CONFRONTING CLIMATE CHANGE:

From Business as Usual to Business as Vital

As we increasingly experience the effects of climate change—predicted by scientists over 50 years ago—business is vital.

Managers have a key role to play in confronting climate change in the market sectors in which they operate and in the political and civic circles in which they hold influence.

HARVARD | BUSINESS | SCHOOL

THE CLIMATE CRISIS IS HERE

Climate change is affecting many economic sectors: THE TIME TO DRIVE INNOVATION IS NOW

- Altering the value of **real estate**, causing some areas to appreciate and others to decline
- Presenting **new financial risks, disclosure requirements,** and **insurance** considerations
- Posing **operating challenges** for businesses and their supply chains

As climate change continues, businesses, governments, and citizens will have an oppotunity to work together to:

- Implement **new policies for mitigating and adapting to climate change** at the local, state, federal, and international levels
- Transform the **sources of energy** we rely on, how and where we grow **food**, the modes of **transportation** we use, the infrastructure of **cities**, and the **materials** we use to build them
- Adapt to climate change by making vulnerable areas **more resilient** and decide when to rebuild, restrict development, or retreat

Economic development and innovative technologies have contributed to climate change—and are also essential to address it. Government policies can create incentives to accelerate progress.

The Intergovernmental Panel on Climate Change (IPCC), which includes more than 1,300 scientists from around the world, **forecasts a temperature rise of 1.4° to 5.5° Celsius by 2100** with serious consequences for business and for the natural systems on which our current ways of life depend. According to the IPCC, **greenhouse gas emissions must be net zero by 2050** to keep global warming below 1.5° C and thereby avoid the most serious impacts of climate change.[1]

MAJOR EFFECTS OF CLIMATE CHANGE

TEMPERATURE RISE
18 of the 19 warmest years on record have occurred since 2001.[2] July 2019 was the hottest month ever recorded on Earth.[3]

SEA LEVEL RISE
By 2050 at least 570 cities and some 800 million people will be exposed to rising seas and storm surges.[4]

EXTREME WEATHER
Annual weather-related natural disasters (hurricanes, intense rain, tornadoes, snow storms) have more than tripled since the 1960s. Every year, these disasters result in some 60,000 deaths, mainly in developing countries.[5]

CLIMATE MIGRANTS
In 2018, 16 million people were displaced by weather-related disasters across 148 countries and territories, including 764,000 displaced by drought in Somalia, Afghanistan, and elsewhere.[6]

POOR HEALTH
Climate change is predicted to be responsible for 250,000 additional deaths each year between 2030 and 2050 as the result of heat exposure among the elderly, childhood under-nutrition, malaria, and other diseases exacerbated by climate change.[7]

MASS EXTINCTIONS AND ECOSYSTEM COLLAPSE Some 1 million species are now threatened with extinction, with climate change as a major cause.[8]

CHANGING AGRICULTURAL CONDITIONS
The growing region for wheat moves further north each year in the U.S., Europe, and Russia.[9] Storms, heat, and drought also impact crop yields and prices.

Visit hbs.edu/beiexhibit for full list of sources

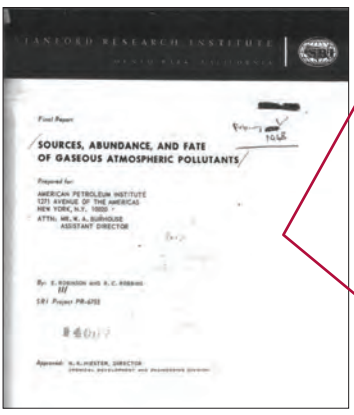
1 Intergovernmental Panel on Climate Change, 2018; 2 NASA, 2019; 3 NOAA, 2019; 4 World Economic Forum, 2019; 5 World Health Organization, 2018; 6 United Nations, 2019; 7 World Health Organization, 2018; 8 IPBES, 2019; 9 NASA, 2019

FROM OBSTRUCTION TO LEADERSHIP

For much of the last 50 years, powerful segments of the business community have opposed government action on climate change. The fossil fuel industry in particular, seeing regulation of CO_2 as a threat to its profits, undertook a concerted campaign in the U.S. to sow doubt about the scientific underpinnings of climate change concerns. **More recently, some companies—including in the energy and automotive sectors—have begun advocating for government policies to address climate change.**

1960s

Internal memos document that the U.S. fossil fuel industry has know since the 1960s that their products were "almost certain to" cause dramatic changes to the Earth's climate.


STANFORD RESEARCH INSTITUTE

Final Report

SOURCES, ABUNDANCE, AND FATE OF GASEOUS ATMOSPHERIC POLLUTANTS

Prepared for:

AMERICAN PETROLEUM INSTITUTE
1271 AVENUE OF THE AMERICAS
NEW YORK, N.Y. 10020

ATTN: MR. W. A. BURHOUSE
ASSISTANT DIRECTOR

By: E. ROBINSON and R. C. ROBBINS

SRI Project PR-4752

Approved: W. A. HUNTER, DIRECTOR

"Significant temperature changes are almost certain to occur by the year 2000...

