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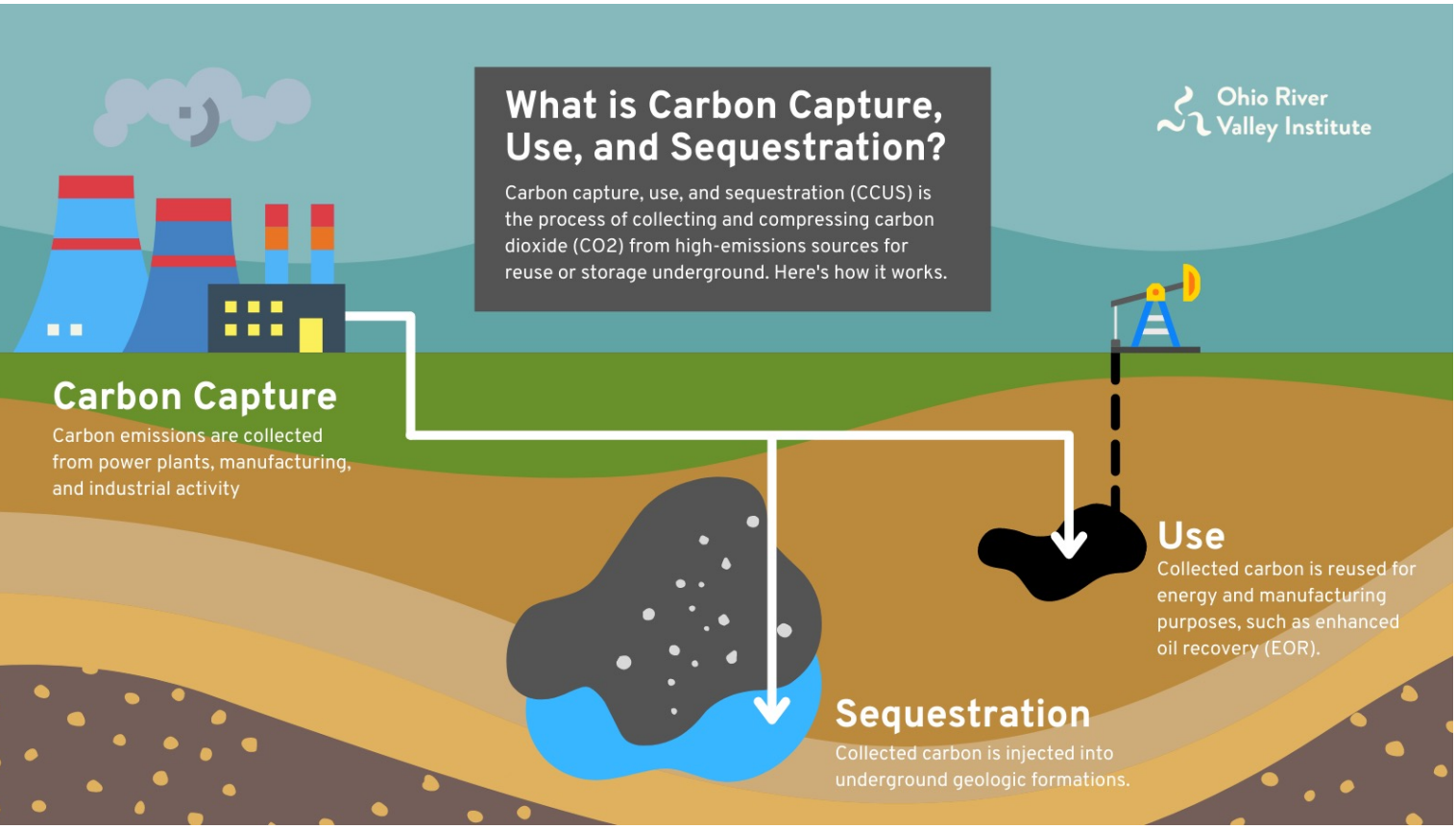
Ohio River Valley Institute

Carbon Capture, Use, and Sequestration (CCUS) Would Decarbonize the Electric System…in the Worst Possible Way

With a price tag of $100 billion/year, the broad-scale adoption of CCUS would spark outrage if its cost showed up in our electric bills. But some climate hawks and climate skeptics in Congress are coalescing around legislation that would make us pay through our taxes instead.

