Low-carbon strategies for utility end-use sectors

Exploring the impacts—and upsides—of building and transportation electrification

By Bill Prindle and Deb Harris, ICF

Introduction

To do their part in solving the climate crisis, the energy utilities through which most of us get our electricity and natural gas are increasingly challenged to reduce their GHG footprints while also modernizing for greater flexibility, reliability, and resilience. Stakeholder and customer pressure, mandates, incentives, and other business imperatives are pushing them to help customers save energy and reduce emissions, increase clean energy supplies, and become more flexible by adding renewable and distributed resources to their systems. And because these are mostly regulated companies, they face additional constraints that must be considered in forming their strategies.

These forces are driving unprecedented changes and new investment in the nation's energy utility supply, distribution, and usage infrastructure. Industry data indicate that total investor-owned utility assets are valued at well over $1 trillion, with a significant fraction of this value invested every year in new or updated infrastructure.

As industry veteran and ICF senior energy fellow, Val Jensen, wrote about electric utilities in a recent paper: "Even if customers purchase their electricity from alternative suppliers, it is still delivered over the utility's wires, measured with its meters, and, in most cases, billed along with the costs for distribution and transmission service. These unique sets of connections position the utilities as a cornerstone of essential community infrastructure."

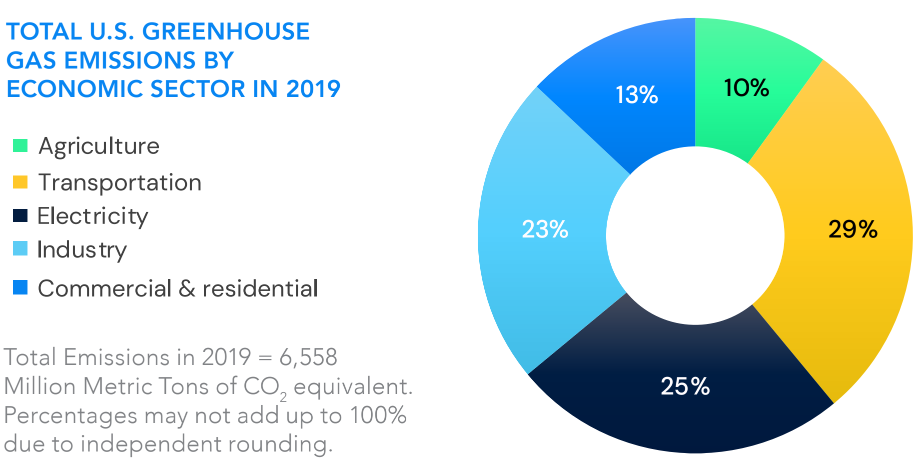
Natural gas utilities that provide a different form of energy face their own set of challenges. Natural gas use has grown in recent years; currently, natural gas utilities deliver energy to about **70.4 million residential households** and **5.5 million commercial accounts**, **representing about 50% of U.S. residential and commercial buildings**. Natural gas utilities also deliver much more energy to the buildings sector during peak periods than is delivered by the electric grid. Between 2016-2020, peak monthly deliveries of **natural gas were 50% higher than peak** monthly deliveries of electricity on a Btu basis.[1]

This paper takes a closer look at two of the key end-use sectors that utilities serve: buildings (which consume most of the nation's utility energy supply) and transportation (which is almost entirely petroleum-fueled today, but is ripe for electrification). We also discuss the customer engagement and load flexibility strategies that can make the impacts of decarbonization in these sectors positive for utilities and their customers.

A tale of two sectors

When looking at total U.S. emissions, two of the most carbon-intensive sectors include transportation (especially road transport) and residential and commercial buildings (lighting, heating and cooling, cooking, and other appliances). In EPA's national emissions inventory, buildings are a lower source of GHG emissions than transportation when evaluating direct fuel consumed. But if we account for the emissions associated with the electricity used in buildings and for transportation, the buildings sector actually exceeds the transportation sector in total GHG emissions. Both sectors are ripe for low-carbon solutions, including electrification, the use of low-carbon fuels, and improvements in efficiency, but a closer look reveals key differences in the solution sets. In this paper, we focus primarily on electrification, while also noting that low-carbon fuels will be needed to some extent in both sectors.

