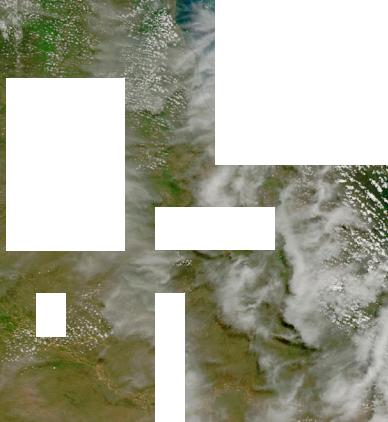


Confronting the reality of climate change

Excerpts from the special report by The Initiative for Global Environmental Leadership (IGEL) and Knowledge@Wharton



The Science of Climate Change

Like 98% of scientists, Irina Marinov knows that climate change is real and is being caused by human activity. As a professor of earth and environmental science at the University of Pennsylvania, what she finds baffling is why so many non-scientists in this country doubt this well-established fact.

According to a report from the National Surveys on Energy and Environment, 27% of Americans either do not believe the science or seriously doubt it. Even more alarming, 37% of Americans believe that natural causes, rather than human activity, are partially or wholly behind the rapid climactic changes of the past century.

Speaking at “The End of the World as We Know It,” a conference on extreme climate disruption sponsored by Wharton’s Initiative for Global Environmental Leadership (IGEL), Marinov asked, “What are we doing wrong? How do we get people to trust us?”

The evidence stretches back more than 100 years.

Svante Arrhenius, Sweden’s first Nobel Prize winner, was the first to calculate how levels of atmospheric carbon dioxide (CO₂) affect the earth’s average temperature. He published his findings in 1896, after collecting the meager data then available and performing what he called “tedious calculations.” His conclusion – that if CO₂ levels doubled, the earth’s surface temperature would rise about 5°C to 6°C – was a surprisingly accurate first attempt. (Scientists now say 2°C to 3°C is more likely.)

Arrhenius, who couldn’t have foreseen the rapid growth of internal-combustion automobiles, was the first to realize that burning coal would increase CO₂ levels and warm the planet, although his timetable was wildly off target. He estimated it would take 3,000 years for CO₂ levels to rise 50%, when, in fact, the average global temperature rose 30% in the 20th century alone. He also anticipated the warming trend would benefit humankind, enabling our distant descendants to “live under a milder sky and in less-barren surroundings than is our lot at present.”

Over the years, scientists confirmed that the world’s increasing reliance on fossil fuels was indeed pumping large amounts of CO₂ into the atmosphere, but like Arrhenius, they remained optimistic about the outcome. Earth’s oceans, said

the experts, would absorb much of the gas and the small amount left in the atmosphere would help nourish plant life, leading to increasingly lush vegetation.

In her closing keynote at the IGEL conference, Margaret Leinen, vice chancellor and current director of the Scripps Institution of Oceanography at the University of California, San Diego, described how this sanguine view began to unravel in 1952 with the publication of a paper by Roger Revelle, then director of Scripps, and chemist Hans Suess. Their groundbreaking study showed that the oceans were absorbing only 25% of the atmospheric CO₂ generated by the use of fossil fuel. That same year, Revelle hired Charles David Keeling, then a post-doctoral fellow at Caltech, to take detailed measurements of CO₂ levels. The result, said Leinen, is “the iconic Keeling Curve of climate change,” which charts the steadily rising concentrations of atmospheric CO₂ from 1952 to the present.

