



## Reports Say Dire Effects Will Be Starting Soon. How Can the Economy Quickly Shed Carbon?

**W**ith the influx of new members of Congress in January, suddenly everybody is talking about a Green New Deal that would address greenhouse gas emissions and a bunch of other social ills via a suite of related policy instruments. Proponents are talking about ridding the American energy economy of carbon, and on a short timeline — perhaps by 2030. Even before the recent change in Congress, policymakers and stakeholders had been talking about what has come to be called *deep decarbonization*. A benchmark proposal calls for eliminating at least 80 percent of greenhouse emissions by mid-century, with further reductions to follow.

The Trump administration's National Climate Assessment released in November predicts global warming will soon have a significant impact on the American economy. A few weeks earlier, the Intergovernmental Panel on Climate Change forecast severe effects starting in the next 10 to 20 years — and getting worse thereafter — and argued for a maximum temperature increase over pre-industrial levels lower than the 2 degrees Celsius established in the 2015 Paris Agreement. The White House's

plans to withdraw from the accord and to roll back regulations aimed at reducing greenhouse gas emissions are the exact opposite of what these reports conclude is required.

Into this policy void have stepped a number of key players who are advocating a rich array of approaches, with the Green New Deal being merely the most famous one. A group of conservative leaders have proposed a carbon tax, an idea endorsed by many academic economists, including 2018 Nobel Laureate William Nordhaus. States such as California, Hawaii, and most of the Northeast have charted their own path toward removing carbon from their energy systems. And the private sector has begun to innovate, with power companies announcing ambitious emission goals, including some planning to go 100 percent carbon-free, and car companies like Tesla and Volvo giving up internal combustion engines.

This Debate in Print concentrates on the U.S. energy system and asks, How should public policy move forward to promote the decarbonization of the American economy? And what blend of law, economics, science, and technology will get the job done?



*"A carbon tax is a 21st century tool for the 21st century problem of decarbonizing the modern economy."*

**Joseph E. Aldy**

*Associate Professor*  
HARVARD KENNEDY SCHOOL OF  
GOVERNMENT



*"The Clean Air Act shows how to create governance mechanisms that promote durability, adaptability, and flexibility."*

**Ann Carlson**

*Faculty Co-Director*  
UCLA/EMMETT INSTITUTE ON  
CLIMATE CHANGE AND THE  
ENVIRONMENT



*"It is technically feasible for the country to reduce its greenhouse gas emissions at least 80 percent in the next three decades."*

**John C. Dernbach**

*Commonwealth Professor of Law*  
WIDENER UNIVERSITY



*"California has built a model that demonstrates how addressing climate change and growing the economy can reinforce one another."*

**Mary Nichols**

*Chair*  
CALIFORNIA AIR RESOURCES  
BOARD



*"A century ago, the right technology and policy enabled us to invent a new energy system. Today, with the right technology and policy, we can reinvent it."*

**Anne Pramaggiore**

*Senior Executive Vice President  
and CEO*  
EXELON UTILITIES



*"Behavior change is the long-term solution, but technological advancements funded by Congress can give us more time to take the steps needed."*

**Mike Quigley**

*Vice Chair*  
HOUSE OF REPRESENTATIVES  
SUSTAINABLE ENERGY AND  
ENVIRONMENT COALITION

## A Few Keys to Saving the Planet Cost-effectively

By JOSEPH E. ALDY

Virtually every activity a person undertakes on a typical day — driving to work, charging a phone, cooking dinner — contributes to carbon dioxide emissions. And the daily activities occurring at a business — running an assembly line, operating a harvester, shipping goods — likewise affect greenhouse gas emissions. With fossil fuels representing four-fifths of U.S. energy consumption, decarbonizing the energy foundation of American society will require a comprehensive, economy-wide approach to emission reductions.

A carbon tax is the most effective approach — environmentally, economically, and politically — to reduce emissions and promote the innovation necessary for realizing a zero-carbon economy.