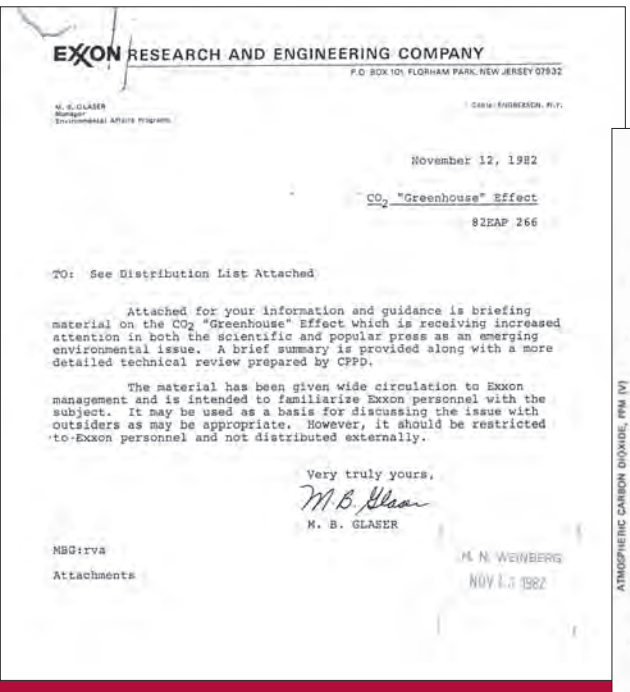
...a number of events might be expected to occur, including the melting of the Antarctic ice cap, a rise in sea levels, warming of the oceans..."

Industry internal document, 1968 American Petroleum Institute[10]

1970s – 1980s

In a 1978 presentation to Exxon executives and scientists, James Black of Exxon's Products Research Division attributed rising CO_2 levels to fossil fuel combustion and warned that "doubling CO_2 could increase average global temperature 1ºC to 3ºC by 2050 A.D."[11] Exxon's temperature warming estimate and other industry estimates from that time align precisely with what the IPCC now expects will happen.[12]

Internal industry documents from the 1980s again reached the same conclusion. Exxon's 1982 estimate of rising CO_2 and temperatures match actual measurements today.


EXXON RESEARCH AND ENGINEERING COMPANY

P.O. BOX 101, FLORHAM PARK, NEW JERSEY 07932

M. B. GLASER
Manager
Environmental Affairs Program

Cable: ENGREASON, N.Y.

November 12, 1982

CO_2 "Greenhouse" Effect

82EAP 266

TO: See Distribution List Attached

Attached for your information and guidance is briefing material on the CO_2 "Greenhouse" Effect which is receiving increased attention in both the scientific and popular press as an emerging environmental issue. A brief summary is provided along with a more detailed technical review prepared by CPPD.

The material has been given wide circulation to Exxon management and is intended to familiarize Exxon personnel with the subject. It may be used as a basis for discussing the issue with outsiders as may be appropriate. However, it should be restricted to Exxon personnel and not distributed externally.

Very truly yours,

M. B. Glaser

M. B. GLASER

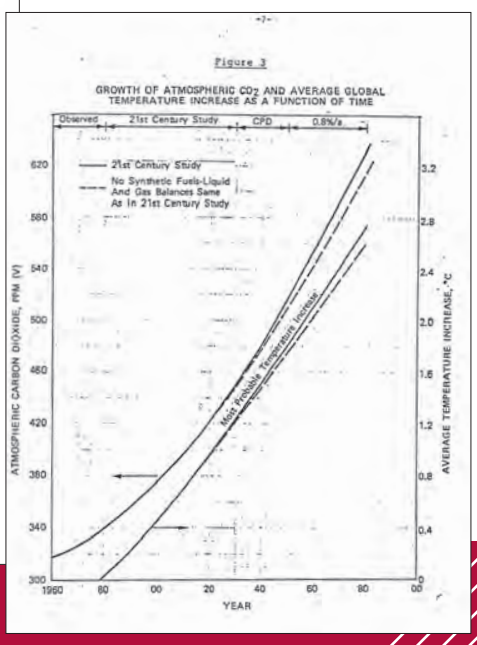
MBG:rva

Attachments

M. N. WEINBERG

NOV 1.3 1982

Industry internal documents showed sophisticated understanding of the relationship between increasing CO_2 concentrations and increasing temperatures.



"All the News That's Fit to Print"

The New York Times

Late Edition

New York: Today, sunny, cool. High 74-79. Tonight, increasing clouds. Low 57-65. Tomorrow, morning clouds, then windy and warmer. High 79-88. Yesterday: High 87, low 67. Details, page A18.

VOL. CXXXVII... No. 47,546 NEW YORK, FRIDAY, JUNE 24, 1988 30 CENTS

Global Warming Has Begun, Expert Tells Senate

Global Warming: Greenhouse Effect?

Average global temperatures through the first five months of 1988. As a baseline, scientists use the global average from 1950 to 1980.

Source: James E. Hansen and Sergej Lebedeff

Sharp Cut in Burning of Fossil Fuels Is Urged to Battle Shift in Climate

By PHILIP SHABECOFF

Drought Raising Food Prices; Inflation Effect Seems Minor

By ROBERT D. HERSHEY Jr.

Caños Zapata in Tijuana, Mexico, the busiest illegal crossing point.

IMMIGRATION LAW IS FAILING TO CUT FLOW FROM MEXICO

ECONOMIC FACTORS CITED

Illegal Entries Are on the Rise as More Come From Large Cities and Stay Longer

By LARRY ROHTER

By 1988 climate change was widely recognized by scientists and the general public.

1990s

In an attempt to prevent regulation, the fossil fuel industry initiated marketing campaigns in the 1990s to, **in their words,** "reposition global warming as theory (not fact)."[13]

"Victory will be achieved when average citizens understand (recognize) uncertainties in climate science..."

