitalization. In addition to analyzing corporate environmental performance trends, Trucost also calculated the cost of companies' environmental impacts to provide insight into the economic consequences of those impacts.

## DATA SOURCES

Corporate environmental performance data is sourced from the Trucost Environmental Register, a database that covers about 12,000 companies,

representing 93 percent of global market capitalization. The Trucost Environmental Register is built on information from companies' annual reports, websites and other publicly disclosed data. Trucost's annual engagement program provides an opportunity for companies to review, improve and verify the research.

## MODELING ENVIRONMENTAL IMPACTS

Where company disclosure data is not available, Trucost applies a wide range of estimation techniques and environmental modeling tools, including standard and hybridized life cycle assessment (LCA) models to compare environmental impacts across companies, supply chains, regions, sectors and investment benchmarks. For this 2018 SOGB analysis, Trucost filled gaps in company disclosure with its environmentally extended input-output LCA model, which estimates the amount of resources a company uses (the inputs) to produce goods or services (outputs), as well as the pollution that results.

Trucost's analysis accounts for impacts from a company's own operations and its supply chain. This provides a means to understand business risk and differentiate between low-impact supplied goods, such as renewable energy, and high-impact supplied goods, such as fossil fuel energy. The methodology models the purchases a company makes and the resultant environmental impacts. This analysis is extended to include first-tier suppliers that the company buys from, through subsequent tiers of suppliers until the supplier of the raw material is reached. In this way, Trucost can calculate the cost of supply chain impacts back to raw materials extraction.

Trucost's model calculates the environmental impacts of 464 standard business activities and has been further enhanced to provide additional detail for environmentally intense sectors. The environmental impacts for each sector are allocated to a company according to its proportion of total revenue, using data from FactSet, Bloomberg and company reports to segment revenues and map each company to a set of sectors. The model also incorporates sector-level

inflation data to adjust calculations in line with annual inflation and movements in commodity prices.

Trucost's model draws on robust data from a wide range of government and academic data sources, such as the U.S. Environmental Protection Agency, covering more than 700 environmental indicators including greenhouse gas emissions, toxic pollutants, water consumption and waste. The system is consistent with the United Nations Millennium Ecosystem Assessment. Data on emissions is combined with economic data from sources such as the U.S. Bureau of Economic Analysis to analyze interactions between economic productivity and the environment.

## VALUING NATURAL CAPITAL AND ENVIRONMENTAL IMPACTS

The production, use and disposal of most materials have environmental and social costs that are not reflected in the market prices of goods and services. Applying environmental or "natural capital" valuation techniques allows businesses to understand and communicate environmental impacts in monetary terms alongside traditional financial performance measures. These costs also can be factored into business and investment decision making, by considering tradeoffs between the implied costs and benefits of financial and economic activity. Natural capital accounting helps companies understand their environmental impacts and potential exposure to increased costs or increased competitiveness due to tightening environmental regulation (such as carbon taxes, reduced water allocations, or greater restrictions on use of toxic materials) or consumer pressure to improve environmental performance.

For the 2018 State of Green Business analysis, in addition to measuring environmental performance in physical units (such as metric tons of greenhouse gases or cubic meters of water), Trucost also valued in monetary terms the

costs of these impacts. An environmental damage cost (natural capital cost) was applied to each unit of resource and emission. The costs represent the quantities of natural resources used or pollutants emitted multiplied by the environmental damage costs to the economy and society. Trucost's natural capital valuations draw on extensive international academic research into environmental economics and are informed by an independent International Advisory Panel of leading academics. If you would like to obtain a copy of the data tables that inform the 2018 State of Green Business metrics, please email [Trucostinfo@spglobal.com](mailto:Trucostinfo@spglobal.com) with "Requesting SOGB 2018 data" in the subject line.

For more information, visit [www.trucost.com](http://www.trucost.com)



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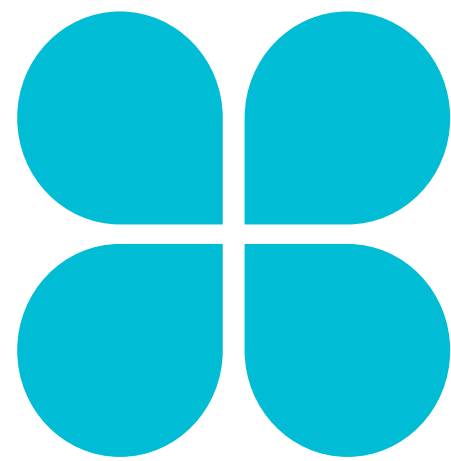
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about  
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Trucost is part of S&P Dow Jones Indices. A leader in carbon and environmental data and risk analysis, Trucost assesses risks relating to climate change, natural resource constraints, and broader environmental, social, and governance factors. Companies and financial institutions use Trucost intelligence to understand their ESG exposure to these factors, inform resilience and identify transformative solutions for a more sustainable global economy. S&P Global's commitment to environmental analysis and product innovation allows us to deliver essential ESG investment-related information to the global marketplace.

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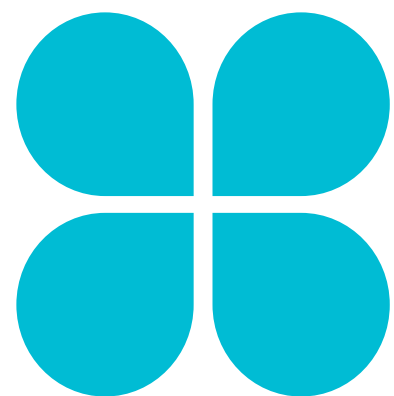
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State of Green Business  
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