Pricing carbon taps into the ingenuity of businesses and entrepreneurs. The technology-neutral approach of a carbon tax allows any clever emission-reducing idea to have consideration in the market. Instead of relying on a small number of government staff to identify and select an industry's abatement technology, letting the market investigate pollution control opportunities would attract many more people, small-businesses, and corporate research offices to tackle the problem.

As a result, pricing carbon would deliver emission abatement at lower cost than anyone would predict ex ante. This reflects the extensive experience in how businesses and individuals have responded to changing energy prices over the past five decades. For example, power sector carbon emissions have fallen by one-quarter in large part due to the shift from coal to natural gas. The increase in the price of coal relative to gas drove this transi-

tion, and a carbon tax would likewise drive further transitions to low- and zero-carbon sources of energy.

By getting the biggest climate bang for the buck, a carbon tax makes the politics and economics of dramatic emission reductions easier. Imposing the same carbon price on all emission sources is fair by ensuring that everyone who pollutes must bear the same cost for their pollution. As a transparent, administratively simple approach, a carbon tax is good public policy in a democracy and mitigates the prospect of regulatory capture by special interests.

By generating revenues, a carbon tax can finance research and development in next generation technologies and target resources — through tax reform, a regular per capita dividend check, or other approach — to ensure a broad, durable political coalition supporting the policy. Finally, a carbon tax would enable U.S. negotiators to reclaim leadership on international climate policy and work with partners around the world for enhanced ambition in their domestic mitigation policies.

A carbon tax would represent a major change from decades of U.S. energy and environmental policy. Traditionally, federal regulators have employed an industry-specific approach — mandating scrubbers on new power plants or requiring improvements in vehicle fuel economy — and Congress has designed technology-specific subsidies in the tax code, such as the wind production tax credit and the electric vehicle tax credit. In contrast, an economy-wide carbon tax is sector-neutral and technology-neutral.

The patchwork of sector-specific regulations and technology-specific subsidies has its supporters. Special interests — who may benefit from subsidies — would likely prefer to sustain these in lieu of a technology-neutral approach. And some environmentalists have criticized a market-based system with no cap because of the resulting uncertainty in emissions.

The status quo regulatory ap-

proach, however, is likewise subject to considerable uncertainty, as evident by the tortured history of the Obama EPA's Clean Power Plan in the courts and under the Trump administration. A carbon tax can be designed to address emission uncertainty. For example, if the country fails to achieve an emission benchmark, the tax could increase automatically, as has been done in Switzerland. Further, the carbon tax can be structured for periodic updating as we learn more about the science of climate change as well as the tax's environmental, economic, technological, and diplomatic impacts.

The current suite of policy tools that emerged in the 1970s and 1980s is not a good fit for today's American energy economy. Consider the questions it raises.

What does it mean to regulate fuel economy in terms of miles per gallon of gasoline if vehicles may be powered by electricity or hydrogen? If we impose stringent emission regulations on the power sector and thus raise electricity prices, does that impede the transition from internal combustion cars to electric vehicles? Likewise, does an industry-specific approach that raises power prices but not the price of natural gas or heating oil delay the electrification of home heating, which may be the most feasible route to zero-emission homes? Would industry-specific and technology-specific regulations and subsidies weaken incentives for new energy technologies with applications across industries and uses?

With energy-related barriers between sectors falling and the rapid emergence of new technologies, the traditional approach to regulations and subsidies will likely lag instead of lead in cutting emissions and driving innovation. A carbon tax is a 21st century tool for the 21st century problem of decarbonizing the modern economy.

**Joseph E. Aldy** is associate professor of public policy at the Harvard Kennedy School.

## Air Act Success Serves As Model for Carbon Cuts

By ANN CARLSON

The technological challenges we face to decarbonize the economy are immense. But the governance challenges necessary to spur technological development and deliver massive greenhouse gas reductions may be even larger. The lag between emissions cuts and climate benefits, the sheer scale of the energy transformation, and the complex connection between emissions and harms make the problems especially thorny. Deep decarbonization requires close attention to governance.