Industry internal document
1998 American Petroleum Institute[14]

Example of advertisement used by Informed Citizens for the Environment, a marketing campaign funded by the fossil fuel industry in the early 1990s.

TODAY

Perhaps as a result of U.S. industry disinformation campaigns, more Americans doubt the connection between human activity and climate change than do people in many other countries. Even today, as climate change becomes apparent just as scientists predicted, 22% of Americans disagree with the statement "The climate change we're seeing is largely the result of human activity."[15]

Despite these disinformation campaigns, large majorities of Americans across the political spectrum currently support policies to address climate change according to a 2019 survey by Yale and George Mason University:

- **87%** of people surveyed supported investments in renewable energy (infrastructure and research)
- **82%** supported regulating GHG emissions (requiring companies to limit their pollution)
- **72%** supported a tax on GHG emissions (requiring companies to pay a tax on their pollution)[16]

While the U.S. federal government has not yet caught up with shifts in public opinion, many other countries and some U.S. states and cities are advancing policies to achieve net zero emissions of GHG emissions by mid-century—France, Great Britain, Sweden, California, Hawaii, and New York City to name a few.

INNOVATION

Increasingly, business leaders from many sectors are taking action to reduce greenhouse gas emissions in their operations and supply chains—and some are going further to urge policymakers to enact laws to require greenhouse gas reductions across the economy.

BUSINESS NETWORKS CONFRONTING CLIMATE CHANGE

CEO Climate Dialogue
Advancing federal climate policy based on Guiding Principles representing perspectives from diverse sectors of the U.S. economy

WE ARE STILL IN

SCIENCE BASED TARGETS
DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

RE 100

BICEP
BUSINESS for INNOVATIVE CLIMATE & ENERGY POLICY
a project of Ceres

CLIMATE LEADERSHIP COUNCIL

Certified B Corporation
bcorporation.net

WE MEAN BUSINESS
economic opportunity through bold climate action

"Compared to companies' efforts to green their own operations, corporate political actions—like lobbying or campaign funding—can have a vastly greater influence on environmental protection, and arguably represent the greatest impact a company can have on protecting (or harming) the environment."[17]

MICHAEL TOFFEL Senator John Heinz Professor of Environmental Management and Faculty Chair, Business & Environment Initiative, HBS; and **AUDEN SCHENDLER**, VP of Sustainability, Aspen Skiing Company

"Every private sector leader should be advocating for effective climate policy, and yet many do not. I decided to teach Reimagining Capitalism to explore that conundrum with my students and learn what would persuade business leaders to support what is clearly in their interest."

REBECCA HENDERSON
John and Natty McArthur University Professor, HBS; Board of Directors Member, Ceres

"The most effective way to address the climate crisis is with national legislation that would impose a significant fee on carbon where it enters the market. Only by pricing in external costs can we eliminate existing subsidies to fossil fuel use and shift to a clean energy economy."

WILLIAM EACHO, HBS MBA 1979
Co-Founder, Partnership for Responsible Growth

Visit hbs.edu/beiexhibit for full list of sources

10 American Petroleum Institute, 1968; 11 Exxon, 1978; 12 IPCC, 2019; 13 Informed Citizens for the Environment, 1991; 14 American Petroleum Institute 1998; 15 Ipsos Global Trends, 2016; 16 Yale University Program on Climate Change Communication and George Mason University Center for Climate Change Communication, 2019; 17 MIT Sloan Management Review, 2011

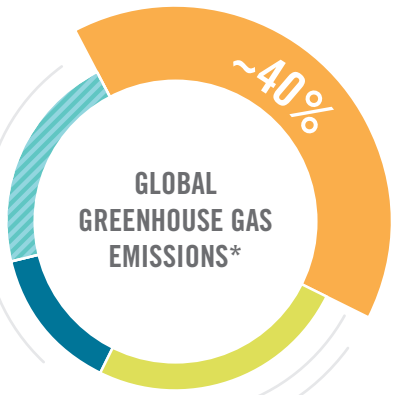
ELECTRICITY GENERATION

The combustion of fossil fuels to generate electricity is the largest source of greenhouse gas emissions and the largest contributor to climate change.[18] The power sector is also especially vulnerable to the impacts of climate change: hurricanes, wildfires, and sea level rise pose immense risks for the reliable delivery of electricity. As one example, restoring electric power in Puerto Rico following Hurricane Maria took nearly one year and cost an estimated $3 billion, and climate change is expected to increase the frequency and intensity of hurricanes.[19] Power suppliers are also subject to risks and opportunities from regulations that address climate change, such as those imposed in Europe and New England that have set limits on CO_2 emissions.

GOLDMAN SACHS ESTIMATES THAT THE RENEWABLE ENERGY MARKET REPRESENTS A $16 TRILLION INVESTMENT OPPORTUNITY BY 2040.[20]