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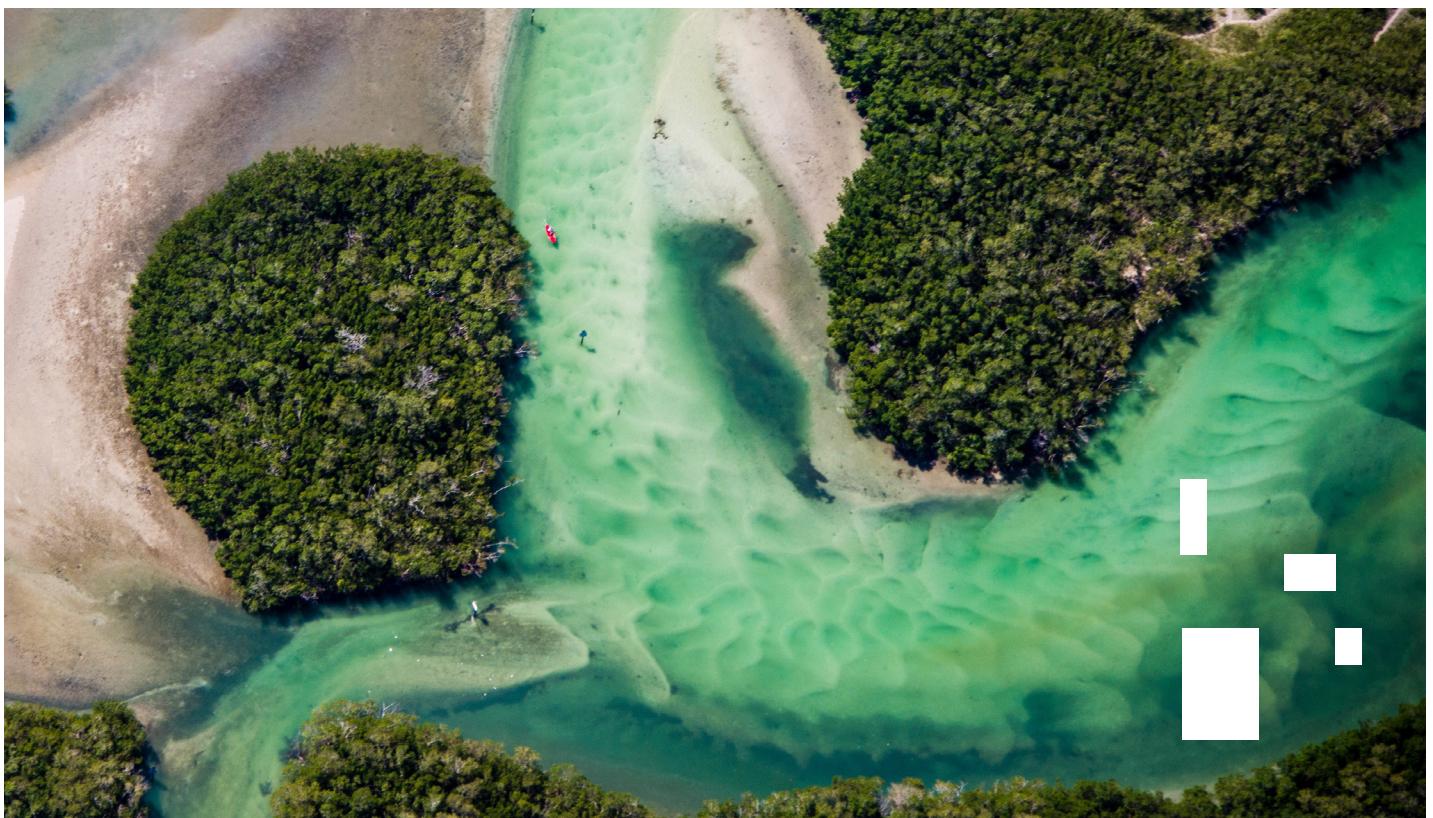
Since then, scientists have taken ice core samples allowing them to measure atmospheric CO₂ over hundreds of thousands of years, as the earth has cycled through ice ages and warm periods. The current CO₂ level, 410 parts per million, does not break any world records, said Marinov (it was equally high 23 million years ago, during the Oligocene Epoch, when seas were 100 feet higher than they are today). What is unique is the speed with which the greenhouse gas is being added. According to Marinov, scientists have been unable to find any time in the geologic history of the earth that CO₂ levels have increased as much as they have in the past 100 years.