TOTAL U.S. GREENHOUSE GAS EMISSIONS BY ECONOMIC SECTOR IN 2019



Total Emissions in 2019 = 6,558 Million Metric Tons of CO_2 equivalent. Percentages may not add up to 100% due to independent rounding.

[1] Based on EIA data, the highest monthly residential and commercial electricity consumption over the last five years was 292,901 Million KWH, or 999,378 MMBtu in July 2020. The highest monthly residential and commercial natural gas consumption was 1,535,246 MMcf or 1,592,050 MMBtu in January 2018.

Transportation

The single biggest direct source of GHG emissions in the U.S. is the transportation sector (on-road and off-road vehicles, aviation, marine shipping, passenger, and freight rail), which accounted for **roughly 29% of the country's annual carbon emissions in 2019.** Therefore, electrifying as much transportation infrastructure as possible will go a long way toward meeting net-zero pledges.

The most prominent piece of good news is that there is a growing coalescence around electrification for personal vehicles in the transportation sector. Transportation is a leading candidate sector for electrification because once electric vehicle (EV) costs reach parity with internal combustion vehicles, EVs will become the preferred choice in the market. A number of automakers such as GM and Jaguar have already announced plans to go all-electric by 2035. Additionally, transitioning to electric vehicles as compared to gasoline vehicles provides immediate GHG reduction benefits and local air quality benefits.

The Biden administration has committed to supporting electric vehicles, by electrifying the entire federal fleet and by supporting EV charging infrastructure deployment.[2] It's possible that future fuel economy standards the administration promulgates could also support electrification. Passenger EVs typically get over 100 miles-per-gallon equivalent, more than four times the U.S. passenger fleet average fuel economy today. So if fuel economy standards increase significantly, EVs will become a preferred option for automakers to meet their fleet average requirements.

Fleet vehicles are also a prime target for low-carbon solutions: they are typically owned by government organizations (including school districts) or private entities such as delivery giants UPS, USPS, and FedEx. Because fleet vehicles tend to have centralized storage facilities, this simplifies the logistics and costs of charging infrastructure. And because many fleet vehicles have predictable routes and hours of use, utilities can work with fleet owners to establish charging schedules that optimize both owner and utility operations and costs. Many utilities are already working with school districts, for example, to help purchase electric buses and install charging infrastructure.

Public transit is also an important part of the equation. According to a recent article on Bloomberg, public transit "maximizes people movement, reduces congestion, and will still be significantly less energy intensive per passenger mile than cars even when individual vehicles are electrified." The administration's new American Jobs Plan proposes $85 billion in new federal spending to upgrade and expand our transit systems.

Impacts on utilities

Electrifying transportation mainly affects electric utilities, as very little of the current transportation fleet or infrastructure depends on natural gas utilities. In this sense, EVs are not shifting energy use from gas utilities to electric utilities, but rather are shifting energy use from the oil industry to the electricity industry.