ELECTRICITY GENERATION

CHALLENGE



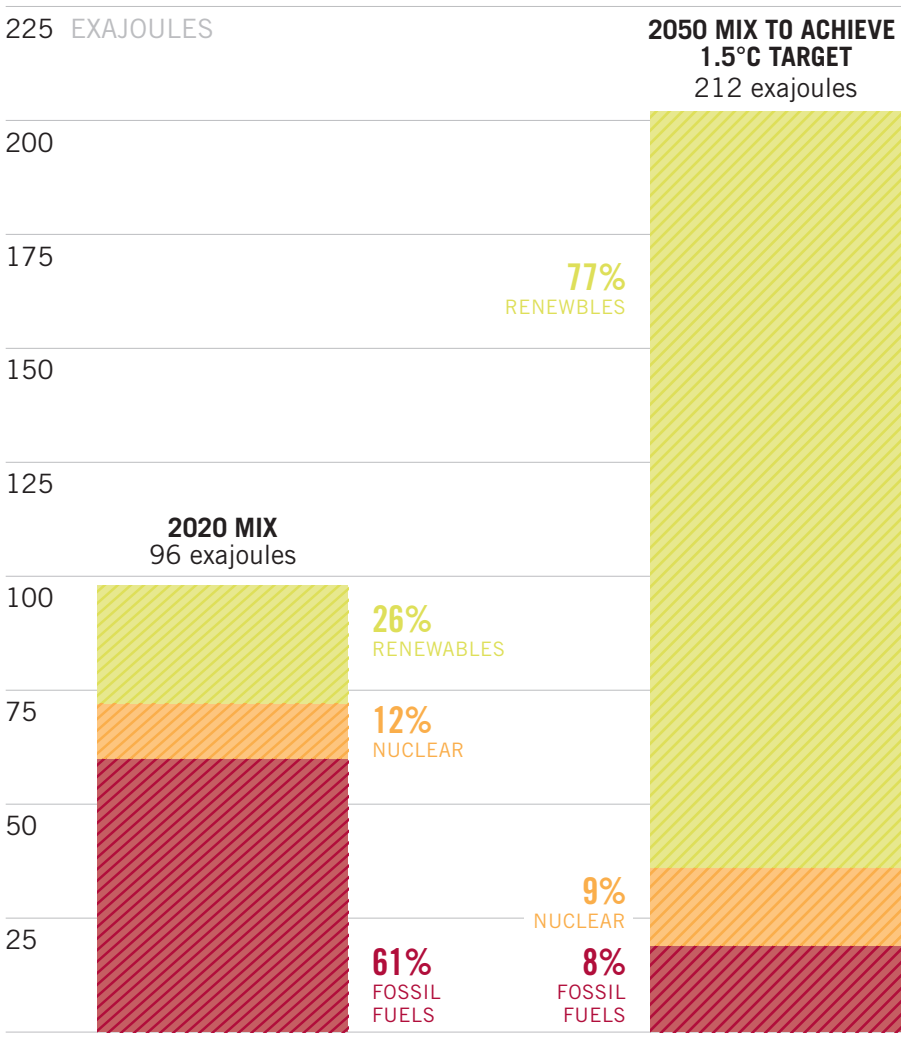
One of the biggest shifts needed to respond to climate change is rapidly transitioning from fossil fuel-based electricity generation (coal, natural gas, oil) to power sources like solar, wind, hydropower, and nuclear that emit far less or even no greenhouse gases.

Yet 20% of the world's population currently lives without access to electricity,[21] and meeting their needs and the growing global demand for electricity—while simultaneously reducing emissions from electricity production—will require major changes in this vital sector of the economy.

ACCORDING TO MCKINSEY, OVER THE COMING 30 YEARS, WIND AND SOLAR WILL GROW FOUR TO FIVE TIMES MORE QUICKLY THAN ALL OTHER POWER SOURCES.[22]

ELECTRICITY GENERATION MIX, 2020 AND 2050[23]

Growing worldwide demand for electricity, combined with the need to limit warming to 1.5° C by 2050, create huge potential growth for alternatives to fossil fuels, especially renewables.



*Each sector's contribution varies by country and region; percentages are approximations. **See hbs.edu/beiexhibit for details.**

ELECTRICITY GENERATION

INNOVATION

INNOVATIONS ARE NEEDED TO GENERATE VAST AMOUNTS OF CARBON-FREE ELECTRICITY AND TO USE ELECTRICITY MUCH MORE EFFICIENTLY.

There is massive market potential for renewable energy, nuclear energy, as well as carbon capture and storage from fossil fuel power stations. With significant cost declines in recent years, solar and wind have become cost competitive with fossil fuels in many places. In addition, hydropower, wave, geothermal, and biomass technologies have potential in some regions.

Some renewables generate electricity only intermittently, and thus require battery storage to provide power reliably. Innovations are needed for grid flexibility and improved demand-response technologies.[24] These opportunities have huge potential to reduce the emissions that cause climate change.

"I'm helping to lead the largest utility in Washington State on its journey to 100% clean electricity. This requires not only dramatically accelerating clean energy development and adopting new business models, but also reinventing deeply engrained business processes and culture."

MOLLY MIDDAUGH, HBS MBA 2018
Product Development Manager, Puget Sound Energy

"Investing in clean energy solutions is necessary to address climate change. Deploying renewable energy globally will allow the world to increase energy access, create new jobs and transition to a more sustainable economy for current and future generations."

MOSES ESEMA, HBS MBA 2014
Vice President, Renewable Energy Finance, Equity Investing, Bank of America Merrill Lynch

"Given the urgency required to reduce emissions and the political realities faced in doing so, I believe that private investors—not governments—will need to be the key financiers of controversial, yet potentially breakthrough, early-stage advanced nuclear power and geoengineering ventures."