There has been amazing progress since Arrhenius' time in measuring climate change. Scientists now have access to vast amounts of real-time data from ships, submarines, buoys, weather stations, balloons, satellites and radar installations around the world. Armed with computing power the 19th century scientist could not have imagined, today's researchers have incorporated the data into climate models that have been tested and refined over the years, based on their ability to accurately account for past climate variations. Scientists are now convinced that climate change is caused by human activity. In fact, according to Leinen, the science is so well established that the upcoming report of the Intergovernmental Panel on Climate Change will be the first to include predictions of future extreme weather events based on statistical probabilities.

A severe 2010 heat wave in Russia left nearly 56,000 dead, and a 2003 heat wave in Europe claimed the lives of almost 70,000 people.

Forecasting “the end of the world as we know it.” In his opening remarks at the climate conference, Eric Orts, Wharton professor of legal studies and business ethics and faculty director of IGEL, pointed out that with hurricanes Harvey, Irma and Maria battering the southeast and wildfires sweeping through California, 2017 was America’s costliest year yet in terms of natural disasters.

And it's only going to get worse, Leinen explained. Scientists can now say with virtual certainty (meaning a better than 99% chance) that the frequency and intensity of extreme high temperature events will continue to increase. The likelihood that extreme precipitation events will also increase in frequency and intensity is only slightly less certain (90% to 99%). The toll from such events is already staggering. Hurricanes and flooding make the headlines, but a severe 2010 heat wave in Russia left nearly 56,000 dead, and a 2003 heat wave in Europe claimed the lives of almost 70,000 people. In California, 99% of the deaths from heat waves have been in poorer regions, raising what Leinen called “an environmental justice issue.”



The food supply is also threatened by climate change. In the developed world, the greatest agricultural losses to date have been due to extreme weather events, especially rain and floods, and across the major farm regions of the U.S., decreasing soil moisture poses a growing threat to crop yields. Of equal concern in today's global economy, 22% of the losses due to natural disasters in the developing world affect agriculture, according to a 2017 report by the Food and Agriculture Organization of the United Nations.

"Extreme weather events are uncovering new kinds of catastrophic losses, as well," said Anthony Wagar, executive vice president of environmental practice at Willis Towers Watson. A featured speaker at the conference, Wagar recounted experiences from his insurance work – flooding that carried industrial pollution into previously uncontaminated areas and toxic mold that grew in the aftermath of major storms. In some areas, flood waters overwhelmed water treatment plants, sending untreated sewage into nearby waterways. Outside of Houston, Hurricane Harvey knocked out critical cooling systems at a chemical plant, which led to a massive explosion.

The cumulative effect of all this scientific and anecdotal evidence is setting off alarms at the highest levels of society. "Doomsday predictions can no longer be met with irony or disdain," said Pope Francis in his 2015 encyclical. "The pace of consumption, waste and environmental change has so stretched the planet's capacity that our contemporary lifestyle, unsustainable as it is, can only precipitate catastrophes, such as those which even now periodically occur in different areas of the world."

The man who convinced the pope to focus his encyclical on climate change is Veerabhadran Ramanathan, professor of atmospheric and climate sciences at Scripps. According to Ramanathan, there is an even chance that the earth's temperature will rise more than 2°C in the next 35 years, and as a result, there is a 5% chance of what he calls catastrophic changes, ranging from deadly heat and widespread drought to overwhelming sea level rise and an explosion of vector-borne diseases such as dengue and chikungunya. To put this in perspective, Leinen asked conference attendees if they would get on a plane that had a 5% chance of crashing (the actual probability of a plane crash is one in 5.4 million).

So why do so many Americans doubt climate change?

Despite rock-solid science, the near certainty of devastating changes and a 5% chance of catastrophic change, millions remain unconvinced of the need to mitigate or adapt to climate change. Neither the pope's encyclical nor the Paris Agreement, an international commitment signed by 174 countries, has appreciably changed anyone's mind. In fact, according to a recent Gallup poll, the number of Americans who believe, disbelieve or remain uncertain about climate change has remained remarkably stable over the past two decades.