The political appeal of carbon capture, use, and sequestration (CCUS) technology is undeniable. In theory, CCUS could vastly reduce carbon emissions from a variety of industries, including, most prominently, America's power system. In doing so, it could save jobs in coal mining and natural gas and in the power plants that burn those fuels. And, with a nod to the realities of present-day politics, it would please industries that made nearly $200 million in political contributions[1] during the 2020 election cycle.



But, when it comes to the task of removing greenhouse gas emissions from America's power system, CCUS has profound drawbacks.

- CCUS has yet to operate cost-effectively at scale.
- Widespread adoption would drive up monthly electric bills by a quarter—and by over half in states like West Virginia that are heavily dependent on coal and natural gas.
- Much of the carbon captured and reused today is pumped underground to stimulate oil production,[2] generating additional CO2 emissions when the oil is burned.
- CCUS would not mitigate the air, water, and ground pollution and the resulting health consequences that are caused by generating power from coal and natural gas.
- CCUS would crowd out cheaper and cleaner renewable resources, which do not harm peoples' health and which would provide far more well-paying jobs even in places that today are heavily reliant on coal and natural gas.

1. Open Secrets. "Election Overview, Sectors Totals." *Open Secrets.* Accessed September 2021. https://www.opensecrets.org/elections-overview/sectors
2. National Energy Technology Laboratory (NETL). "Enhanced Oil Recovery." *NETL.* Accessed September 2021. https://www.netl.doe.gov/oil-gas/oil-recovery

Fig. 1 illustrates how much more Americans would have to pay for electricity if current levels of coal-fired and gas-fired power generation were supplemented with CCUS.

Fig. 1: Current Average Monthly Residential Electric Bill and Projected Bill Including Cost of CCUS

Source: Author's calculations using U.S. Energy Information Administration (EIA) data

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Meanwhile, clean, renewable resources, such as wind and solar, would more thoroughly reduce greenhouse gas emissions, they would eliminate the localized pollution effects associated with extracting and burning fossil fuels, and they could be developed and implemented at little additional cost to customers or taxpayers.

However, despite the clear economic and environmental superiority of clean energy resources for generating electricity, members of Congress have introduced a gaggle of bills that could provide $100 billion and possibly more in annual subsidies to the electric power industry and others to adopt CCUS. The power industry plus the coal and natural gas industries employ approximately 544,000 people[3] nationally. So, even if every one of those jobs were at risk…and they're not…the cost to ratepayers or taxpayers, depending on how CCUS is financed, would be about $189,000 per year per job.