JOSEPH B. LASSITER
Senator John Heinz Professor Management Practice in Environmental Management (retired), HBS

Visit hbs.edu/beiexhibit for full list of sources

18 Project Drawdown, 2019; 19 NPR, 2018; 20 The Goldman Sachs Groups, 2019; 21 The World Bank, 2019; 22 McKinsey, 2019; 23 IPCC, 2019; 24 Project Drawdown, 2019

FOOD & AGRICULTURE

The Green Revolution in the 20th century dramatically increased crop yields and reduced global poverty by half.[25] These life-sustaining advances, which have included the introduction of nitrogen-based fertilizers and clearing of forests for agricultural uses, have also increased greenhouse gas emissions. **Food and agriculture are the second largest contributor to climate change.[26]**

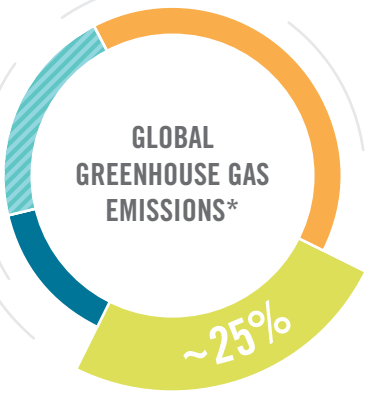
This sector is also especially vulnerable to climate-change impacts. Farmers are already experiencing more extreme temperatures, increasing droughts and floods, more violent storms, and new plant diseases and insect pests.

The United Nations forecasts that **by 2050 the world's population will grow by more than two billion people,** mostly in sub-Saharan Africa and South and Southeast Asia where climate change is expected to worsen conditions for growing food.[27]

BARCLAYS PREDICTS THAT MARKETS FOR MEAT ALTERNATIVES COULD BE WORTH $140 BILLION WITHIN 10 YEARS (BY 2029).[28]

FOOD & AGRICULTURE

CHALLENGE



Agriculture's contributions to climate change come from a variety of sources.

Enteric fermentation—a natural part of the digestive process of ruminant animals such as cattle—produces methane,

A GAS ABOUT 20 TIMES MORE DAMAGING THAN CO_2

in terms of its global warming potential.[29]

Modern farming techniques emit CO_2 by releasing some of the carbon that is stored in soil and by using fossil fuel-based fertilizers. Rice cultivation produces fermentation, another contributor. Compounding the problem, clearing forests to create land for cattle and cropland eliminates the CO_2 absorption that trees provide.[30]

REGENERATIVE AGRICULTURE COULD PROVIDE A $1.9 TRILLION FINANCIAL RETURN BY 2050 ON AN INVESTMENT OF $57 BILLION.[31]

2019 GLOBAL AGRICULTURE EMISSIONS[32]

11% RICE CULTIVATION

10% BURNING; CROP RESIDUES; AND CULTIVATION OF ORGANIC SOILS

13% SYNTHETIC FERTILIZERS

27% MANURE

39% ENTERIC FERMENTATION

*Each sector's contribution varies by country and region; percentages are approximations. **See hbs.edu/beiexhibit for details.**

FOOD & AGRICULTURE

INNOVATION

Several types of innovations can reduce the sector's greenhouse gas emissions and facilitate its adaptation to climate change.

- **Production innovations** such as seeds that require less fertilizer, regenerative agriculture practices, and nutrient management
- **Supply chain innovations** that reduce food waste and transportation impacts
- **New product development innovations** that shift demand toward less greenhouse gas emissions-intensive foods, including plant-based alternatives
- **Innovations to help food producers adapt to climate change,** including drought-resistant and flood-resistant seeds and sustainable agricultural practices

"I'm promoting climate-sensitive and resilient agricultural practices and equipping African farmers with the information, tools, inputs, and innovations to thrive."

NDIDI NWUNELI, HBS MBA 1999
Managing Partner, Sahel Consulting Agriculture & Nutrition

"Farmers and agricultural lands are a particularly hopeful opportunity to bend the arc of climate change while restoring resiliency to farms and farmers. Slowing climate change requires innovating to harness photosynthesis. Plants naturally remove carbon dioxide from the atmosphere, and only plants are affordable, immediate and scalable to the size of the problem."

DAVID PERRY, HBS MBA 1997
CEO, Indigo Ag

"The technologies necessary to move the needle on climate change exist today but need help being brought to market. At Pattern Ag, we are harnessing innovations in genetic sequencing to help farmers improve their soil health, and in turn, improve the productivity and profitability of their acres."

KATIE HSIA-KIUNG, HBS MBA 2019
Head of Strategy and Business Operations, Pattern Ag

Visit hbs.edu/beiexhibit for full list of sources

25 National Geographic, 2014; 26 Project Drawdown, 2019; 27 National Geographic, 2014; 28 Barclays, 2019; 29 Food and Agriculture Association, 2019; 30 International Union for Conservation of Nature, 2017; 31 Project Drawdown, 2019; 32 University of Virginia Darden School of Business, 2019

BUILDINGS & CITIES

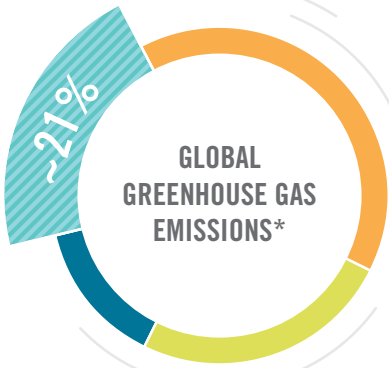
The world is currently undergoing the largest wave of urban growth in human history. More than half of the global population is now concentrated in urban areas, a proportion that is expected to increase to nearly 70% by 2050.[33]

Because nearly all the world's largest cities—and 40% of all other major cities—are located along coasts, these population centers are especially at risk from sea level rise, hurricanes, and flooding. Climate change threatens urban land values as well as important historic landmarks and public resources such as hospitals. Heat tends to concentrate in dense urban centers, increasing health risks.