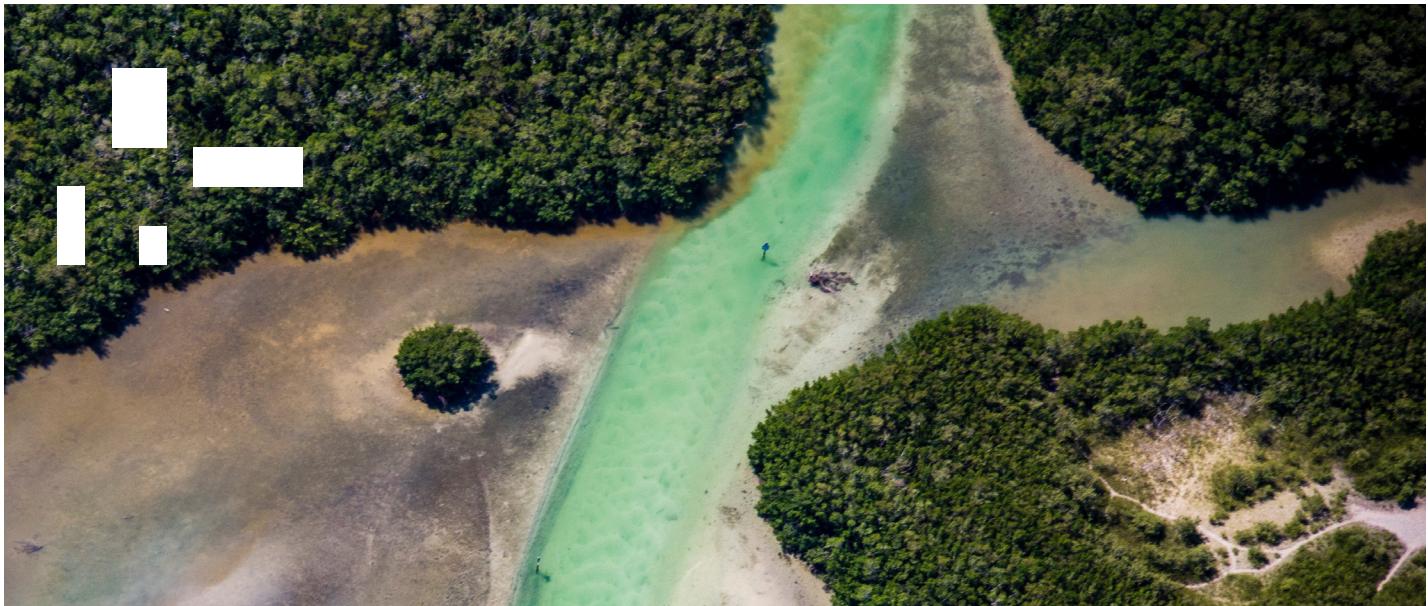
Colby Manwaring, CEO of Innovyze, a global provider of business analytics software for water-related infrastructure, offered a possible explanation during his morning keynote address at the climate conference. He suggested that people react to climate change disasters as they do to any traumatic event, moving from denial to anger and bargaining before finally coming to terms with the reality of their loss. Denial was rampant after 2012's superstorm Sandy, said Manwaring, who quoted one resident of a flooded New York neighborhood as saying, "I don't want to live in a high-risk flood zone, but I don't want to move."

Others, he said, have reacted with anger, blaming big business or corrupt politicians or even duplicitous scientists for the problem. And one instance of bargaining he mentioned bordered on the ludicrous, with New York City officials negotiating with FEMA to change the contours of flood maps because the new scientifically determined flood zones would be unpopular with residents.

Howard Kunreuther, co-director of the Wharton Risk Management and Decision Processes Center, offered another possible explanation. Kunreuther and Robert Meyer (also co-director of the risk management center), focused their recent book, *The Ostrich Paradox: Why We Underprepare for Disasters*, on confronting the cognitive biases they believe influence people's thinking about climate change.

Rather than taking on people's surface attitudes directly, ... the goal of Jiu Jitsu persuasion is to identify the underlying motivation, and then to tailor the message so that it aligns with that motivation.

