Electricity Matters

Paul A. DeCotis

What Got Us Here Will Not Get Us There

Hats off to the US and selected states, and countries across the globe for successfully advancing energy efficiency and demand response initiatives to reduce energy use and costs. And as a result, reducing the harmful pollutant and greenhouse gas (GHG) emissions associated with fossil fuel use. Thanks in large part to efficiency investments in buildings and industry, appliances, lighting and transportation, US energy use is about the same today as it was in 2000, despite economic growth of approximately 30 percent. This represents a significant improvement in energy productivity.

Globally, the International Energy Administration (IEA) reports energy efficiency improvements have been running between 1.5 percent and 3 percent over the past decade, although the IEA projects these rates to fall as countries emerge from the pandemic and economic growth rebounds.[1] Along with economic rebound comes increased demand for energy, and with the ongoing war in Ukraine fossil fuel prices are expected to remain high for some time—as is continued investment in mining and drilling to meet increases in energy demand.

The Natural Resources Defense Council, in a recent study, shows energy efficiency has done more to meet US energy needs than oil, natural gas, and nuclear power over the past four decades. On top of this, the energy efficiency industry boasts more than 2.2 million jobs in the US—10 times more than oil and natural gas drilling and 30 times more than coal mining. The transition to a cleaner energy economy is in full swing and unlikely to revert any time soon, other than some short-term aberrations as world socioeconomic and political conditions change. And scaling up US energy efficiency efforts to meet more stringent decarbonization goals is expected to create tens of thousands of additional jobs.[2] The IEA expects energy

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[1] International Energy Agency. (2019). *Energy Efficiency 2019.* Retrieved from https://bit.ly/3QnlNjt.

[2] NRDC. (2017, June 1). *NRDC and Energy Efficiency: Building the Clean Energy Future.* Retrieved from https://on.nrdc.org/3xMScZJ.

efficiency to be a major driver of reduced energy use and GHG emissions over the next several decades. Renewable energy and distributed energy resources (DERs) and storage are expected to complement energy efficiency, paving the way for continued progress toward decarbonizing the economy.

Anecdotally, energy efficiency and demand management can cut in half the amount of energy needed to decarbonize the US economy by 2050 if history is any indicator of its potential. Even with the push toward economy-wide electrification, numerous studies and projections are showing that the electric grid can manage the expected increase in load. This is not to say that new generation and transmission and distribution (T&D) infrastructure will not be needed to meet this new load. In fact, some wholesale market operators and planning entities are projecting a need for new infrastructure additions beginning in 2023.

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Utility grids in the northeast, central, and western US are projected to become winter peaking utilities rather than summer peaking, as building fossil fuel use is converted to electricity. And due to current low load factors on the electric grid, there is significant headroom to support large increases in base-load electricity demand without significant upgrades to the grid. Many utilities believe they can meet the load for electrifying buildings and transportation easily, much like they managed to meet aggressive growth in demand post-World War II. The fact is, however, that the economy of 70 years ago was vastly different from the economy today. In addition, population densities have increased, rural areas have become more fully developed, and grid operations and controls are more advanced—managing multiple interconnections and grid-edge resources. Siting new generation and T&D infrastructure across multiple states and jurisdictions is more complex than it was 70 years ago. And the costs of optimizing grid operations and managing grid-edge DERs at scale presents a whole new set of challenges.

A DILEMMA

While there is reason to believe economic growth and significantly increased loads can be met with more energy efficiency and demand response, significant investment in new generation, T&D infrastructure, and energy storage is needed. Meeting higher year-round loads and higher peak demands requires continued investment in infrastructure to ensure the continued safety, reliability, and resiliency of our energy systems. However, buildings and transportation can be electrified using fuel sources like heat pumps, green hydrogen-based fuel cells, and other DERs where applicable, requiring less investment in traditional grid infrastructure.

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As previously reported in this column (April 2022),[3] 24 states and the District of

[3] DeCotis, P.A. (2022). Leadership and deliberate action. *Climate and Energy,* 38, pp. 27–32. https://doi.org/10.1002/gas.22283.