A 40-year-old technology that still isn't ready for prime time

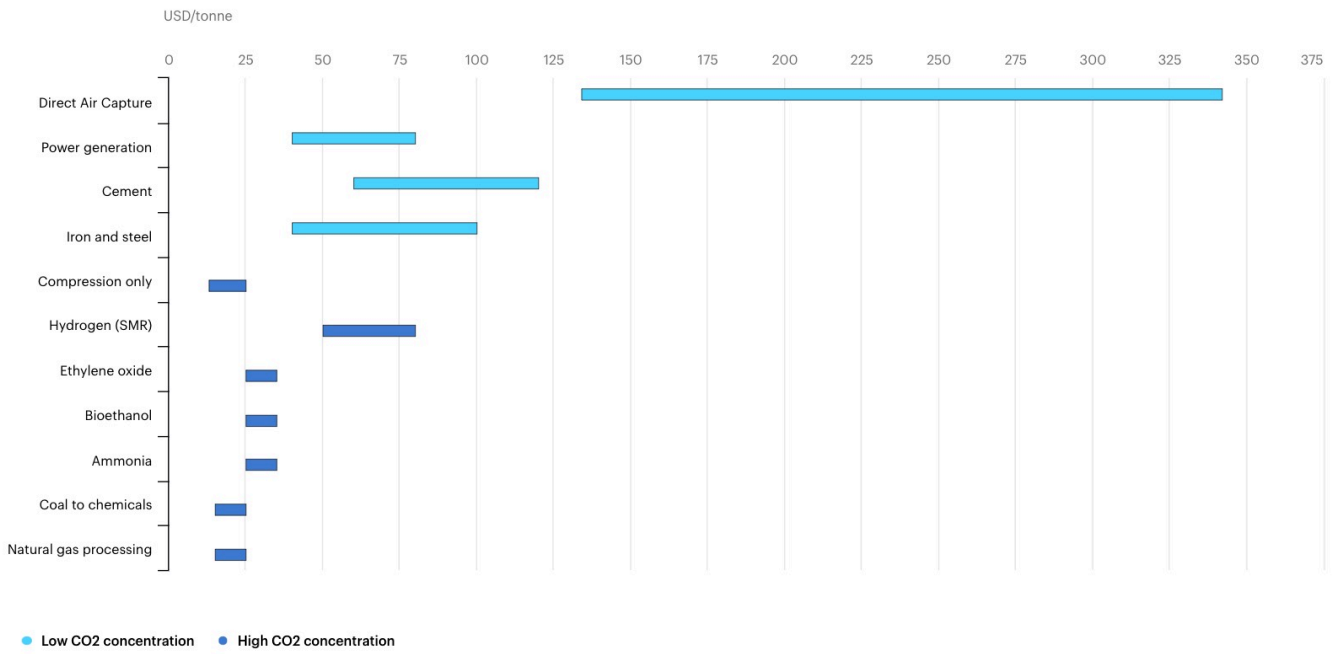
A 2021 International Energy Agency report[4] found that CCUS technology was first implemented as far back as 1972. Since then, about $7.5 billion has been spent on CCUS projects,[5] but today there are still only 21 large-scale carbon capture projects in the world, nine of which are in the United States.

3. National Association of State Energy Officials (NASEO) and Energy Future Initiatives (EFI). "2020 U.S. Energy & Employment Report." *NASEO* and *EFI.* April 2021. https://www.usenergyjobs.org/
4. International Energy Agency (IEA). "Energy Technology Perspectives 2020: Special Report on Carbon Capture Utilisation and Storage." *IEA.* September 2020. https://iea.blob.core.windows.net/assets/181b48b4-323f-454d-96fb-0bb1889d96a9/CCUS_in_clean_energy_transitions.pdf
5. Barnard, Michael. "Carbon Capture's Global Investment Would Have Been Better Spent on Wind & Solar." *CleanTechnica.* April 2019. https://cleantechnica.com/2019/04/21/carbon-captures-global-investment-would-have-been-better-spent-on-wind-solar/

Only one of the U.S. projects, NRG's Petra Nova coal-fired power plant in Texas, is in the electricity generating sector. However, NRG suspended operations at Petra Nova in May 2020 because the value of captured carbon, which can be used in oil production, plummeted in concert with declines in oil prices. The subsequent recovery in oil prices has not caused NRG to resume operations because, while the price of oil may be high on some occasions and low on others, it is always volatile.

The unstable market for captured carbon isn't the only problem facing CCUS. The technology's direct cost is also prohibitive for all but a few niche industrial applications. The following IEA chart (Fig. 2)[6] estimates the cost in "dollars per ton of CO2 captured" that CCUS would add to production costs in various industries, including power generation.

Fig. 2: Levelized Cost of CO2 Capture by Sector and Initial CO2 Concentration, 2019



Source: International Energy Agency

Some industries, such as cement-making and steel-making, which have few cost-effective alternatives for emissions reduction and which already have high production costs, can more easily absorb the CCUS price tag of $40+ per ton of carbon captured. Electricity, on the other hand, is comparatively inexpensive to produce and, unlike cement and steel, there are alternative resources—renewable energy, such as wind and solar combined with storage and energy efficiency—that eliminate greenhouse gas emissions and entail little additional cost.