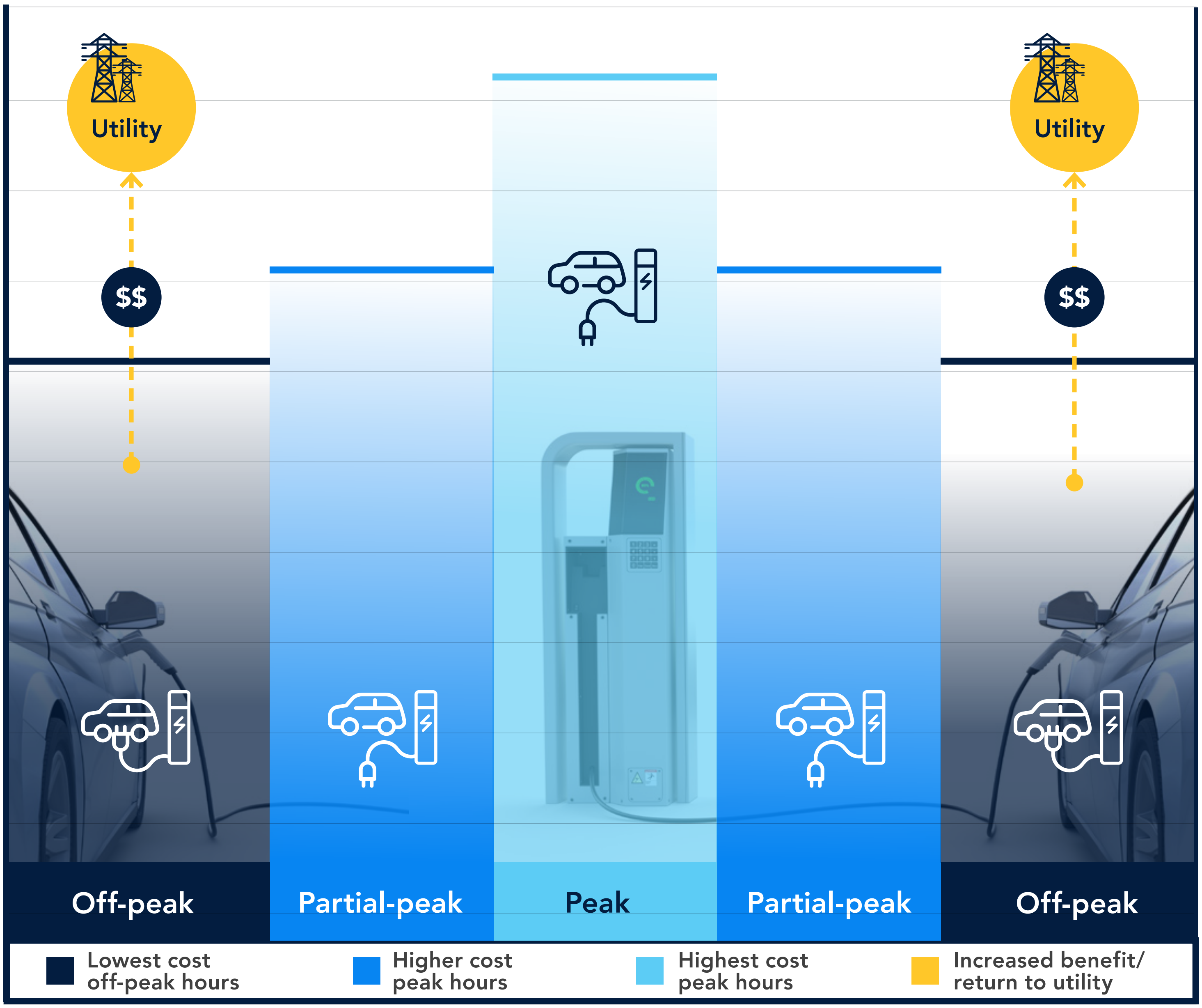
It's also true that EV loads on the grid can be shaped to some extent, and this shaping would be relatively easier than in the building sector. Because EV infrastructure is still in its infancy, utilities can play a major role in shaping EV electric loads. Much depends on the timing and the power demand intensity of EV charging patterns:

- For households with home chargers, personal vehicle charging typically involves Level 1 chargers, which run off standard 110-volt household current, or Level 2 chargers, which usually take a dedicated 240-volt circuit similar to an electric range or dryer. Utilities can offer electric rates or other program options to encourage customers to charge their cars in off-peak hours in order to reduce the impacts on system peak demand.
- Public charging at parking or fueling facilities may involve Level 2 and/or Level 3 chargers. Level 3 chargers use substantially higher voltages and offer shorter charging times but are also much more expensive. They typically require specific utility connection hardware to support their operation. If Level 3 chargers operate during utility peak hours, they can impose substantial peak load challenges—potentially requiring expansion of the grid if such charging facilities reach critical deployment levels.

[2] https://www.forbes.com/svites/stacynoblet/2020/07/26/building-out-electric-vehicle-charging-in-the-west-means-all-hands-on-deck/

- Fleet charging, typically at dedicated fleet facilities, is more likely to be able to be shaped to fit preferred utility load profiles. It may also be linkable to energy storage battery systems, further increasing grid flexibility.

The hope is that EV charging can be accommodated with limited impact on utility grids, such that EV loads fill "valleys" in current utility load curves. If utility power throughput increases without imposing too many new costs to expand the system, that can help moderate electricity rates. If EV loads can be added to the grid in this way, vehicle electrification can become a big win-win: customers get low-emission vehicles that cost less to buy and run, and utilities get new loads that don't increase grid costs to the overall customer base.