Columbia have adopted GHG reduction targets and all but four of the 30 largest US electric utilities have set net-zero GHG emission targets for 2050 in line with state and regulators' directives. California has a legislated goal of achieving 50 percent zero-emission electricity production by 2030, and 100 percent by 2045. Hawaii has a legislative mandate to become completely energy self-sustaining using 100 percent renewable energy sources by 2045, with a nearer-term goal of 70 percent by 2030. Illinois is considering legislation to mandate a clean energy goal of 100 percent by 2050, as is Minnesota. New York has targeted 2040 as the year in-state electricity production is to be generated 100 percent carbon-free, with an interim goal of 70 percent renewable energy by 2030. In addition to states that have formally adopted GHG reduction targets, 33 states have released a climate action plan or are in the process of revising or developing one.

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Yet, even given all of these initiatives in the states, the US Energy Information Administration (EIA) energy forecasts reported in the Annual Energy Outlook (AEO) paint a dire picture of the ability for renewable energy resources and energy efficiency to reach the penetration levels necessary to significantly reduce GHG emissions and meet established GHG reduction goals. EIA models and forecasts short- and long-term energy production and use in the US based on current technologies and costs, and with minimal expectations for large-scale innovations, change in economic conditions, or supply and demand for electricity. AEO projections take into consideration existing legislation, tax code, and energy and environmental trends without predicting future legislative mandates or policy actions and their impact on energy demand and supply.

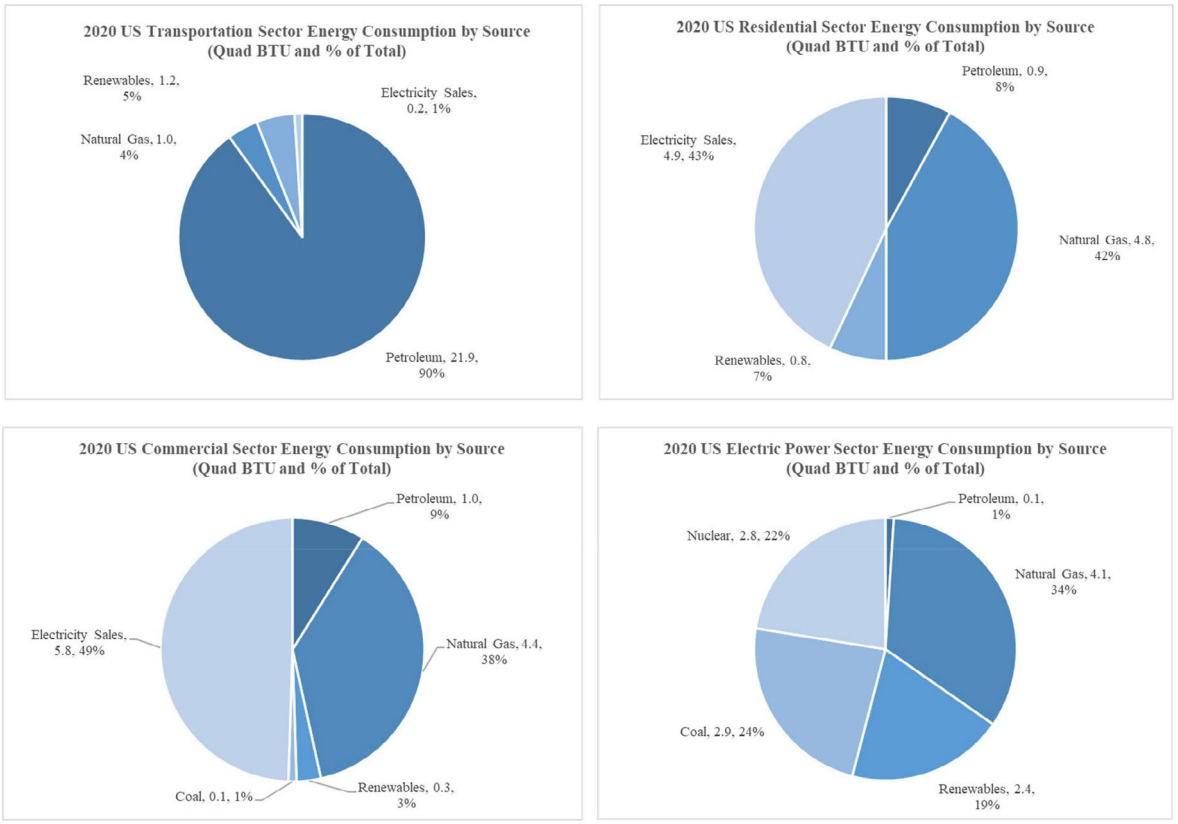
Recognizing that electrifying everything requires more than a single-source solution, it is imperative that policymakers, regulators, and industry consider the most economically cost-effective way to meet aggressive decarbonization goals.