In a forthcoming book, my co-authors and I suggest that climate policy will need to build in three attributes in the regime that governs multi-decadal greenhouse gas reductions. To start, policy should be durable, capable of sustaining a long-term energy transformation through steadily declining emissions. We need to send a consistent signal to the private sector to invest in substantial infrastructure. Policy must also be adaptable to incorporate and respond to new scientific, technological, and economic information. Policies then must both endure and evolve. Finally, the climate transformation will be the most complicated environmental challenge we have ever confronted. Decisionmakers should also embrace policy flexibility, drawing on emitter knowledge and experience to determine how best to reduce emissions at lowest cost.

Though the governance challenge is an immense one, the United States has confronted other major environmental problems with significant success. The Clean Air Act, in particular, has delivered extraordinary benefits in the five decades since its adoption, reducing multiple

pollutants across the country from a huge number of sources.

Our book contains in-depth studies of five CAA programs from an interdisciplinary team of legal scholars, economists, and political scientists to examine the extent to which these programs incorporate mechanisms to promote durability, adaptability, and flexibility. Our focus is not on the use of the act to reduce greenhouse gas emissions — even though the CAA requires that. Instead, the book evaluates our experience in reducing traditional air pollution to see what it can tell us about promoting policy that meets the three necessary attributes.

The book reaches several conclusions: Policymakers should delegate significant, but not unlimited, discretion to an expert agency. Limitations might include the setting of deadlines, requirements to collect updated information, and citizen suit provisions. One of the most powerful adaptive mechanisms in the CAA is the broad delegation to the Environmental Protection Agency of authority to set National Ambient Air Quality Standards. Importantly, this authority is cabined by the requirement that the standards be revisited every five years and, if warranted, tightened based on up-to-date scientific information and enforced in part through citizen suits. The NAAQS program has not only led to massive reductions in ubiquitous pollutants that had been identified at the time the CAA was passed, such as lead and carbon monoxide, but also to the reduction of pollution whose harm was not even recognized in 1970, such as fine particles.

Well-structured, adaptable policy promotes durability — the two are deeply intertwined. Policies that promote regularized adaptability with built-in processes can make policy long-lasting, delivering pollution reductions decades after a statute is passed but in a manner that is predictable and legitimate.

With regularized review and procedural fairness, policymakers can signal how regulation will develop in the future and help regulated parties form expectations that guide investment decisions.

Regularized, built-in processes will also foster stakeholder involvement, allowing supportive coalitions to emerge and adapt to new information and to coalesce around new proposals. CAA programs that contain provisions that promote regularized adaptability include not only NAAQS but also technology-based standards for stationary sources that require the Best Available Control Technology, and California's special role in regulating mobile sources.

Flexible mechanisms can also make policy more durable and adaptable. Such mechanisms in the CAA draw on the expertise of regulated parties, incentivize private innovation, and minimize the cost of pollution reduction, making regulation more politically palatable. Flexibility has also produced adaptability by producing information about cost-effective regulatory approaches and technologies that have led to further pollution reductions. Examples here include the phase-out of lead in gasoline, the Acid Rain Program, the Clean Air Transport Rule, and technology-based standards for stationary sources.

Our book is based on this foundational premise: to develop the technology necessary to achieve deep decarbonization by mid-century, we need to create governance mechanisms that promote durability, adaptability, and flexibility. The Clean Air Act provides crucial lessons about how to do so.

**Ann Carlson** is Shirley Shapiro Professor of Environmental Law and faculty co-director, Emmett Institute on Climate Change and the Environment, at the UCLA School of Law. Her book *Lessons From the Clean Air Act: Building Durability and Adaptability Into U.S. Climate and Energy Policy*, co-edited with Dallas Burtraw, will be available in May.

