Science Policy Snapshots

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FAS Federation of American Scientists

These Congressional Science Policy Initiative (CSPI) Science Policy Snapshots expand upon seven different scientific exchanges between Congressman Bill Foster (D, IL-11) and his new FAS-organized Science Council.

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July 2021

Police misconduct and violence: Let the data talk

Limited insight into police misconduct makes it difficult to improve policing, but a national registry could help

Police misconduct and violence have vaulted to the forefront of the national discourse on civil rights and safety. Researchers have found that Black people are three and a half times more likely to be killed by police when not holding a weapon, or not attacking, than white people. Tragically, one out of every thousand Black men in the U.S. will be killed by police violence.

While the removal of offending police officers from their positions would be a straightforward solution, it is rarely easy to permanently expel bad actors from police departments. Yale researchers found that police officers who are fired for misconduct from one department are often hired by another department within three years. These officers also tend to move to smaller departments that serve communities with greater numbers of people of color. To make matters worse, these officers' bad behavior can spread through the departments in which they work. For example, as depicted in Figure 1, officers involved in excessive force complaints were more likely to work with officers with histories of similar complaints. Because of this behavioral trend and the difficulty of removing transgressive officers, it is unsurprising that law enforcement misconduct and violence remains largely unresolved by police departments or policymakers.

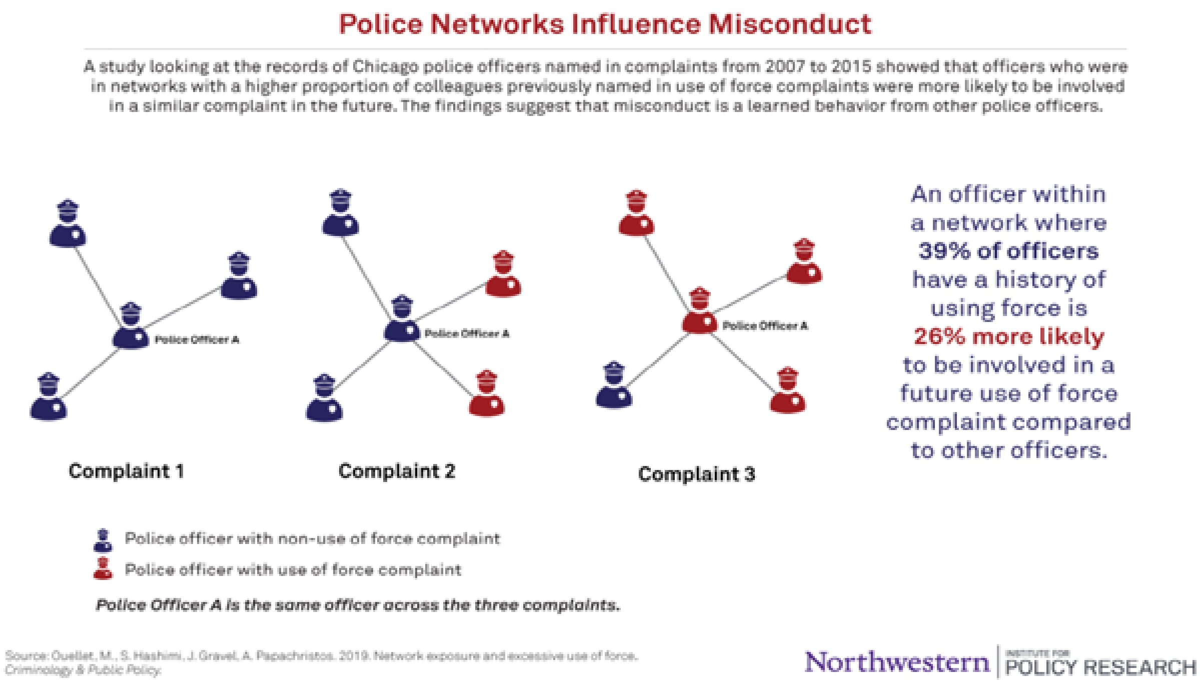

Figure 1. Officers with use of force complaints on their records can set a trend of behavior in their departments where other officers become more likely to receive use of force complaints in the future. Figure reproduced from Ouellet, Hasimi, Gravel, and Papachristos 2019, Criminology and Public Policy.