A WORLDWIDE INVESTMENT OF $3.2 TRILLION IN ENERGY CONSERVATION WOULD PAY FOR ITSELF IN 3 TO 5 YEARS, ACCORDING TO THE U.N. FOUNDATION.[34]

BUILDINGS & CITIES

CHALLENGE



To accommodate rapid urbanization and avoid the worst impacts of climate change, new buildings can be designed to meet zero-emission standards, and existing buildings can be retrofitted to greatly reduce their energy requirements. Areas of focus include accelerating reliance on renewable energy for heating and cooling and deploying resilient infrastructure designed to withstand the impacts of climate change.

40% OF GHG REDUCTIONS REQUIRED BY 2050 COULD BE ACHIEVED THROUGH ENERGY EFFICIENCY, ACCORDING TO THE INTERNATIONAL ENERGY AGENCY. [35]

*Each sector's contribution varies by country and region; percentages are approximations. **See hbs.edu/beiexhibit for details.**

BUILDINGS & CITIES

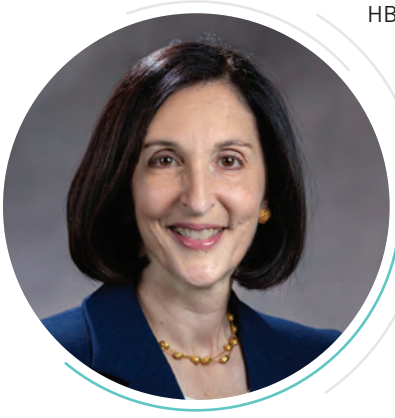
INNOVATION

Because such a large—and growing—percentage of the world's population lives in cities, cities are an important place to innovate to reduce greenhouse gases. Several types of innovations offer promise:[36]

- **Energy demand-reducing innovations** that increase the efficiency of existing buildings and new construction through improvements in lighting, insulation, heating and cooling systems, and building automation.
- **Infrastructure resilience innovations** that take into account the likelihood of flooding and other climate-related disruptions, including elevated roadways, urban swales, and other natural features that absorb excessive water, and protective barriers—along with novel finance models to support the investments needed to implement these improvements.
- **Energy-sourcing innovations** that allow for efficiently transitioning from fossil fuels to renewables to meet building heating, cooling, and lighting loads.

"If storms worsen, seas rise, and fires and drought increase, society (and businesses and investors) will need to figure out which assets to harden and defend, which to abandon, and which to prepare to rebuild after events. I'm interested in how we can cost justify and mobilize investments in real property—and address the human vulnerabilities as well."

JOHN D. MACOMBER, HBS MBA 1983
HBS Senior Lecturer



"I believe urgently transitioning to clean, green energy is essential to addressing the climate crisis. In the City of Newton, we made an important step toward this goal by switching our electric supply for residences and businesses to a supplier that is sourcing the equivalent of 60% of its electricity from local, renewable sources."

RUTHANNE FULLER, HBS MBA 1983
Mayor, City of Newton, Massachusetts

"In an era of climate change, one of the greatest challenges of sustainable urbanization is managing the efficiency of water systems. At Orbia, we are striving to make cities more resilient. For example, Cape Town in South Africa has embraced our solutions to reduce water wastage in a city that is facing severe water shortages."

JUAN PABLO DEL VALLE, HBS MBA 2001
Chairman of the Board, Orbia

Visit hbs.edu/beiexhibit for full list of sources

33 United Nations, 2018; 34 UN Foundation, 2007; 35 International Energy Agency, 2015; 36 International Energy Agency, 2019

TRANSPORTATION

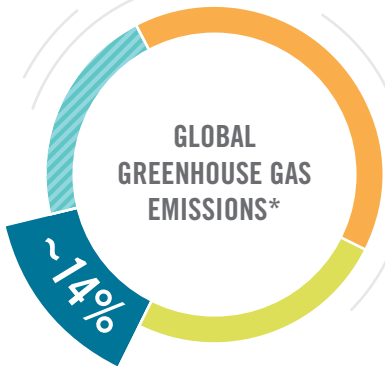
The transport sector accounts for about 14% of the world's greenhouse gas (GHG) emissions and about half of global oil consumption. In some countries, transportation's contributions are even greater; in the U.S., transportation is the top GHG contributor.[37]

Transportation infrastructure—roads, bridges, airports, and ports—is particularly at risk of disruption from climate change. Flooding, storms, and heat threaten the reliability and efficiency of this vital system.

BATTERY COSTS FOR ELECTRIC VEHICLES HAVE DROPPED 85% SINCE 2010.[38]

TRANSPORTATION

CHALLENGE



Globally, transportation is the fastest-growing source of GHG emissions. Reducing GHGs from this sector is difficult because economic growth usually requires increased mobility of goods and people. While innovation in some transportation modes is happening at a rapid pace, many modes are proving difficult to decarbonize, particularly aviation and freight.[39]

BY 2040, BLOOMBERG NEW ENERGY FINANCE EXPECTS 57% OF ALL PASSENGER VEHICLE SALES, AND OVER 30% OF THE GLOBAL PASSENGER FLEET, TO BE ELECTRIC.[40]

A host of changes to all transportation modes will reduce greenhouse gases that cause climate change:

AIRPLANES
alternative fuels and technologies to increase aircraft efficiency

CARS & ELECTRIC VEHICLES
hybrid cars, battery and plug-in vehicles

ELECTRIC BIKES
electric bikes instead of cars for urban travel

HIGH-SPEED RAIL
track construction for high-speed rail for intercity travel

MASS TRANSIT
mass transit or public transport to get around cities

RIDESHARING
more people in fewer vehicles

SHIPS
increased efficiency and alternative fuels

TELEPRESENCE
replacing flying for business meetings with telepresence technologies

TRAINS
increased electrification of freight railways

TRUCKS
increased efficiency and alternative fuels

*Each sector's contribution varies by country and region; percentages are approximations. **See hbs.edu/beiexhibit for details.**

TRANSPORTATION

INNOVATION

Innovations to reduce transport-sector GHG emissions—and other air pollutants—include technologies that increase vehicle efficiency and rely on less carbon-intensive fuels such as electricity from renewables and sustainably produced biofuels.