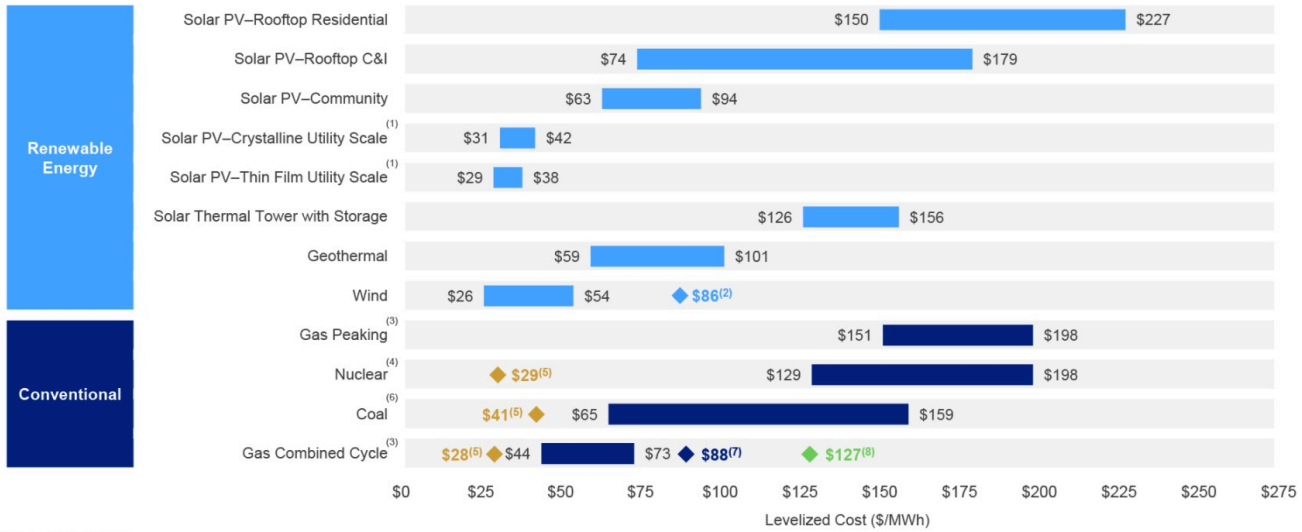
Electricity customers would be hammered by the added cost of CCUS

A recent study[7] by researchers at Rutgers University examined the "Total Cost of Carbon Capture and Storage Implemented at a Regional Scale: Northeastern and Midwestern United States". The study found that implementing CCUS in the power generating sector would cost between $52 and $60 per ton of captured carbon in coal-fired operations and $80 to $90 per ton in gas-fired power plants. These figures imply that CCUS would add at least 6.19 cents/kWh to the cost of coal-fired power and 3.87 cents/kWh to power from natural gas.

5. International Energy Agency (IEA). "Levelised cost of CO2 capture by sector and initial CO2 concentration, 2019." *IEA*. June 2021. https://www.iea.org/data-and-statistics/charts/levelised-cost-of-co2-capture-by-sector-and-initial-co2-concentration-2019
6. Schmelz, John W., Gal Hochman, and Kenneth G. Miller. "Total Cost of Carbon Capture and Storage Implemented at a Regional Scale: Northeastern and Midwestern United States." *Interface Focus*. June 2020. https://www.researchgate.net/publication/342215771_Total_Cost_of_Carbon_Capture_and_Storage_Implemented_at_a_Regional_Scale_Northeastern_and_Midwestern_United_States

A brief review of the levelized costs for generating electricity[8] shows how significant these increases are (Fig. 3).

Fig. 3: Levelized Cost of Energy Comparison—Unsubsidized Analysis
Selected renewable energy generation technologies are cost-competitive with conventional technologies under certain circumstances

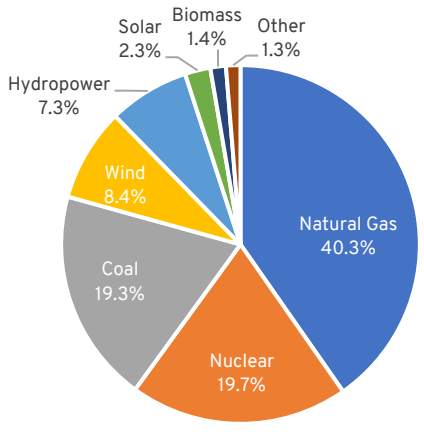


Note: The analysis assumes 60% debt at 8% interest rate and 40% equity at 12% cost. The low case represents a single-axis tracking system and the high case represents a fixed-tilt system.
Source: Lazard

The cost of power generation without CCUS from utility-scale wind and solar power ranges from $26 to $54 per megawatt hour (MWh) or 2.6 cents to 5.4 cents/kWh. Natural gas and coal are in roughly the same range for existing, fully depreciated plants and higher for new generation. Adding 6.19 cents to the cost of production from coal or 3.87 cents for gas would render both coal and gas-fired generation uncompetitive with renewable resources. That's why, despite the availability of federal tax incentives for more than a decade, there has been almost no adoption of CCUS by the power industry.