## A Legal Playbook for Deep Cuts in Greenhouse Gases

By JOHN C. DERNBACH

Deep decarbonization in the United States is economically and technologically feasible. More than 1,000 legal mechanisms — federal, state, local, and private — are available to do the job. And there is a wide variety in the tools, enhancing the likelihood of political agreement on some combination that would work.

No one had really figured out the basics of entirely removing greenhouse gas emissions until 2012. Jim Williams and others published a paper in *Science* saying that there has “been little physically realistic modeling of the energy and economic transformations required” to reduce greenhouse gas emissions by 80 percent from 1990 levels by 2050. That article provides a model for deep decarbonization using three pillars: energy efficiency, zero-carbon electricity, and moving from liquid fuels in the transportation and building sectors to decarbonized electricity.

The article spurred formation of the Deep Decarbonization Pathways Project. The DDPP is a global effort to assess the technological and economic feasibility of deep decarbonization in 16 countries representing 74 percent of the world’s emissions.

In 2014 and 2015, DDPP published two reports on deep decarbonization in the United States. These reports conclude that “it is technically feasible” for the country to reduce its greenhouse gas emissions at least 80 percent in the next three decades. They also conclude that the cost of this effort would only be one percent of U.S. gross domestic product. They do not calculate the considerable public health, safety, security, economic, environmental, and other benefits,

which are likely to contribute significantly to GDP.

Enormous changes would be required to achieve this level of reduction, the reports say. The United States would need to more than double the efficiency with which energy is used. Nearly all electricity would be carbon free or use carbon capture and sequestration. Electricity production would also double, because gasoline and diesel fuel for transportation would be mostly replaced by electricity.

But how is this to be accomplished? Deep decarbonization is not likely to occur unless general policies are translated into specific laws and then implemented.

To that end, in late 2015, Michael Gerrard of Columbia Law School and I began planning an edited volume to comprehensively analyze and explain the various laws that could be employed, building on the DDPP reports. The resulting book, *Legal Pathways to Deep Decarbonization in the United States*, is being published by the ELI Press in March. In 35 chapters authored by 59 experts, the book identifies hundreds of legal tools that could be employed to achieve deep decarbonization.

*Legal Pathways* describes a dozen different types of such mechanisms. These are not just the usual suspects — for instance, command-and-control regulation, market-leveraging approaches, and tradable permits or allowances — but also reduction or removal of legal barriers to clean energy and removal of incentives for fossil fuel development and use. The tool set also includes information and persuasion, better infrastructure, technology R&D, insurance reforms, property rights, and social equity.

The book is more than a toolbox. To switch metaphors, it is ultimately a playbook for deep decarbonization. In American football, a playbook is a comprehensive listing of all of the formations that can be em-

ployed by a particular team. In any one game, some of these plays will be used, and some will not, depending on the circumstances. Similarly, we realize that not all of the *Legal Pathways* tools will be used, but public and private decisionmakers can choose various combinations to achieve the needed reductions in U.S. greenhouse gas emissions. Indeed, various legal tools could be designed and combined to achieve quicker and deeper reductions than 80 percent by 2050, and even to achieve negative overall emissions.

While both the scale and complexity of deep decarbonization are enormous, the book has a simple message: deep decarbonization is achievable in the United States using laws that exist or could be enacted. These and other legal tools can be employed with significant economic, social, environmental, and national security benefits.

The wide range of types of mechanisms also provides great opportunity for building consensus. One particularly important category, for example, is reduction or removal of legal barriers. The many types of tools also make clear that a great many types of lawyers and other professionals are important in this effort, including not only energy and environmental experts, but also including specialists in finance, corporations, municipalities, procurement, contracting, and real estate.

Toward that end, Professor Gerrard and I are launching a project to turn the recommendations into legal language — drafting model federal and state statutes and regulations, blueprints for local ordinances, guidance documents, transactional agreements, and the like. We welcome lawyers from all backgrounds to join in this effort — all environmental professionals have a role to play.