Well-designed public transit and freight rail infrastructure—alongside policies and technologies to discourage use of private automobiles, short-haul aviation, and long-distance trucking—could change the travel demand trends that are driving emission increases. Infrastructure investments would enable shifts to less energy-intensive modes, including walking, cycling, micromobility options (e-scooters and e-bikes), and public transit.[41]

"I believe everyone deserves access to clean, quiet transportation. At Proterra, we are designing and manufacturing zero-emission buses that abandon fossil fuels, improve environmental quality, and reduce operating costs."

RYAN POPPLE, HBS MBA 2006
President and CEO, Proterra

"Climate change is one of the biggest, if not the biggest, challenges facing my generation. Shared, electric, autonomous vehicles will enable urban areas to become more sustainable and more livable by providing a better alternative for first and last mile transportation."

STEPHANIE WU, HBS MBA 2017
Head of Product, Optimus Ride

"I'm committed to slowing climate change by creating almost-carbon-neutral transportation fuels, on a commercial scale, by 2025 by partnering our startup, Synthetic Genomics, with ExxonMobil."

JUAN ENRIQUEZ, HBS MBA 1986
Managing Director, Excel Venture Management

Visit hbs.edu/beiexhibit for full list of sources

37 Project Drawdown, 2019; 38 Bloomberg New Energy Finance, 2019; 39 U.S. Global Change Research Program, 2018; 40 Bloomberg New Energy Finance, 2019; 41 Project Drawdown, 2019

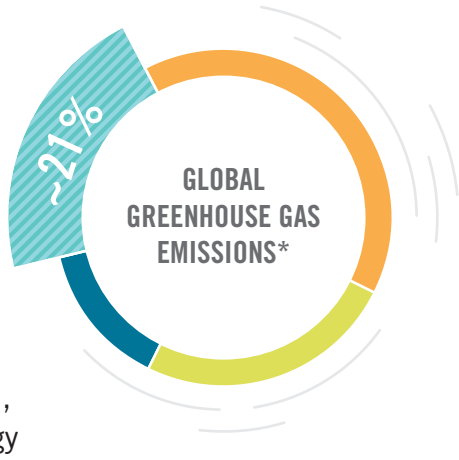
INDUSTRIAL PRODUCTION & MATERIALS

Industrial activity that produces many of the materials used in commerce, as well as consumer products and packaging, also produces a significant percentage of the pollutants that cause climate change. **Transitioning to fossil-fuel free energy sources for these processes, improving efficiency and reducing waste, and bringing low-carbon alternatives to market could dramatically reduce greenhouse gas emissions.**

ACCORDING TO MCKINSEY, ADOPTING CIRCULAR ECONOMY PRINCIPLES NOT ONLY YIELDS ENVIRONMENTAL AND SOCIAL BENEFITS, BUT COULD ALSO GENERATE A NET ECONOMIC BENEFIT OF €1.8 TRILLION BY 2030 FOR EUROPE.[42]

INDUSTRIAL PRODUCTION & MATERIALS

CHALLENGE



Linear production processes—where material is extracted, processed, transported, manufactured, used, and discarded—waste the energy embodied in materials and required for handling waste streams. Because closed-loop processes are more efficient, they emit fewer greenhouse gases.

MAJOR IMPACT AREAS

REFRIGERANT MANAGEMENT

Refrigerant gases, commonly used in air conditioning, are particularly damaging to the climate. Controlling refrigerant leaks and implementing more robust strategies to recover, recycle, and destroy refrigerants at the end of their useful life can mitigate climate change impacts.[43]

CEMENT

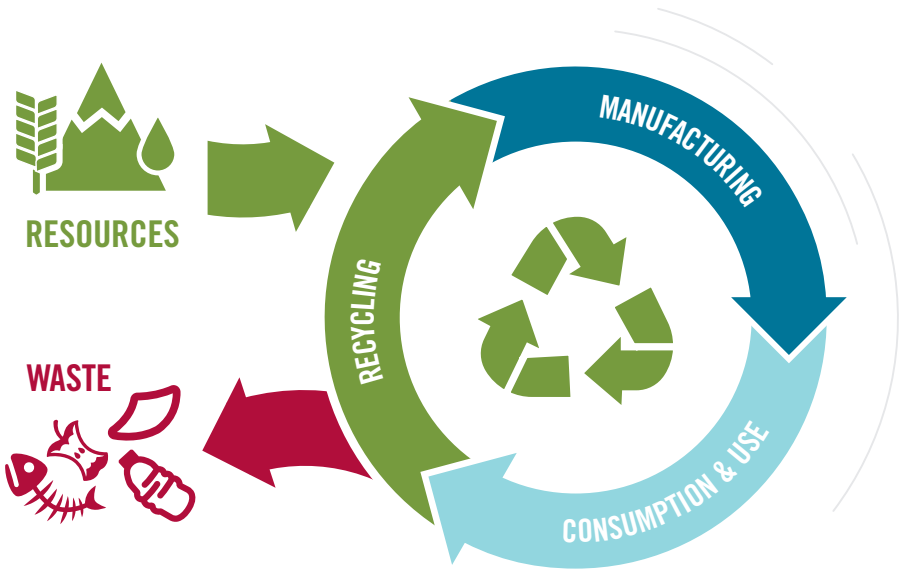
The manufacturing of cement **generates 5%–6% of global GHG emissions annually.**[44] Coal continues to be the fuel of choice for most cement plants. Alternative fuels and low-carbon cement made with recovered fly ash offer significant potential.