Transportation electrification will have a direct impact on utilities as it increases their need to consider more grid hardening and resilience upgrades. These are any number of actions taken by utilities to minimize the consequences of extreme events (weather and otherwise) and protect utility customers from outages. If the result of these efforts is fewer blackouts, that will reassure customers that they will not be stranded by—and businesses and agencies will still be operative during—large-scale power outages.

Buildings

Residential and commercial buildings present a somewhat different decarbonization picture. **While direct GHG emissions from onsite combustion in furnaces, boilers, and water heaters account for about 13% of the national total, buildings use about three-quarters of our electricity supply.**[3] Accounting for those related power plant emissions as well puts buildings slightly ahead of transportation in total emissions impact.

Reducing GHG emissions through changes in buildings' end-uses presents additional challenges:

- The long life of building stock—especially the building "envelope" that includes roofs, walls, and windows—can stay in place indefinitely, making upgrades to these basic features more expensive. Passenger vehicles, by contrast, are typically replaced within 10-15 years, creating multiple natural stock turnover opportunities over a 30-year period. This means that most of the work to be done in the buildings sector is in existing buildings.
- The economics of upgrades are more difficult in existing buildings compared to new construction; it is typically more cost-effective to optimize energy use and emissions in new building designs than to realize those savings as retrofits. Vehicles typically cannot be retrofit for electrification, but rather provide their benefits as new vehicles as the whole fleet stock turns over.
- Optimum decarbonization in buildings typically requires a bundle of efficiency upgrades, especially in building envelope measures (such as replacing windows or upgrading insulation) and new heating equipment in order to make the package more economical and to limit electric grid impacts. New vehicles, by contrast, provide both efficiency in higher fuel economy and lower emissions in a single package.
- While some existing building upgrades are very cost-effective, such as installing high-efficiency lighting and appliances, some measures present longer economic paybacks, such as installing new electric heating systems. The full range of upgrade measures are also challenging to install in a single package, but rather tend to require multiple transactions over time as various existing components and equipment are replaced. The economics of new EVs—especially as new vehicle costs approach parity with those of internal combustion vehicles—are increasingly competitive and can be obtained in single transactions.

These factors combine to make it harder to electrify and retrofit the buildings sector. Regional factors also affect the difficulty of electrifying the building stock. For example, our New York City decarbonization study revealed that a large fraction of the building stock is at least 100 years old, has older windows and little to no insulation, and has old steam boiler heating systems that are hard to electrify. Historic preservation requirements also limit retrofit options for many older buildings. By contrast, a state like California has a relatively younger building stock, and has had the strictest energy codes in the nation for over 40 years. Its building stock is comparatively easier to electrify, in part because a higher portion of the stock has ducted HVAC systems that can be electrified more easily.

Impacts on utilities

Buildings' electrification affects both gas and electric utilities because, in many if not most cases, electrification involves a reduction in end-use energy provided by gas utilities. Outside gas utility service areas, electrification typically displaces fuel oil or propane fuels. In urban areas, the tradeoff is typically a direct substitution of electricity for natural gas, with impacts on both electric and gas utilities. While in many areas gas and electric service are provided by the same company, gas and electric services frequently are provided by separate and often competing utilities.

This fuel-shifting impact creates potentially significant challenges:

- Buildings' heating electrification loads are harder to "shape" than EV charging loads. Heating loads are weather-driven, so on the coldest days, it's hard to defer heating system use, whereas EV charging can more typically be fit into a utility's daily load curve with less impact on peak demand.

[3] https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

- Because it creates harder-to-shape electric loads, large-scale heating system electrification can lead to substantial system expansion costs. In New York City, for example, our analysis shows that electrifying over half of the City's building heating systems would create a new winter peak demand for Con Edison, and a much higher overall system peak.[4] The Con Ed system would have to increase its capacity to serve those loads, potentially raising rates and straining system reliability under peak winter conditions.
- Shifting large amounts of gas usage to electricity can strain the economics of gas utilities. As their sales fall, their fixed costs have to be recovered from a smaller volume of energy consumption. This creates a potential "death spiral" where gas rates keep rising, as more and more customers are converted to electricity—and potentially imposing new cost burdens on customer populations that can least afford to pay, either for electrification or for more costly gas service. In worst case situations, gas utility systems could become "stranded assets," placing financial burdens on various parties including utility shareholders, local governments, and utility customers.