**John C. Dernbach** is commonwealth professor of law at Widener University.

# The Path to Zero Goes Through California

By MARY NICHOLS

Last November, California burned. Again. As the Camp Fire devastated the town of Paradise, the Woolsey Fire tore through Malibu. More than 15,000 families — humble retirees and celebrities alike — lost their homes. At least 88 people lost their lives.

For the third time in just over a year, smoke blanketed our state. The long shadow of suffering stretched hundreds of miles for weeks. Hazardous air pollution affected millions of Californians. They were the lucky ones.

Schools closed. Kids were stuck inside for days on end. Again.

Climate change has many names — like Maria, Harvey, Sandy, or Katrina. No region is exempt, whether it's the melting permafrost that underlies Alaska or the vanishing fisheries that sustain so many.

There is no longer a conflict between mitigation and adaptation. We must do both. And do it quickly, before the costs of inaction become insurmountable.

That is why, ahead of the Global Climate Action Summit in San Francisco last September, then Governor Jerry Brown signed an executive order calling on California to achieve net-zero greenhouse gas emissions as soon as possible, and no later than 2045, and to achieve and maintain negative emissions thereafter. It positions California as the largest economy in the world to commit to climate neutrality before mid-century.

Achieving climate neutrality entails four big steps. They are all feasible, and all offer significant economic and health benefits in addition to their role in putting a stop to catastrophic climate change. Each

is well underway in California and several other states.

First, we must immediately slash emissions of the most potent, fast-acting “super pollutants” — methane, black carbon, and hydrofluorocarbons. Doing so will save millions of lives globally and cut the expected rate of global warming in half by 2050. California has a detailed plan to cut these harmful pollutants by 40-50 percent by 2030, and plans to launch its own satellite capable of pinpointing methane leaks around the world, allowing fast and cost-effective remedial action.

Second, we must transition to 100 percent clean energy, wherever possible and as quickly as possible. California is one of an increasing number of jurisdictions committed to 100 percent clean energy in its power grid. Next up are vehicles.

With renewable power already cheaper than fossil fuels and electric cars and trucks promising to be so soon, these transitions will lower energy and transportation costs for families and businesses, while improving public health. We must accelerate these transitions through incentives, infrastructure investment, regulations, and improved education and outreach.

Third, we must quickly scale carbon dioxide removal strategies. California has committed \$1 billion to improve management of our forests and reduce wildfire risk, with the goal of enabling forests to pull and store more carbon from the atmosphere. We will significantly ramp up efforts to protect our natural landscapes and rural communities, and unleash their potential in the fight against climate change.

With emerging technologies, we will pull carbon dioxide from the air and put it to use to make clean fuels and new materials — creating entire new industries. California's Low Carbon Fuel Standard offers one proving ground for these technologies and industries. We need a mix of new policies, including financial

and regulatory incentives, to move rapidly from the laboratory to the mainstream.

Finally, we must work together. California has the will and the ability to be a test bed for innovation, but we need collaborators to foster global action. We need to create new partnerships with cities, regions, and civil society actors to fight climate change and its ugly sibling air pollution, which together threaten the health of children and the most vulnerable in California, and all over the world.

No single approach will work everywhere. Greenhouse gases twine themselves throughout the world economy. Imposing a price on carbon through a tax or a cap-and-trade program is surely necessary, but a carbon price alone does not make car companies build cleaner cars, oil companies provide cleaner fuels, builders construct low-carbon buildings, landfill operators limit methane leaks, or industries transition away from hydrofluorocarbons. Indeed, the recent IPCC report highlights that a mixture of regulations with carbon pricing offers the lowest cost and quickest path to deep decarbonization.

California does not have all the answers, but we have built a model that demonstrates how addressing climate change and growing the economy can reinforce one another. We are on the path and will keep forging ahead, all the way to zero.

**Mary Nichols** is chair of the California Air Resources Board, where she oversees the state's efforts to improve air quality and fight climate change.

# The Grid Is a Force Multiplier for Decarbonization

By ANNE PRAMAGGIORE

Deep decarbonization is no pipe dream. But it demands a focus on the most powerful lever for transformation in our energy system: The electric grid.