– American Psychologist



Calling on the pioneering work of Nobel laureate Daniel Kahneman, Kunreuther and Meyer outline six biases rooted in what Kahneman calls “system one thinking” (fast, intuitive and emotional), as distinguished from “system two thinking” (slower, more deliberative, and more logical): (1) myopia (focusing on the short-term); (2) amnesia (forgetting the lessons of the past); (3) optimism (underestimating the likelihood of extreme events); (4) inertia (a bias toward the status quo); (5) simplification (attending to just a few factors); and (6) herding (basing choices on others’ actions).

“We are not going to change these biases,” said Kunreuther. “They are part of the way we deal with the world.” But he said there are ways to mitigate their influence. One key strategy, he suggested, is to stretch people’s time horizons. If the upfront cost of a solar installation deters people from investing in its long-term benefits (myopia), create financing programs that stretch the upfront cost over the life of the system. If people underestimate the risk posed by extreme weather events (optimism), don’t tell them there’s a one in a hundred chance of a flood or hurricane next year, tell them there’s at least a one in five chance of disastrous weather occurring more than once in the next 25 years.

Marinov herself suggested a third explanation for the disconnect between science and public opinion when she pointed out that Americans’ beliefs about climate change are determined more by political affiliation than by science, a fact confirmed more than once by polling data. This partisan divide has nothing to do with educational level. In fact, a Gallup poll from 2015 showed that the more education Democrats and Republicans have, the more their beliefs about climate change diverge.

According to an analysis published in *The New York Times*, this counter-intuitive relationship between education and partisan beliefs holds true for just a handful of complex issues. “On these kinds of matters, many Americans don’t necessarily have their own views, so they look to adopt those of political elites,” reports the *Times*. And when political elites disagree, “their views tend to be adopted first by higher-educated partisans on both sides, who become more divided as they acquire more information.” And partisan beliefs are inherently resistant to rational persuasion. According to a 2010 study, “committed participants” clung tenaciously to misperceptions even when shown accurate corrections. “Even worse,” noted the researchers, the corrections “actually strengthen misperceptions among ideological subgroups in several cases.”

A recent article in *American Psychologist* suggests using what the authors call “psychological Jiu Jitsu” to overcome such resistance. “Rather than taking on people’s surface attitudes directly (which causes people to tune out or rebel), the goal of Jiu Jitsu persuasion is to identify the underlying motivation, and then to tailor the message so that it aligns with that motivation.” Other researchers have found, for example, that Republicans become less likely to deny climate change when presented with free-market solutions more in keeping with their core beliefs.

It remains to be seen whether any or all of these strategies can help persuade a majority of Americans to accept the reality of anthropogenic climate change. Whatever the solution, “the window for action is closing,” said Leinen at the conference. “What we do this decade will determine the degree of suffering, versus mitigation and adaptation, we will experience.”

Climate Change and Government: State and Local Step Up in a Federal Vacuum

Eric Orts, Faculty Director Of Wharton's Initiative For Global Environmental Leadership (IGEL), opened the center's conference this year with a set of ominous questions. Given the increasing likelihood that climate change will lead to catastrophic consequences, "how can we best prepare for the possibility of coming catastrophes? How can we best preserve our foundational institutions of free enterprise, democratic government and basic human rights in a radically changing world? In a word, how can we preserve civilization?"

Orts, who is also a Wharton professor of legal studies and business ethics, noted the timeliness of the conference theme, "The End of the World as We Know It: The Consequences of Extreme Climate Disruption for Business and Democracy."

"With each year of inaction, climate damage is increasing and increasingly likely to be more severe in the future."

— Eric Orts, faculty director of Wharton's Initiative for Global Environmental Leadership (IGEL)

"The timing for this conference is critical given the unfortunate political situation in the United States," Orts said. "A major party has reversed course from policy positions that had previously endorsed market-based approaches to climate regulation – including cap-and-trade and carbon fee options – to a complete and irrational denial of science and scientific warnings. With each year of inaction, climate damage is increasing and increasingly likely to be more severe in the future. It is incumbent on academics and business leaders to prepare for long-term extreme risks."