To keep harmful police misconduct from spreading throughout new police departments, some researchers and policymakers suggest developing a national registry for police behavior. This independent registry would catalogue misconduct among police officers and be available for policymakers and police department leadership to use for decision-making about hiring, training, or policing duties. Currently, a less comprehensive National Decertification Index records officers who have engaged in misconduct severe enough to lose their state policing certifications—typically a requirement to work in a police department. The goal of the Index is to prevent former police officers who were guilty of misconduct from being rehired without their new departments knowing about their prior misconduct. Unfortunately, there is a significant amount of police misconduct that does not result in decertification, such as illegal searches and use of excessive force, but that is still important to track. Tracking all police misconduct in a national registry for police behavior could serve as a significant resource in the effort to reduce destructive policing practices.

However, a national registry of police behavior would face several challenges. For example, each police department has different protocols for complaint records. And even when officer misconduct is reported and addressed by the community, recommendations from civilian review boards on officer misconduct are adopted infrequently. Police unions can also create obstacles to weeding out bad actors in police departments. For a national registry of police behavior to be maximally effective in helping to reform policing, additional measures need to be taken in parallel.

Policymakers, community members, and police departments are exploring policy options for policing, and national registries of misconduct and complaints could help indicate trends of behavior in officers, aiding decision-makers in their pursuit of more just policing systems.

Empowering healthy eating in America

Poor diets present elevated health risks, and Americans need help finding the time and resources to eat nutritiously

Americans get bombarded with promotions for unsubstantiated diet fads on the internet, are exposed to dubious weight-loss branded foods in grocery stores, and often struggle to eat nutritiously. The Dietary Guidelines for Americans recommend a balanced diet of two and a half cups of vegetables, two cups of fruit, six ounces of grains, three cups of dairy, five and a half ounces of protein, and 27 grams of oil every day. This diet is well-balanced, but it is neither practiced by, nor accessible to, all Americans (Figure 1).

Increasing numbers of Americans do not eat healthful diets. In 2018, the National Health and Nutrition Examination Survey found that one in three Americans eats fast food on any given day. Moreover, both rural and urban Americans report that lack of time and access to nutritious foods prevents them from cooking healthy meals. Indeed, a 2017 study indicated that the higher prices of healthy foods—nearly double those of unhealthy foods—can play a role in the U.S. population's failure to achieve a nutritious diet. When healthy food cost even