Electricity is responsible for 28 percent of U.S. greenhouse gas emissions. Much of the rest comes from other sectors now powered by fossil fuels. But vast swaths of these sectors can be electrified.

As the electricity system gets cleaner, so too does every car and appliance connected to it. The integrated and networked grid that delivers this electricity can be a decarbonization force multiplier.

In an era dominated by platform businesses, the electric grid is the ultimate platform: capable of rationalizing assets, matching consumers and producers of energy, and animating new markets.

A decarbonized electricity system requires more affordable carbon-free resources and energy storage technologies with expanded capacity. We are on our way. Twenty percent of U.S. electricity demand is already met by carbon-free nuclear energy, and the prices of solar, wind, and storage are all down more than 70 percent since 2009. The size of the global energy storage market is projected to double six times over by 2030.

But accelerating these trends — in the most optimally economic and socially equitable way — will require even more ambitious and creative policymaking.

In this energy transformation, technology may lead, but policy rules. Decisions made by policymakers and regulators will direct hundreds of billions of dollars in capital investment and determine whether

deep decarbonization is achievable in the time frame our climate challenge demands.

Let's be clear about what's required: We are reinventing and redesigning the energy system that fueled the U.S. economy and our quality of life in the last century to ensure the success of our nation's economy and quality of life in the 21st century. If the United States gets it right, we can be a model for the world.

An economic, equitable, and ultimately carbon-free reinvention requires more connection, not less. We need the power of networks. We need to drive change at scale. In a world where more power sits on roofs and batteries sit in basements; where there are more electric vehicles on the road; and where power is coming from and going to many different places, the grid becomes the most important platform in the economy.

The policy to spur this energy reinvention is tough. The politics can be even tougher. Witness the street protests that wracked France last year over the government's proposed fuel tax increase. One way to mitigate this kind of backlash could be returning funds raised from a national carbon tax back to the public as a dividend. Exelon announced our support for such a proposal last year.

Many states and cities have committed to reduce carbon emissions 80 percent by 2050 and are taking varying regulatory approaches to get there. California has relied on policy mandates to incentivize the transition to renewables, smart grids, and distributed energy resources. New York has relied more on market incentives. Illinois's approach falls somewhere in between.

Each state will find the model that works best for its citizens. But every state should see the grid as indispensable to its decarbonization goals.

Exelon has developed a multi-step maturity model that envisions

the evolution of the grid from the starting point of functional modernization to a future where the grid is the essential connective tissue for communities taking on the inter-related challenges of climate change, economic development, and improved quality of life.

Many utilities — empowered by innovative regulatory frameworks — have already made the foundational investments in smart-grid infrastructure to progress through the first two stages of this model: modernizing for reliability and improving resiliency and security against threats like cyberattacks and extreme weather events.

Now, a new wave of policy innovation is needed to enable utilities to take the next steps to expand customer choice and accelerate the adoption of distributed resources — and to achieve decarbonization through growing amounts of carbon-free supply resources and more rapid electrification of transportation and manufacturing.

When Thomas Edison devised a power-distribution system for lighting bulbs in millions of homes, he remarked there “was no precedent for such a thing.” Over 100 years later, the IPCC described our climate challenge in similar terms, saying it requires a scale of economic and societal transformation with “no documented historical precedent.”

Over a century ago, the right technology and policy enabled us to invent a new energy system. Today, with the right technology and policy, we can reinvent it, to achieve deep decarbonization.

**Anne Pramaggiore** is the senior executive vice president and CEO of Exelon Utilities, with responsibility for electricity and natural gas for approximately 22 million people in Illinois, Pennsylvania, Maryland, the District of Columbia, Delaware, and New Jersey.