PLASTIC

Globally, 310 million tons of plastic are produced each year, almost all made from fossil fuels. Experts estimate that **90% of current plastics could be derived from plants instead, emitting fewer GHGs.**[45]

WATER CONSUMPTION

Industry accounts for about **20% of global water usage,** the second highest usage after agriculture.[46] Except when powered by renewable or nuclear energy, pumping and treating water emits GHGs. More efficient water usage, water reuse, and wastewater management all conserve water—increasingly important steps as droughts become more frequent.



*Each sector's contribution varies by country and region; percentages are approximations. **See hbs.edu/beiexhibit for details.**

INDUSTRIAL PRODUCTION & MATERIALS

INNOVATION

Transitioning away from carbon-intensive energy to power industrial production, designing products with efficiency in mind, and instituting policies and technologies to minimize waste have potential to reduce emissions significantly.[47]

"Our mission is to make it easy for people to make the environmentally responsible choice in the products they buy and consume by offering plastic-free alternatives. We want to empower everyone to tackle climate change through these types of easy and simple changes that can add up to a monumental impact."

GINA PAK, HBS MBA 2015
Founding Member/Marketing, Blueland

"With 80% of sewage globally being discharged directly into waterways and ultimately ending up in the atmosphere as CO_2 or methane, private companies can address our climate and water crises by stepping in where governments, with their strained balance sheets, are not."

OMAR ABOU-SAYED, HBS MBA 2004
Chief Executive Officer,
Advantek Waste Management Services

"We produce carbon black from end-of-life tires for the tire, rubber, and paint industries. With our breakthrough technologies we preserve valuable raw materials and dramatically reduce CO_2 emissions and pollution."

MARTIJN CARDOZO, HBS MBA 2000
Member Supervisory Board, Circle Economy

Visit hbs.edu/beiexhibit for full list of sources

42 McKinsey, 2015; 43 Project Drawdown, 2019; 44 Project Drawdown, 2019; 45 Project Drawdown, 2019; 46 World Water Council, 2019; 47 Project Drawdown, 2019

ENCOURAGING AWARENESS AND ACTION TO CONFRONT CLIMATE CHANGE

THIS EXHIBIT WAS DEVELOPED BY THE HBS BUSINESS & ENVIRONMENT INITIATIVE IN PARTNERSHIP WITH HBS SUSTAINABILITY.

HARVARD BUSINESS SCHOOL
Business & Environment Initiative

ABOUT THE HBS BUSINESS & ENVIRONMENT INITIATIVE (BEI)

BEI serves as a hub for environmentally focused research, teaching, and discourse at HBS. By connecting world-class faculty, students, alumni, and practitioners, BEI works to deepen understanding of the environmental challenges confronting business leaders – and to inspire new ideas and practical, effective solutions that benefit managers everywhere.

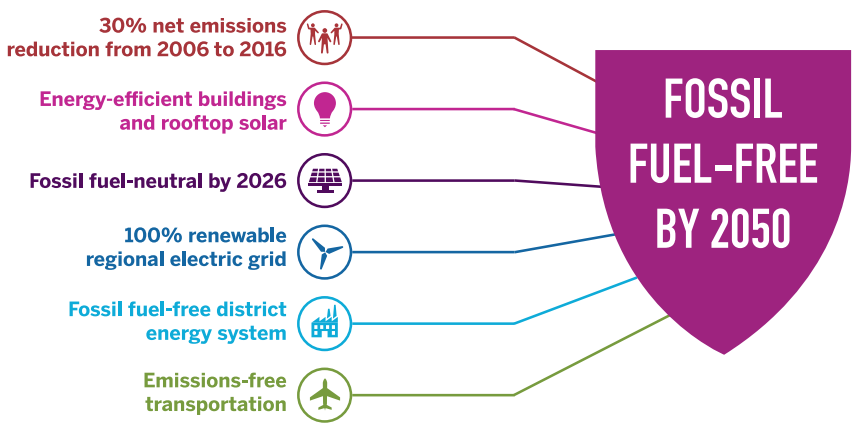
EDUCATE
students to lead in a rapidly changing world

CATALYZE
research by connecting faculty, alumni, and other leaders

PROMOTE
new managerial mindsets and innovative business solutions

ABOUT HBS SUSTAINABILITY

The HBS Sustainability team, part of the HBS Operations department, works to increase the health and sustainability of our campus to act as a living lab for sustainability solutions and to act as a model for other organizations to replicate. The team works to meet the University's fossil fuel-neutral and fossil fuel-free goals by implementing energy conservation measures and renewable energy projects, serving food with a lower emissions footprint, designing LEED-certified buildings and projects, and inspiring the community towards action through education.



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