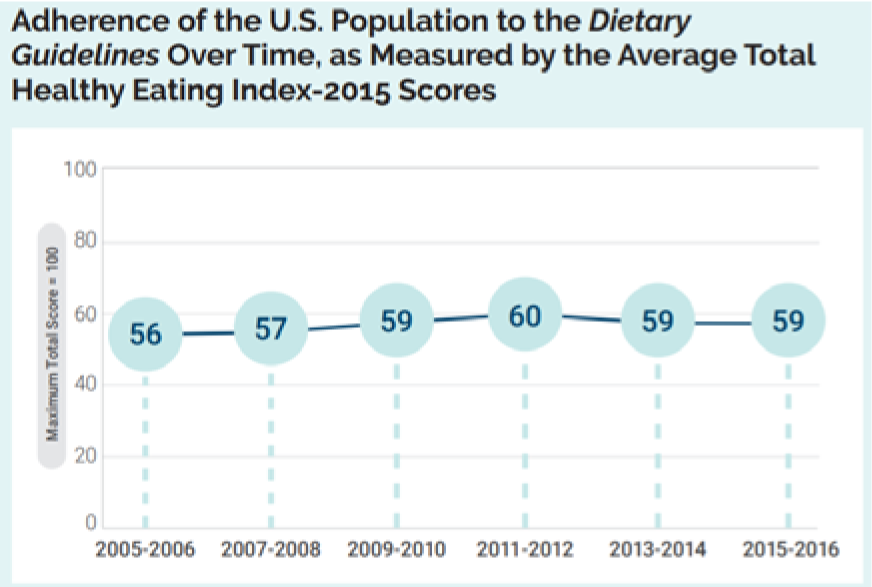

Figure 1. On average, people in the U.S. score between 56 and 60 (out of 100) when evaluated for healthy eating. The maximum test score of 100 points indicates adherence to the American Dietary Guidelines. Figure reproduced from Dietary Guidelines for Americans, 2020-2025.

14 percent higher than unhealthy food, there was a 24 percent decrease in consuming a high-quality diet. Unfortunately, an unhealthy diet can lead to a variety of health issues, such as obesity, type-2 diabetes, heart disease, and an increased risk of some cancers. To reverse poor health metrics such as the 42.4% of American adults over 20 years of age who suffered from obesity in 2018, policymakers and health experts alike hope to make healthy diets more accessible to all Americans.

To empower people to develop more nutritious eating habits, some experts recommend:

- Teaching better practices for caloric intake, which can increase life expectancy;
- Incentivizing healthy eating with financial rewards, such as coupons, when purchasing fruits and vegetables;
- Teaching and encouraging adults to buy and prepare their own meals; and
- Enabling mutual aid initiatives such as community fridges, food banks, and free breakfast programs for those who are food insecure.

For some, the transition to eating a well-balanced diet will require learning how to cook, carving out time to prepare meals, or gaining an understanding of the nutritional value of various foods. In the U.S., there is no justifiable reason people should not be supported by their local, state, and federal governments in efforts to eat healthy.

To improve American dietary habits, policymakers can learn about and implement public health initiatives for nutritional education, as well as break down systemic barriers to healthy eating lifestyles.

Extending human life with senescent cell treatments

Research into senescent cells could result in extended human lifespans and significant policy implications

Improved housing, sanitation, and healthcare have significantly increased humans' life expectancy, and biomedical advances have the potential to further extend people's lives. The life expectancy of a person born in 1860 was only about 39 years; a person born today can expect to live about 79 years. Now some researchers are studying whether altering humans' senescent cells could increase lifespans to an even greater extent.

Cellular senescence—a process by which cells stop replicating after a set amount of time—is vital to prevent devastating cancers, but also contributes to age-related diseases. Every time a cell replicates, its DNA accumulates a low number of errors. If cells replicate unchecked, these errors can snowball, forming masses of non-functioning cells that damage healthy tissues. For example, the cells responsible for malignant cancers, which can be deadly, do not show any sign of senescence. On the other hand, senescent cells, which are alive but no longer dividing, can build up in a person's tissues, release harmful chemicals, and contribute to age-related health issues.

Reducing the numbers of senescent cells in peoples' bodies could extend human lives. Studies in mice have shown that removing senescent cells can help mice live longer and maintain their physical abilities. Treated mice lived, on average, 36 percent longer than mice that retained senescent cells. Furthermore, old mice given a drug that reduces the number of senescent cells were able to survive COVID-19 in significantly higher numbers than old mice not given the drug. While these results are promising, whether the results can be reproduced in humans is an open question. Some early trials in humans testing drugs that reduce populations of senescent cells are targeting specific diseases, such as age-related macular degeneration, glaucoma, and chronic obstructive pulmonary disease.

If it becomes possible to further diminish the effects of aging over the next few decades, there would be substantial policy implications. For example, greater longevity could mean older Americans experience longer periods of dependency on their families or the government, increasing retirement and medical costs. People might also stay healthier for longer, which may necessitate an increase of the retirement age. As this research into human longevity matures, it is important that policymakers consider the fiscal, legal, and medical implications of extending human lives.