AEO projections show continued retirement of nuclear and coal generation, with natural gas remaining a significant part of electric generation capacity mix in 2050, at 36 percent. Yet, even with natural gas generation projected to represent a larger share of capacity in 2050 in AEO 2021 than in AEO 2019, the share of capacity from renewable energy resources is projected to be larger, at 42 percent up from 34 percent in AEO 2019. In AEO 2021, the share of coal and nuclear capacity is 11 percent for each, compared to AEO 2019, with 29 percent coal and 19 percent coal and nuclear capacity, respectively.

LEVEL SETTING

Recognizing that electrifying everything requires more than a single-source solution, it is imperative that policymakers, regulators, and industry consider the most economically cost-effective way to meet aggressive decarbonization goals. Consider the following high-level insights based on most recent EIA data and a simplified analysis of what it might take if transportation and

Figure 1. US Energy Consumption in Transportation, Residential, and Electric Power Sectors, 2020*



*Data from EIA, US Energy Consumption by Source and Sector, 2020.

buildings fossil energy use was to be met by new sources of emission-free electricity generation, and in particular solar, wind, and storage.

As illustrated in **Figure 1,** 90 percent of transportation load in the US is met with petroleum products, including gasoline and diesel fuel. And close to 60 percent of electricity generation in the US is fueled by fossil fuels, including petroleum (1 percent), natural gas (34 percent), and coal (24 percent). Similarly, as illustrated in Figure 1, residential and commercial building loads are met by petroleum and natural gas, 50 percent and 48 percent, respectively, not accounting for fossil fuel use in electric generation to provide electricity to buildings. Electric generation is comprised mostly of fossil fuel generation and represents approximately 43 percent and 49 percent of energy use in residential and commercial buildings, respectively.

The challenge of electrifying everything is not trivial. This is not to say that policymakers and industry cannot deal with the challenges of electrifying fossil energy use in transportation and buildings successfully, including addressing the need for new clean electricity generation, and T&D and electric vehicle charging infrastructure. Nonetheless, the challenges do need to be acknowledged and leadership at all levels and cooperation among parties with differing

Table 1. 2020 US Energy in Quad Btu

Energy Source	Quantity			End-Use Sector	Quantity	
	Quad Btu	% Total			Quad Btu	% Total
Petroleum	32.2	35%		Industrial	25.2	24%
Natural Gas	31.5	34%		Transportation	24.3	23%
Renewables	11.6	12%	105.4	Residential	11.5	11%
Coal	9.2	10%		Commercial	8.7	8%
Nuclear	8.2	9%		Electric Power	12.5	12%
Total:	**92.9**	100%		Electricity Losses	23.2	22%
Total Acct. for Losses:				Total End-Use:	82.2	100%

views is required. And only if all options are considered, will the US achieve carbon neutrality by 2050.

HIGH-LEVEL ANALYSIS AND OBSERVATIONS

A high-level analysis of EIA data suggests that the amount of new energy infrastructure needed to electrify fossil energy use in transportation and buildings to meet decarbonization goals is significant. Energy use by sector is reported in **Table 1** for a total US energy use of 92.9 quad Btu. By sector, energy use in the US accounting for losses was 105.4 quad Btu.