But, what would the effect on customers' bills be if the energy system implemented CCUS at these costs in order to perpetuate the current share of electricity generated from coal and natural gas?

Fig. 4: U.S. Power System Fuel Mix, 2020



Source: Author's analysis of EIA data

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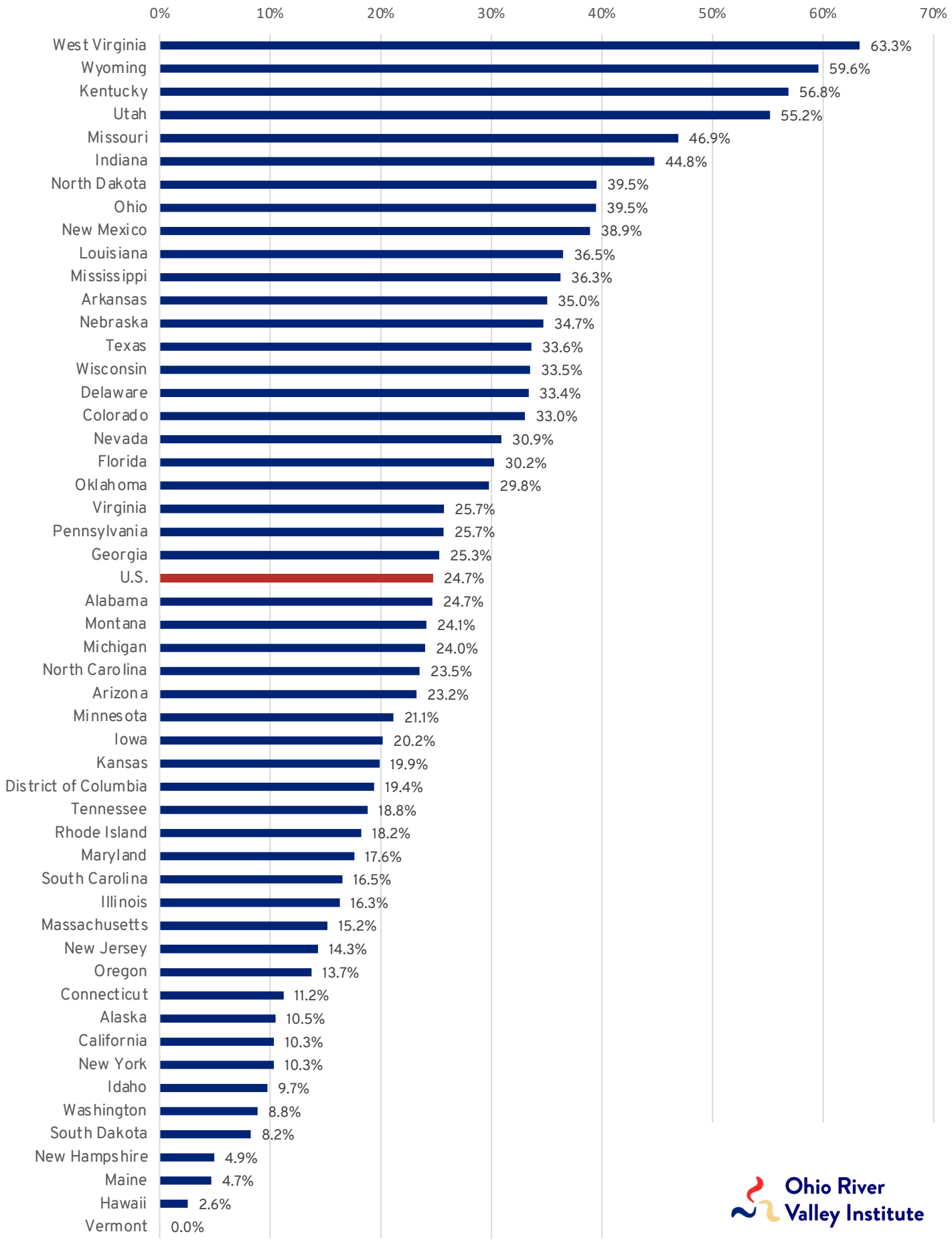
In 2020, coal provided 19.3% of the nation's power, and natural gas was responsible for 40.3% (Fig. 4).[9] In all, coal generated 773,805 gigawatt hours (GWh) of electricity. Natural gas produced 1,616,748 GWh. That means if all existing coal and gas-fired generation in 2020 had been supplemented with CCUS at the costs of $56/ton of captured emissions for coal-fired plants and $85/ton for gas-fired plants, the incremental annual cost to customers would be just under $100 billion each year.