Safeguarding benchtop DNA synthesis

Benchtop DNA synthesizers could become more ubiquitous, and it's up to policymakers to chart the way forward

The genetic blueprints for humans, plants, disease-causing bacteria, and all other living things are written in DNA, and machines capable of synthesizing DNA are becoming more accessible to potential users. Benchtop DNA synthesizers promise to increase the speed and efficiency of research in academic and industrial laboratories; however, it will be critical to incorporate safeguards into benchtop machines to prevent the printing of DNA sequences that would be used for harmful purposes. Researchers should be permitted to operate a benchtop DNA synthesizer to, for instance, make genetic material that is then used by a microbe to build a biofuel. But, aside from research conducted by pre-approved specialists, printing DNA that codes for deadly agents like the ricin or diphtheria protein toxins, for example, should be prohibited. As instruments capable of small-scale, rapid-turnaround DNA synthesis are already starting to enter the market, policymakers may be faced with a new era of democratized DNA synthesis, and should grapple with how to maximize the benefits of this technology while minimizing potential harm.

A National Academies of Sciences, Engineering, and Medicine report speculated that by 2027, individuals both with and without formal scientific training would be rapidly prototyping and developing biological designs and products. In both institutional and DIY contexts, there are protections that could be put in place to drastically reduce the likelihood of the misuse of benchtop DNA synthesizers. For instance, a January 2020 report from the World Economic Forum, crafted in collaboration with the Nuclear Threat Initiative, recommends that benchtop DNA synthesizers:

- Be sold to and accessed by only legitimate, validated users;
- Incorporate a mechanism that compares DNA sequences entered into the machine for synthesis to a database of pathogen and toxin DNA sequences before DNA strands are printed;
- Allow synthesis of potentially hazardous DNA only for users preauthorized for such sequences, and prohibit the synthesis of pathogen or toxin DNA requested by unauthorized actors; and
- Be used by individuals who have received training in biosafety and biosecurity.

Before efficient benchtop DNA synthesizers become even more ubiquitous, decision-makers have an opportunity to craft forward-thinking policies that both (i) protect the technology from misuse and (ii) promote its potential to advance human health, a cleaner environment, and many other public goods.

DNA for data storage and retrieval

To reduce the burden on traditional data centers, improving on DNA data storage could be the key

The pace at which data—such as photos, videos, and social media posts—are being generated is ramping up drastically, exceeding the scaling limits of traditional silicon-based data storage technologies, and DNA could be deployed to help meet this challenge. As an indication of the massive amount of data storage that may be required, one model predicts that by the year 2030, electricity use by data centers could approach about eight percent of total global electricity demand. New paradigms for data storage, such as the use of DNA for preserving information, are necessary.

DNA is genetic material that contains plans for the design of living things, but DNA can also be used to store data created by living things. DNA is an attractive material for data storage—it is stable, writable, readable, and information dense. In theory, the entire world's data could be stored in a coffee mug-sized portion of DNA.

So how does storing, for example, a video, in DNA work? (See Figure 1.) First, an algorithm is used to encode the video into the As, Ts, Cs, and Gs that make up DNA molecules. The DNA molecules are then synthesized, and stored. To access the data, the DNA molecules would be sequenced, and the DNA sequences translated using the same algorithm, reproducing the video.