[4] https://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/Carbon-Neutral-NYC.pdf

How can utilities work with customers to shape a low-emission future?

As regulated companies with both a public service mandate and a shareholder obligation to remain profitable, investor-owned utilities face increasing pressure to support public policy goals that call for large-scale GHG emission reductions, while also adapting to changing climate conditions, providing affordable and reliable service, and seeking to balance revenues and costs. While there are a lot of pieces to this complex puzzle, many of them involve changing utilities' relationships with their customers.

In the past, utilities served a one-way purpose: provide reliable and affordable service at the lowest possible cost. The main imperative was to "keep the lights (or burner tips) on" at the lowest cost without disrupting customers' lives.

In today's rapidly changing policy and technology environment, utilities are increasingly focused on engaging customers in new ways that provide equal or greater value and quality of service, while increasing load flexibility and deploying low-carbon technologies at customers' facilities.

While this paper focuses primarily on electric utilities, we also recognize gas utilities' efforts, such as: increasing energy efficiency programming; sourcing low-carbon fuels such as biogenic methane from landfills, wastewater treatment, and agriculture; exploring "green' hydrogen using renewable electricity; and other strategies. Gas utilities are proposing alternative approaches to decarbonization that are designed to maintain the value of the gas distribution system at costs that may be lower than decarbonization approaches that rely on high degrees of electrification.

In addition to renewable power generation, electric utilities are likely to include a range of strategies, such as evolving their business models to adapt to a changing business climate or modernizing distribution grids to increase reliability and resilience—all while accommodating a wider range of clean and distributed energy resources.

Engaging utility customers to support win-win behaviors

Utilities have a long history of communicating with their customers, on topics ranging from safety to tips on winter weatherization or how to stay cool in the summer. But while that flow was mostly one-way for the utilities of old, the question in today's era—with all of its communication and control network possibilities—is to what extent can utilities effectively engage customers in large-scale behavior change? And can they sustain it over time?

Our team has helped utility clients create behavior-based program designs like rebates for reducing peak usage.

But the data also shows that customers stop participating when the required actions become too onerous or demand repeated action over too long a period. Are there options for the customer to "set it and forget it" that make it easier to automate and sustain doing the right thing?

This is where using smart technology can make a real difference. Programs that use smart thermostats let the utility make small adjustments in short increments with the customer's agreement. Similarly, utilities can work to put in place more smart charging stations and encourage more EV owners to buy their own Wi-Fi equipped smart chargers, which can send and receive signals from the meter. Motivated customers can change their behavior in response to savings offered by charging at non-peak times.

But even smarter possibilities exist in the places we work, shop, and study. While most of the focus on customer behavior programs has concentrated on residential households, the majority of electricity sales go through organizations—commercial and industrial customers.

Organizations are better equipped to collect, analyze, and track energy usage and equipment data, often using building automation systems. Enterprising organizations use this kind of data infrastructure to set up longer-term energy management programs, applying data to drive both operational efficiency and guide investments in efficient and grid-interactive technologies. Utilities can leverage these strategic energy management programs to help larger customers with data access, performance benchmarking, and analytics to support energy savings and load flexibility—not only at peak periods but over the longer term.

Improving load flexibility to help manage extreme weather events

The recent Texas winter energy crisis is an extreme example of grid resilience failure. Failures in fuel supply and power plant operations were compounded by surging customer demand, primarily from low-efficiency electric heating systems in under-insulated buildings. Even though Texas utilities have been running efficiency and load management programs for over 20 years—and the state has instituted a better energy code for new buildings—too many homes and businesses lack the kind of high-performance, flexible load capabilities that can help moderate or prevent such crises.