A radical change in direction. Three years before signing the Paris Agreement in 2016, the most ambitious climate change accords in history, President Barack Obama introduced his Climate Action Plan. It accepted the scientifically proven reality of climate change and called for decisive action to help prevent a warming planet's most devastating effects. The Obama plan targeted a 17% reduction in greenhouse gas emissions by 2020, encouraged and incentivized renewable energy, and enacted far-reaching curbs on carbon dioxide from tailpipes, power plants and other sources.

Nine months later, President Donald Trump announced that the country was withdrawing from the Paris Agreement. Today, climate denial is official federal policy. Scott Pruitt, the first Environmental Protection Agency (EPA) administrator appointed by Trump, circulated this view: "Human activity impacts our changing climate in some manner. The ability to measure with precision the degree and extent of that impact, and what to do about it, are subject to continuing debate and dialogue." Pruitt also did not agree that carbon dioxide was a "primary contributor" to climate change, and asserted that the human race has mainly profited from warming trends.

Pruitt has left office, but the department did not change course under acting EPA Administrator Andrew Wheeler. The EPA has removed many references to planetary warming from its website. Christine Todd Whitman, who headed the EPA under President George W. Bush, said the culling of online scientific data on climate change is "to such an extreme degree that [it] undermines the credibility of the site."

The inevitable result of this radical shift in federal policy will be intense, varied and catastrophic climate effects. "It will become more and more apparent that global climate change is the most significant challenge that human civilization will face in the 21st century," said Orts. "Formerly verdant parts of the world will likely become overburdened and uninhabitable. Migrations and environmental refugee flows will likely multiply exponentially. Tropical diseases will likely spread. Many species will likely continue to die off."

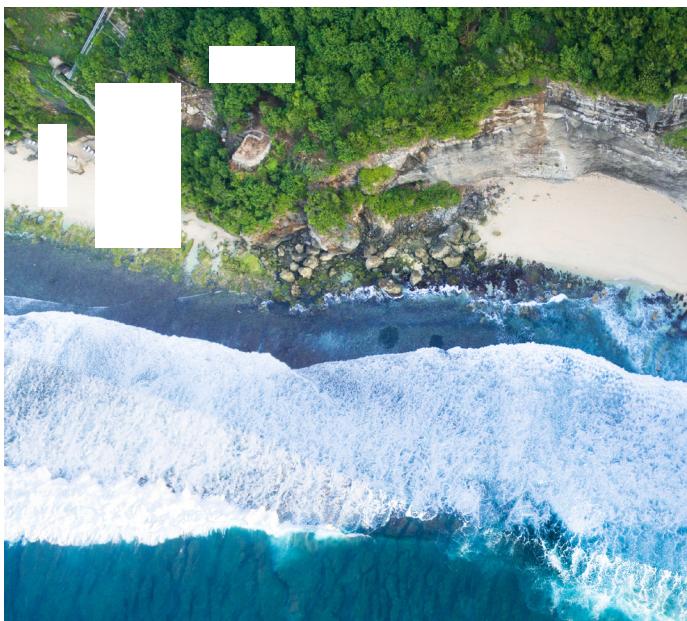
State and local municipalities step up. In the vacuum created by federal stonewalling on climate change, mayors have taken action and many states have organized themselves into compacts and passed unilateral regulation. Perhaps the strongest position was taken by California's

state legislature, which in August 2018 voted that 60% of its electricity generation would come from renewable sources by 2030, and 100% by 2045. “This is a pivotal moment for California, for the country and the world,” stated Michael Brune, the Sierra Club’s executive director.

Nine Northeastern and Mid-Atlantic states have joined together in the Regional Greenhouse Gas Initiative (RGGI). The states together represent the world’s sixth largest economy, with a combined GDP of \$2.8 trillion in 2017. The states formed their own cap-and-trade system, and pledged to reduce power plant emissions by 3% each year over the previous year, resulting in emissions in 2030 that will be 65% lower than in 2009, the first year of RGGI.