This represents a 24.7% increase in the retail price of electricity annually and would amount to nearly a trillion dollars over a decade. Because individual states vary in the degree to which they rely on coal and natural gas to produce electricity, the impact of the increase would vary considerably, with more coal- and gas-intensive states absorbing a greater share of the cost.

Vermont, which gets almost no electricity from coal and gas, would see almost no increase in annual electric bills. But West Virginia, which in 2020 got 88% of its electricity from coal and another 5% from natural gas, would see an annual electricity bill increase of 63% (Fig. 5).

8. Lazard. "Levelized Cost of Energy, Levelized Cost of Storage, and Levelized Cost of Hydrogen." *Lazard*. October 2020. https://www.lazard.com/perspective/levelized-cost-of-energy-levelized-cost-of-storage-and-levelized-cost-of-hydrogen/
9. U.S. Energy Information Administration (EIA). "Monthly Generation Data by State, Producer Sector and Energy Source; Months Through December 2020." Source: EIA-923 Report. *EIA*. Accessed September 2021. https://www.eia.gov/electricity/data.php

Fig. 5: CCUS-Adjusted Percent Increase in Annual Electric Rates by State



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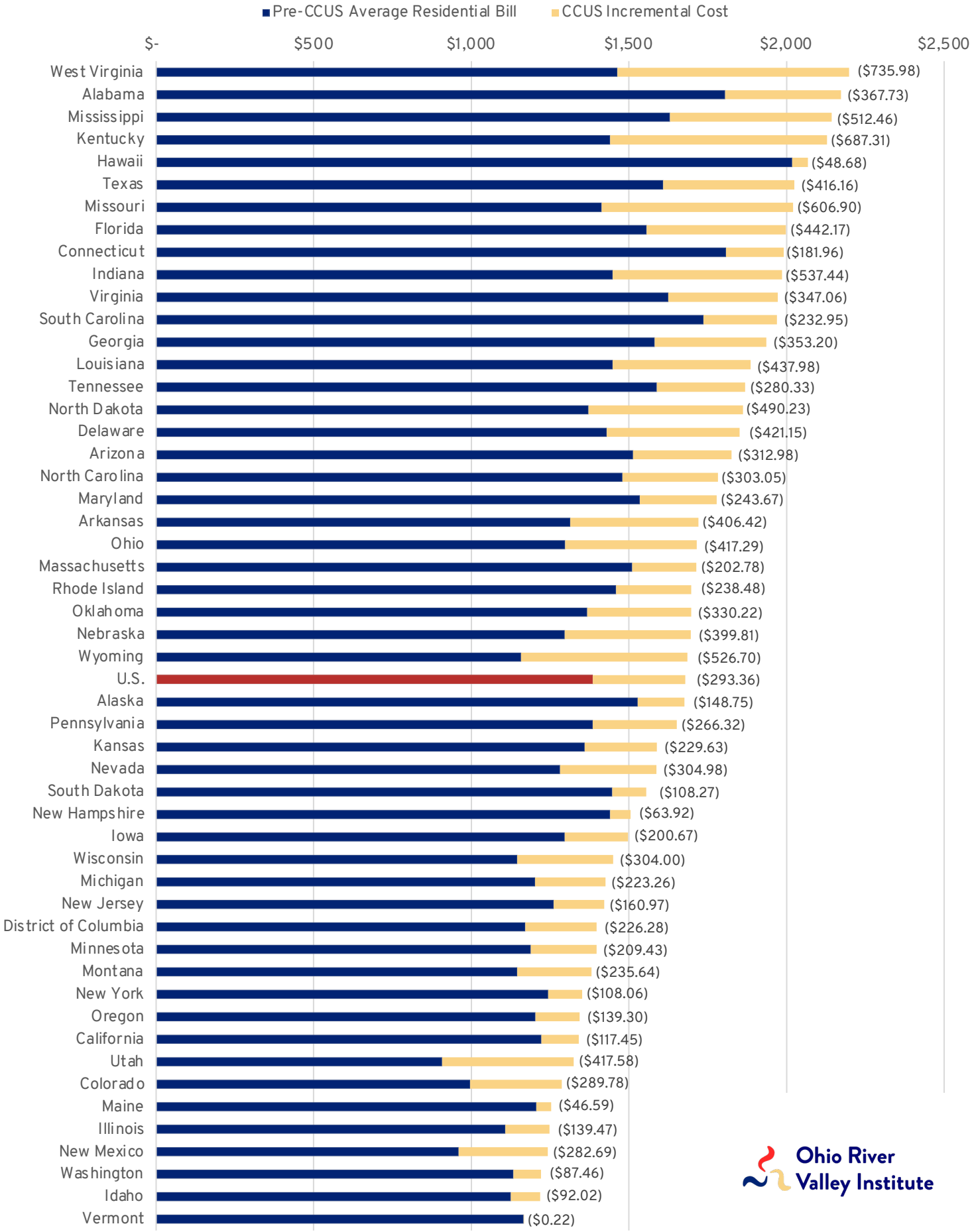
Source: Author's calculations using EIA data