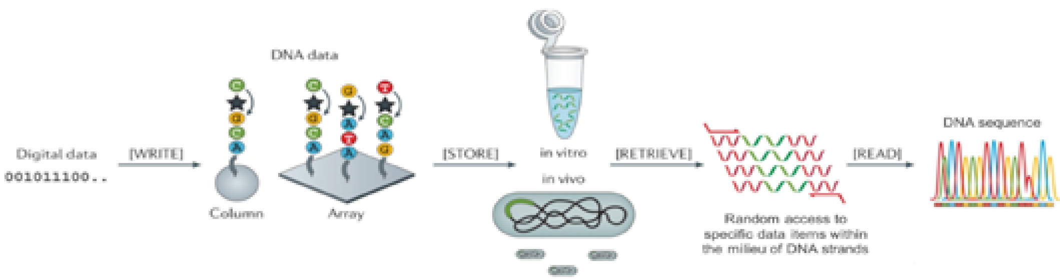

Figure 1. Data storage and retrieval in DNA. First, data—like those stored on a computer hard drive—are processed by an algorithm that translates 1s and 0s into DNA sequences made up of As, Ts, Cs, and Gs. DNA strands with those sequences are then synthesized—or written—and stored either in living cells (in vivo) or in the test tube (in vitro). Data can be retrieved from storage in part by using PCR—the same technology deployed to test for the coronavirus that causes COVID-19—to selectively target specific data packages. The PCR products can be read with DNA sequencing instruments, providing the original DNA sequences, and reproducing the data. Figure adapted from Ceze, Nivala, and Strauss 2019, Nature Reviews Genetics.

DNA is a polymer—a substance consisting of a high number of similar building blocks that are linked together—and other polymers can be used to store information, too. For example, plastic polymers are being explored for information-storage applications; one group synthesized a plastic polymer that, when read out, reproduced a quote by Jane Austen. By expanding experimental development efforts into (i) increasing the rates at which DNA can be synthesized and sequenced and (ii) detecting and correcting for errors in DNA synthesis, and by pursuing fundamental research into data storage across a variety of polymers, it is possible the U.S. science and technology enterprise could devise a polymer-based method for rapid data storage and retrieval, and meet the data storage challenge.

Digital IDs for securing personal information

Digital driver's licenses can offer greater protection of personal information, and some states are already skipping the line at the DMV

From submitting personal information over email to scheduling telehealth appointments, safe and verifiable forms of personal identification are crucial. While physical driver's licenses are standard, they can be stolen or forged. To improve security and ease of use, some states have developed digital driver's license programs, and even the federal government has signaled its interest in digital IDs. The most common form of digital ID—a mobile driver's license, or mDL—allows the license holder to authorize the sharing of only those personal details that are absolutely necessary for specific types of transactions. For example, when purchasing alcohol at a liquor store, a mDL could show only a person's name and age, and hide other personal information, such as an address, and even an exact birth date. Furthermore, forging digital identification is more difficult than forging traditional ID because of public key cryptography, where virtual information, in this case a driver's license, is encrypted, and can only be decrypted through a virtual verification system that authenticates the ID. This technology is more advanced than the barcodes used to verify identification on traditional driver's licenses. These systems can help prevent forgery and reduce underage purchases of products such as alcohol and tobacco.

Beyond typical uses of physical driver's licenses, mDLs could be helpful in the healthcare and finance sectors. Applying digital identification to patient records can increase the accuracy of electronic health records, and also make medical records more accessible to patients. A streamlined authentication process enabled by digital identification can improve banks' fraud management and support their compliance with verification guidelines that foster financial companies' abilities to identify their customers as potential money laundering risks. Deploying verified forms of digital identification can improve users' experiences and modernize operations for institutions moving toward digital services.

Given the success of mDLs in states like Illinois, Oklahoma, and Louisiana, Congress is laying the groundwork for the widespread adoption of digital identification. In Louisiana, drivers can get a mDL by paying $5.99 to download the LA Wallet app, and since the app's launch in 2018, it is being used by 670,000 residents—nearly 20% of all Louisiana drivers. Louisianans can also upload their COVID-19 vaccination status into the app, or verify their identities when registering for the Disaster Supplemental Nutritional

Assistance Program in the wake of a hurricane. LA Wallet is the first mDL app legalized by a state government, and Louisiana has set the standard for how mDLs could operate nationally. In December 2020, Congress passed the REAL ID Modernization Act, which updated federal identification guidelines, authorized the use of electronic driver's licenses, and established the beginnings of protections against unwarranted smartphone seizure by law enforcement when using a mobile identification app. The act gives states a deadline of October 1, 2021 for all Americans to be issued a REAL ID-compliant driver's license, which can be switched to a REAL ID-compliant mDLs.