Transitioning fossil energy use in transportation and buildings alone to electricity, given inefficiencies in electric generation, conversion factors, and losses, on a Btu basis suggests

- converting transportation sector energy use to electricity would require up to 10,457 gigawatt hours (GWh) of new electricity generation above current levels
- converting residential sector energy use to electricity would require up to 2,632 GWh of new electricity generation above current levels
- converting commercial sector energy use to electricity would require up to 2,527 GWh of new electricity generation above current levels

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In aggregate, converting transportation and buildings fossil energy use to electricity would require on the order of 15,617 GWh of new electricity generation. Furthermore, if all new electricity generation were to be met by solar and wind generation resources (land-based and offshore), the US would require upwards of 10 million GWh of new generation. This compares to total US electricity generation in 2021 of approximately 3.5 million GWh, meaning that the US would need over three times the amount of electricity generation required today. To support this amount of new generation, significant investments will be required in T&D and vehicle charging infrastructures to serve these new loads, as well as customer investment in building energy system conversions.

The cost of generation alone to meet the electricity loads for transportation and

buildings is on the order of $546 billion, assuming new generation was comprised of solar and wind generation, given their respective availability. Given that electrifying transportation and buildings would force a higher load factor for generation and given the intermittent nature of solar and wind resources, storage would need to be integrated into the grid to meet loads 24 hours daily, seven days per week. The amount of storage needed to complement solar and wind generation is estimated at 7 million GWh.

The challenge of electrifying everything is not trivial. This is not to say that policymakers and industry cannot deal with the challenges of electrifying transportation and building energy use successfully, including addressing the need for new clean electricity generation, and T&D and electric vehicle charging infrastructure.

Applying levelized costs for solar, wind, and storage resources reported by EIA[4] for resources entering service in 2027, reported in 2021 dollars, equates to approximately $1.45 trillion, with $546 billion needed for new generation and $903 billion for storage. Again, this does not include the cost of new T&D infrastructure or the cost of vehicle charging stations and building owner upgrades needed to electrify buildings. Nor does it include expected cost reductions and improved efficiencies in solar and wind technologies.

Reporting by the American Society of Civil Engineers[5] estimates that the US would require upwards of $637 billion in new generation and transmission and distribution system investment just to meet the renewable portfolio standard (RPS) of US states over the 2020 to 2027 time period. Knowing not all states have an RPS, and that most standards are projected to be met post-2027, it can be extrapolated that if all states had an RPS with equivalent targets it could cost upwards of $1.5 trillion just to meet state-level RPS goals. So, the $1.45 trillion and $1.5 trillion estimates, while derived differently and representing somewhat of a different approach to decarbonizing, seem to arrive at a similar ballpark estimate of costs.

The order of magnitude of the investment required to electrify transportation and building is a significant challenge that policymakers, industry, and consumers need to acknowledge.

Again, the analysis in this column is high level, with many caveats. However, the order of magnitude of the investment required to electrify transportation and building is a significant challenge that policymakers, industry, and consumers need to acknowledge.

CONCLUSION

Decarbonization goals among states, corporations, and countries are laudable. The innovations and investment needed to meet these goals are not trivial. Such aspirational and aggressive goals drive innovations and the enterprising spirit required to bring about cataclysmic change. Roles for a plethora of new market actors, technological advancements, improvements in system operations, and upgrading and repurposing existing energy infrastructures will all be needed to meet these goals. Keep in mind that economic, environmental, and social costs cannot be ignored, including the impacts on fairness and equity of consumers as the US transitions to a cleaner energy economy.

[4] International Energy Agency. (2002, March). *Levelized Costs of New Generation Resources in the Annual Energy Outlook 2022.* Retrieved from https://bit.ly/3aZWHam.

[5] American Society of Civil Engineers. (2021). *Report Card for America's Infrastructure.* Retrieved from https://bit.ly/3tBllVg.