Fig. 6: CCUS-Adjusted Average Annual Residential Bill by State
(CCUS Incremental Cost)



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Source: Author's calculations using EIA data

Because residential electricity customers already pay a higher retail rate than commercial and industrial customers for electricity, the percent impact on their bills would be somewhat less. Still, most residential customers would be hit with hundreds of dollars per year in higher electric bills, topping out in West Virginia, where there would be an average increase of $736 jumping from a current figure of $1,463 per year to $2,199. Nationally, the average residential electric bill would jump by an average of $293 annually (Fig. 6).

That's not the end of the cost

While CCUS technologies are effective, they are not foolproof. After implementation in the power system, as much as 10% of emissions may not be captured. And that doesn't take into account upstream emissions that take place in fossil fuel supply chains.

The Environmental Protection Agency estimates that the combined oil and gas industries leak about 8 million tons of CO2 equivalents each year. In 2018, the Environmental Defense Fund cited a series of studies which suggest that the actual figure is roughly 60% greater than that. But coal mines are even worse. EPA estimates that U.S. mines emitted 61 million metric tons of CO2 equivalents in 2015.[10] The alternative to CCUS-supplemented fossil fuel generation is clean, renewable resources such as wind, solar, hydro, and, in some places, nuclear. In addition to generating no direct emissions, their upstream emissions are a fraction of those associated with coal and gas.

Clean energy resources would also avoid another major cost that CCUS would fail to address. Oil and gas production, coal mining and combustion, and fossil fuel power generation are major sources of particulate matter and ozone pollution that measurably shorten lives and increase the severity and prevalence of medical conditions ranging from upper respiratory conditions to heart disease, strokes and cancer.[11] Proximity to coal mining operations is linked to elevated cancer rates, an increased occurrence of birth defects, and an outsized mortality rate.[12,13,14] Point source pollution from unconventional natural gas extraction, or fracking, is similarly associated with inflated cancer rates, reproductive risks, and serious respiratory and pulmonary diseases.[15]

Individuals living in zip codes containing fuel-fired power plants are up to 17% more likely to be hospitalized for respiratory diseases than those who do not live near a power plant.[16] In its ongoing study, the Clean Air Task Force finds that fine particulate matter from U.S. power plants is responsible for over 3,000 deaths annually.[17] Other studies attribute as many as 50,000 premature deaths per year to U.S. coal- and natural gas-fired power generation.[18]

If CCUS is adopted by the power system, Americans will pay one way or another

We've seen the financial reasons why the power sector can't afford to implement CCUS and what the impact on customers would be if it did. But, that doesn't mean it can't happen. Widespread adoption of CCUS by the power sector could become reality depending on what Congress decides to do with a gaggle of bills that have been proposed to modify section 45Q[19] of the U.S. tax code. At present, section 45Q offers a credit to power plants, refineries, factories, and other fossil fuel-burning facilities for the capture of carbon monoxide and dioxide, which is then stored underground, put to commercial use, or used for enhanced oil or gas recovery.