These proposed digital solutions for identification are not without their downsides. mDLs have been flagged by civil society groups, like the American Civil Liberties Union, that are raising concerns about surveillance risks. One such risk is unwarranted police access to non-ID content on phones when mobile driver's licenses are presented to police officers during traffic stops. Another risk is that because the licenses would be linked to the Department of Motor Vehicles and an app developer, the issuer or verifier could use their direct access to personal information, such as where people are shopping or visiting, for unlawful purposes—like the federal government observing and prosecuting activity, such as purchasing marijuana, that is legal in a particular state. Additionally, if this technology becomes a legal requirement rather than an opt-in choice, it could further disadvantage people in vulnerable communities who do not own smartphones.

A mDL is just one option for more secure identification systems, and in order to make mDLs widely available, issues such as (i) having reliable internet access to use the app, (ii) the affordability of smartphones should mDLs become required, and (iii) the guarantee that user information is secure from unauthorized tracking must be addressed before a federalized system is put in place.

Countering climate change with renewable energy technologies

Renewable energy technologies, such as advanced biofuels for transportation, are key for U.S. efforts to mitigate climate change

Climate change is bringing about rising temperatures, which have significant negative impacts on humans and the environment, and transitioning to renewable energy sources, such as biofuels, can help meet this challenge. One consequence of higher global temperatures is the increasing frequency of extreme weather events that cause massive amounts of harm and damage. As depicted in Figure 1, six of the 10 costliest extreme weather events in the U.S. have occurred in the last 10 years, amounting to over $411 billion in damages (in 2020 dollars and adjusted for inflation). The other four occurred between 2004 and 2008, and the costs of future extreme weather events are expected to keep climbing.

Moreover, the World Health Organization estimates that, globally, climate change is responsible for over 150,000 deaths per year. This is because in addition to extreme weather

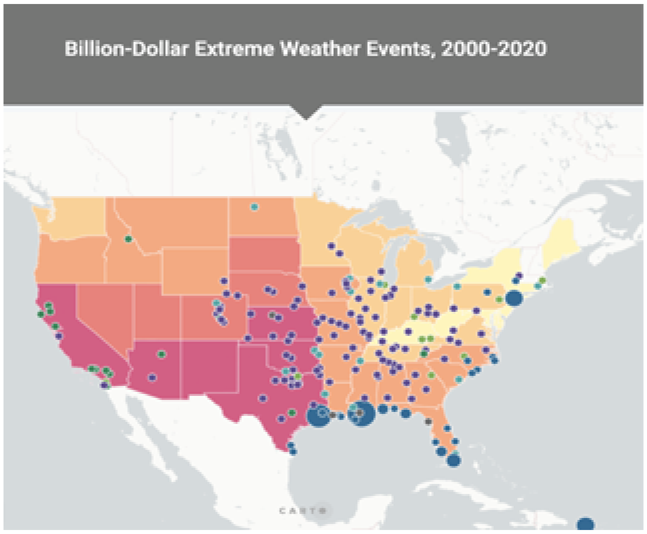

Figure 1. U.S. extreme weather events from 2000 to 2020 resulting in at least $1 billion in damages. Figure adapted from an interactive Center for Climate and and Energy Solutions tool.

events, climate change contributes to the spread of diseases, reduced food production, and many other problems. Transitioning to renewable energy, and reducing reliance on fossil fuels, is one way to help slow down the effects of climate change. While renewables used to be a more expensive option, new clean energy technologies are lowering costs and helping to move economies away from fossil fuels. For example, solar panel prices decreased 75 to 80 percent between 2009 and 2015. Due to similar trends in other renewables like wind and hydropower, renewable energy generation technology accounts for over half of all new power generation capacity brought online worldwide every year since 2011.