## A Transition in Energy Use Is a Moral Imperative

By MIKE QUIGLEY

It didn't take the recent release of the fourth National Climate Assessment or the Intergovernmental Panel on Climate Change's latest report to alert us to the not-so-slowly unfolding ecological and economic catastrophe that is anthropogenic climate change. I've witnessed these impacts firsthand through my climate change tours in our national parks. Anyone observing the world and following the science with even a shred of intellectual honesty has long known the dangers that a rapidly warming world presents to modern civilization, and supporting ecosystems, around the world. It has become even clearer that the transition to a climate-resilient, low-carbon economy is a moral imperative.

Recent enthusiasm behind the concept of a Green New Deal, a massive legislative effort to create clean energy jobs, modernize the electric grid, decarbonize the transportation sector, and transition to renewable energy sources, stems largely from dissatisfaction with the federal government's response to the climate crisis, especially during the Trump era. In addition to his withdrawal from the Paris Agreement and roll-back of keystone protections for clean air and water, President Trump has spent an inordinate amount of time and money propping up shrinking fossil fuel industries at the expense of good-paying jobs in clean energy. He has been a singularly damaging figure, standing in the way of responsible environmental stewardship and improved public health.

But bad environmental policy did not start in 2016. Congress has long been an impediment to a proactive approach, and the Republican Party's hostility to even the most marginal

action to reduce emissions is both irresponsible and dangerous. However, the new Democratic House majority is in a strengthened position to stop the current backsliding on environmental protection and clean air regulation.

It is my hope that the recent dire reports of coming climate impact help galvanize the energy needed to achieve a sweeping, economy-wide policy solution: namely, pricing carbon.

Taking a free market approach to emissions reductions, and supplying regulatory certainty by putting a price on carbon pollution that reflects its social cost, is the most effective way to deal with greenhouse gasses across the economy. It lets firms find the emissions solutions right for them. Perhaps more importantly, a carbon price makes the costs of climate change more real and more relevant, which will undoubtedly inform consumer choice and inspire behavioral change from the world's largest emitters. If consumers start making purchasing decisions based upon the global impacts of those purchases, we'll see the economy reform much more quickly than through regulation.

Luckily, pricing carbon isn't the only solution on the table.

As we continue to produce greenhouse gases at an unsustainable pace, the likelihood that we will need to rely on technology to help dig us out of this mess increases. Through its annual appropriations, Congress, frequently in a bipartisan fashion, has provided substantial funding for crucial R&D programs within the Department of Energy. These include the energy efficiency and renewable energy office and ARPA-E, the energy equivalent of the Pentagon's advanced innovation incubator that spawned, among other things, the internet.

More focus on fostering innovation is needed, and the public sector is best positioned to make the investments necessary to get that done. With government support, private companies have led the way on inno-

vations like direct air carbon capture, grid efficiency, and clean power generation to great effect. U.S. emissions have successfully decoupled from GDP growth, thanks in large part to a reduction in power consumption despite an increase in the number of users.

Perhaps more than any other potential innovation, improved energy storage can revolutionize our approach to climate change. Battery technology has only improved at the margins for nearly a generation, but significantly improved storage can open the door to massively scaling up of variable power generation sources like wind and solar, make electrification of the transportation sector more viable, and provide the energy reliability that proponents of fossil generation claim only resources like coal can provide.

One of our most important assets in the fight against climate change is our ability to attack the problem from multiple angles at once, and improved technology is an important piece of the puzzle.

It should be abundantly clear that we are well past the time for equivocation and inaction on climate change. 2018 was an abject failure in both policy to address the climate crisis and in real-world emissions reductions to combat it, both in the United States and globally. We cannot afford another year like that. Behavior change, perhaps spurred by a price on carbon, is the ultimate goal and the long-term solution, but technological advancements, funded by Congress and overseen by scientists and inventors in the federal government, can give us more time to take the steps needed to curb emissions in the direction of a low carbon, high-growth economy.

**Representative Mike Quigley**, a Democrat from Illinois's fifth district, is vice chair of the House Sustainable Energy and Environment Coalition. He sits on the Interior, Environment, and Related Agency Subcommittee.