Following President Trump’s decision to abandon the Paris Agreement, a group of 36 U.S. mayors signed the 2017 Chicago Charter, agreeing to abide by the principles of the international pact. “We’re all going to get to the same destination in our own individual way,” said Chicago Mayor Rahm Emmanuel. “It’s designed in such a way that it is measurable.” In 2018, the so-called “Climate Mayors” had more than 400 U.S. cities, representing 70 million Americans, pledge to meet the provisions of the Paris Agreement.

One of those cities is Orlando, Fla., which under the leadership of Mayor Buddy Dyer, has installed 20 megawatts of solar power (through the municipal utility), testing systems to trap carbon dioxide from its power plants, and looking at closing plants that burn coal.



Globally, the London-based C40 Cities Climate Leadership Group, founded in 2005, has signed on 90 cities (including in the U.S. Austin, Tex., Boston, Portland, Ore., Chicago, Houston, Los Angeles, New York, Philadelphia, San Francisco, Seattle and Washington, D.C.). The 90 cities represent more than 650 million people and a quarter of the international economy. C40 is focused both on reducing urban emissions and reducing risks to cities from a dramatically warming world.

The current C40 chairperson, succeeding former New York Mayor Michael Bloomberg, is Anne Hidalgo, mayor of Paris, who made a major climate commitment in the French capital by pledging to ban diesel vehicles by 2024, and internal-combustion vehicles of all types by 2030. Further, France has said that, under the Paris climate accords, it will end the sale of all diesel and gas-powered cars by 2040.

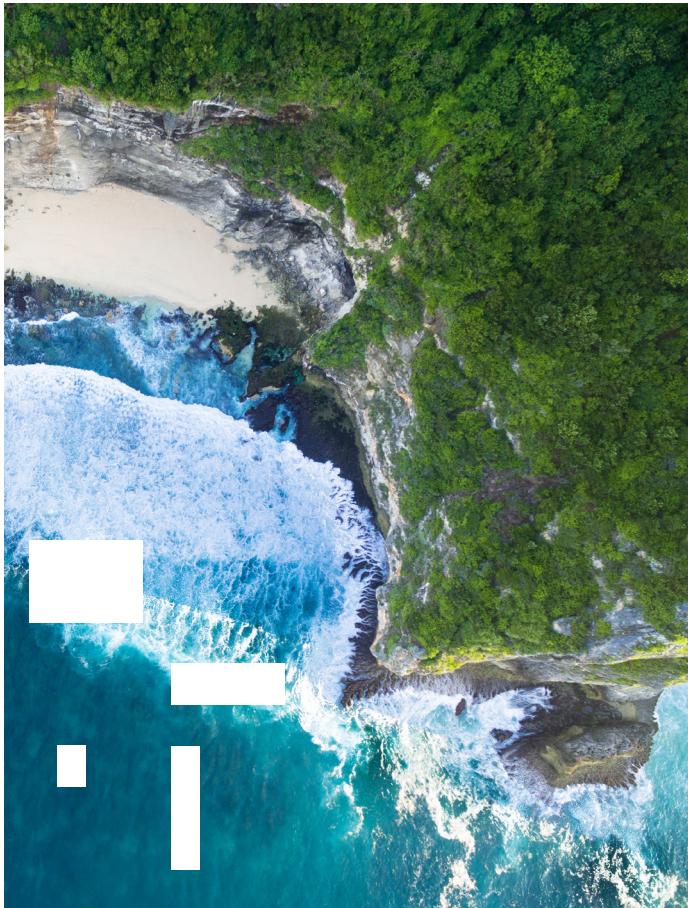
“Our methods and plans need to be dynamic, not static, and we can’t pretend that new data won’t emerge over time.”

— Colby Manwaring, CEO, Innovuze

Adapting to climate change. It’s too late to escape significant global warming impacts. States and cities are recognizing the inevitability that they will “feel the heat” from climate change, and the Wharton conference highlighted some of the ways they are making preparations. Or, in some cases, resisting them.