More must be done to ensure that renewable energy technologies are key contributors to the mitigation of climate change. As of 2018, solar and wind accounted for less than 4% of all the energy used in the U.S. (Figure 2). The amount of energy generated by solar panels has increased almost 46-fold since 2008, but still only amounts to about 1% of the total energy generated in the country. Unfortunately, renewables currently provide only a small fraction of the total energy produced, and to counter climate change, this contribution must drastically increase.

Nonrenewable sources are still frequently used because they are very dense in energy. In the transportation sector, for example, gas or diesel fuels have about 40 times more energy, pound for pound, than the leading electric battery technologies. In order for an electric car to travel 360 miles, which is the average distance traveled on a full 12.4 gallon tank of gas, the car would need a battery weighing over 1,300 pounds.

To reduce reliance on petroleum-based fuels, particularly for heavy-duty vehicles and airplanes, one potential solution is biofuels. Biofuels are produced by breaking down plant material and converting it into usable

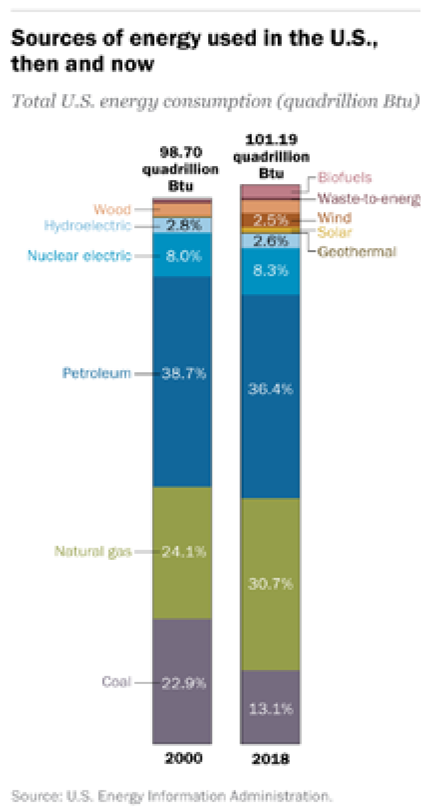

Figure 2. Sources of energy used in the U.S. during the year 2000 and the year 2018. Figure reproduced from Desilver 2020, Pew Research Center.

fuels, such as ethanol or biodiesel. Corn ethanol is already added to gas to cut down on greenhouse gas emissions. However, creating ethanol is not a zero-carbon process, and supplementing with corn ethanol averages just under 40 percent lower carbon emissions than using only gasoline. Corn ethanol also relies on land which could be used for growing other food crops. Researchers are currently studying how to use invasive plants, as well as plants that require little water, fertilizer, or land to grow, to create the next generation of biofuels. Some promising plant feedstock options include hemp, switchgrass, carrizo cane, jatropha shrubs, and algae. New biotechnologies are also being studied to develop more efficient ways to break down biomass into sugars, which microbes then convert into biofuels. There is also ongoing research to create microbes that can directly convert plants to biofuels, and to enable microbes to produce long-chain, energy-dense hydrocarbons that could be used to fuel heavy-duty vehicles and airplanes.

The Information Technology and Innovation Foundation developed several recommendations which could bolster the implementation of biofuels. These recommendations include:

- Increasing investments in bioenergy and biomanufacturing research and development by 150 percent by the next five years;
- Engaging the Department of Energy and the Department of Agriculture to support the development of biofuels for aviation, shipping, and “other hard-to-electrify transportation sectors;” and
- Expanding research into gene-editing tools that can be used to improve biomass processing, increasing the diversity of plant feedstocks that could be leveraged for lower-cost biofuel production.

By improving the efficiency of renewable energy technologies like biofuels, wind, and solar, and further innovating in the renewables space, the U.S. science and technology community can help ensure that renewables are leveraged in the effort to counter the climate crisis.