Climate science predicts that such extreme weather events will become more frequent and more severe, challenging utilities to evolve new strategies to become more resilient. Longer and hotter summers will raise the saturation and usage of air conditioning, while continued "vortex" winter events will drive new winter peaks in some areas, especially where heating systems are electrified. As utilities assess their strategy options, several promising solutions are worthy of consideration:

- **High-performance envelopes:** Utilities have long offered summer peak load control programs that cycle off air conditioners, typically for 15- to 30-minute periods, engaging thousands of customers to reduce overall system peak. But in the coldest weather conditions, it takes well-insulated buildings to "weather" the loss of heat for that long. Promoting insulation, efficient windows, and air leakage reduction can allow utility programs to cycle heating systems almost as effectively as cooling systems.
- **Dual-fuel heating:** It's possible in many cases to keep the existing fuel heating system in place—and to run it during electric system peak hours—such that most of the annual heating needs are met with electric heating and the fuel-fired system is used during the coldest hours. This can reduce the infrastructure requirements associated with electrification for electric utilities—although it will impact load factor on the natural gas grid—and may require changes in cost recovery across utilities if implemented on a wide scale.
- **Energy storage:** Battery storage is rapidly gaining traction in power grids, primarily in large-scale applications at the grid level to accommodate variable renewable generation from wind and solar. But as battery economics continue to improve, building scale use could also come into play, such that batteries can be charged during off-peak hours and used during peak load hours. Customers with solar photovoltaics may find battery systems add value to their investments. As EVs become more common, vehicle-to-grid strategies may also come into wider scale use.

To modernize their distribution systems for such strategies, electric utilities will need to invest in automated distribution management systems (ADMS) and distributed energy resource management systems (DERMS). Many electric utilities have already invested in advanced metering infrastructure, which typically includes digital customer meters that provide for two-way communication, and the associated communications, meter data management, and customer information system upgrades. This digital transformation can help pave the way for ADMS and DERMS technology if regulators, customers, and other stakeholders support such needed grid upgrades.

Engaging customers in demand-side management programs, which began more than 30 years ago to bring greater balance to utility resource planning practices, has proven itself to be a cost-effective strategy for energy efficiency and load management.

Now, the stakes for customer engagement are higher than ever as utilities work to keep energy systems affordable, reliable, and resilient while evolving them into low-emission networks that give us the clean energy we need for a prosperous and sustainable future.

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Bill brings more than 40 years of energy and environmental experience to the technical and business strategy leadership for our clean energy and climate services. He provides senior advisory support for federal, state, and local governments in the U.S. and overseas projects in Africa, Asia, and Latin America.

Bill is a lead solution architect for energy projects like our USAID Energy Efficiency for Clean Development Program global cooperative agreement. His subject matter expertise includes policy analysis, energy analytics, program design, and field implementation, gained through resource assessment projects. He also works on public policy development, utility-sector efficiency programs, building codes, and appliance standards.

Bill harnesses his experience to testify before legislative and regulatory bodies, serve on nonprofit organization boards, and make media appearances as an energy and climate expert. Bill is also a senior fellow with the ICF Climate Center. In this role, he provides compelling research and objective perspectives on a wide range of climate-related topics to help advance climate conversations and accelerate climate action.

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Deb works across subnational and national climate action and energy plans, greenhouse gas inventories, and decarbonization scenarios analyses. She leads and manages the technical analysis and varied levels of stakeholder and public engagement. Deb's long-standing experience with carbon capture, utilization, and sequestration enables her to collect, interpret, and analyze sustainability data and metrics; fluorinated greenhouse gases; climate risks; and greenhouse gas monitoring, reporting, and verification.

Deb works with a broad range of domestic and international clients. Examples include the Commonwealth of Pennsylvania, Delaware, New York City, the City of Philadelphia, Arlington County, Fairfax County, the City of Los Angeles, and various utilities. She also supports the U.S. Environmental Protection Agency, the U.S. Department of Homeland Security, the U.S. Agency for International Development, the UK Department of Energy and Climate Change, the Global Carbon Capture and Storage Institute, the Western Climate Initiative, and the World Bank Partnership for Market Readiness, among others.

Deb is also a senior fellow with the ICF Climate Center. In this role, she provides compelling research and objective perspectives on a wide range of climate-related topics to help advance climate conversations and accelerate climate action.

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We have a deep bench of 1,000+ environmental science, policy, and technical experts. From environmental program management to transportation, water, and energy projects, our team works together to help clients navigate complex environmental requirements and address the interconnected causes and effects of climate change. For more than 30 years, we've brought a trusted reputation to our work: executing environmental impact assessments, managing complex projects, engaging diverse stakeholders, and navigating multiple layers of regulation. Our technical expertise—such as conducting cost-benefit analyses and advanced energy analytics—helps our clients achieve sustainability goals within the context of their broader mission.