Colby Manwaring, the CEO of Innovuze, a global provider of business analytics software for water-related infrastructure, said at the conference that outdated flood maps with misleading 100-year-storm data have given coastal residents false assurances about their likelihood of experiencing catastrophic events. In the wake of superstorm Sandy, the Federal Emergency Management Agency (FEMA) used big data analytics to draw new flood maps that take into account higher variability in the weather. Manwaring emphasized the importance of these statistically sophisticated maps, and noted that the effort must be ongoing. “Our methods and plans need to be dynamic, not static, and we can’t pretend that new data won’t emerge over time,” he said.

But simply having accurate data won’t guarantee that elected officials will respect the message contained in it. The new FEMA flood maps for New York City were rejected by some city officials, because they would reduce property values and force thousands of people to buy flood insurance.



Other cities, like New Orleans, are taking more realistic approaches, said Elinor Haider, vice president for market development at Veolia North America, which applies sustainable solutions to energy, water and waste issues. “The old model,” she said at the conference, “is to run infrastructure to failure, then look to government to bail us out.” With the federal government in climate-denial, this strategy has failed dramatically.

Haider pointed to Puerto Rico, which at the time of the conference still had 100,000 people without power because of Hurricane Maria in 2017, and grappling with \$9 billion in related debt. “The future is in sustainable infrastructure,” Haider said. “The island has a strong incentive to privatize its utility system and invest in microgrid technology. Every dollar invested can save \$6 in costs.” She defined microgrids as “interconnected systems of distributed generating sources and controllable consumption loads.” The model of these small, decentralized power plants she cited combine solar, battery back-up, and combined heat-and-power units (CHP).

“We have a responsibility to produce chemicals safely and operate reliably.”
— Erica Campo, global sustainability strategy manager,
The Dow Chemical Company

According to Haider, those business complexes, campuses and hospitals with microgrids were able to keep the power on when they were hit by Sandy (which caused \$70 billion in damage). Because of its Washington Square microgrid, she said, New York University’s campus had electricity, heat and hot water during the storm, while nearby NYU Langone Medical Center went dark at a critical time. (Since the storm, Langone installed an 11-megawatt CHP plant and microgrid that Haider said “will be state-of-the-art and keep the power on during the next storm.”)

In part because of the state’s Sandy experience, New York’s Public Service Commission in 2014 ordered utility Con Edison “to enhance system reliability, to achieve a higher level of storm hardening and resiliency in the face of anticipated climate change and sea level rise.” Specifically, Con Ed was told to invest in distributed generation as an alternative to its existing power plants. Other New York utilities were also told to build predicted climate impacts into their planning.

Private industry can help when local and state governments get overwhelmed, added Erica Campo, global sustainability strategy manager at The Dow Chemical Company. “The chemical industry in Texas employs nearly 79,000 people,” she said. “We have a responsibility to produce chemicals safely and operate reliably.” Campo also pointed to Gulf-area plants that were shut down without toxic releases, or allowed to continue running at adjusted levels.

According to Campo, Dow has made contributions to recovery efforts, provided interest-free loans to homeowners so they could rebuild, and has become a large investor in renewable energy, installing 150 megawatts of it. “A huge value chain depends on our reliability,” Campo said. “The areas directly affected by Hurricane Harvey account for \$155 billion in shipments.” She quoted climate scientist John Holdren, an advisor to President Obama: “We have three choices: mitigation, adaptation and suffering. We’re going to do some of each; the question is what the mix is going to be.”

Anthony Wagar, executive vice president for environmental practice at Willis Towers Watson, agreed that business will have to work with government, and step up with comprehensive adaptation plans. “We’re seeing non-traditional liability exposure as a result of extreme weather events,” he said. “We need to be proactive about this, and ask questions: Is that plant close to the shoreline properly situated? Risk management has to be in place, and acted upon. Fortunately, we’re seeing companies be more transparent with environmental disclosure, and the impacts they’re facing.”

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WTW-NA-2018-WTW139347

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