10. U.S. Environmental Protection Agency (EPA). "About Coal Mine Methane." *EPA*. Accessed September 2021. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.
11. Lu, Jintao et. al. "Evolution of External Health Costs of Electricity Generation in the Baltic States." *International Journal of Environmental Research and Public Health*, 17(15): 5265. July 2020. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7432347/
12. Hendryx, Michael, et. al. "Self-Reported Cancer Rates in Two Rural Areas of West Virginia With and Without Mountaintop Coal Mining." *Journal of Community Health.* July 2011. https://www.motherjones.com/files/final_jch_cancer_2011.pdf
13. Ahern, Melissa et. al. "The association between mountaintop mining and birth defects among live births in central Appalachia, 1996-2003." *Environmental Research*, 111(6):838-46. August 2011. https://pubmed.ncbi.nlm.nih.gov/21689813/
14. Hendryx, Michael and Benjamin Holland. "Unintended consequences of the Clean Air Act: Mortality rates in Appalachian coal mining communities." *Environmental Science and Policy*, 63:1-6. September 2016. https://www.sciencedirect.com/science/article/abs/pii/S1462901116301137
15. Concerned Health Professionals of New York and Physicians for Social Responsibility (PSR). "Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking, 7th edition." *Concerned Health Professionals of New York* and *PSR*. December 2020. https://www.psr.org/wp-content/uploads/2020/12/fracking-science-compendium-7.pdf
16. Liu, Xiaopeng, Lawrence Lessner, and David O. Carpenter. "Association between Residential Proximity to Fuel-Fired Power Plants and Hospitalization Rate for Respiratory Diseases." *Environmental health Perspectives.* June 2012. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3385425/
17. Clean Air Task Force (CATF). "Raising Awareness of the Health Impacts of Coal Plant Pollution." *CATF*. 2021. https://www.catf.us/educational/coal-plant-pollution/
18. Caiazzo, Fabio et. al. "Air pollution and early deaths in the United States." *Atmospheric Environment*, (79):198-208. November 2013. https://www.sciencedirect.com/science/article/abs/pii/S1352231013004548
19. Legal Information Institute, Cornell Law School. "26 U.S. Code § 45Q – Credit for carbon oxide sequestration." *Legal Information Institute, Cornell Law School*. Accessed September 2021. https://www.law.cornell.edu/uscode/text/26/45Q.

Although section 45Q was enacted in 2008, it has had relatively little impact to date. That's in part because, until 2018, the credit was limited to the first 75 million metric tons of emissions claimed annually, which is a tiny fraction of the 3.2 billion tons of carbon dioxide and equivalents produced each year by the nation's electricity and industrial sectors.[20] Also, the amounts of the credits have been and remain well below the cost of CCUS implementation and operation. Finally, in order to qualify for a credit, the taxpayer must have sufficient tax liability, which is often not the case for owners of coal-fired power plants and other facilities whose finances have been strained by the nation's transition to clean energy resources.

Fig. 7: Current Section 45Q Credit Amounts per Metric Ton

Year	CO2 put into geological storage	CO2 used for oil & gas recovery and other uses
2021	$34.81	$22.68
2022	$ 37.85	$25.15
2023	$40.89	$27.61
2024	$43.92	$30.07
2025	$46.96	$32.54
2026	$50.00	$35.00

Source: Author's analysis of Section 45Q

However, a number of bills that are being considered by Congress would remove these barriers and, depending on which are enacted, could produce a situation in which the federal government—and therefore taxpayers—would effectively underwrite the entire cost of CCUS implementation and operation at any qualified facility for at least 20 years and maybe in perpetuity.

The first step toward turning section 45Q from a pilot project funding program into general industry subsidy took place when the Bipartisan Budget Act of 2018 removed the 75 million ton cap on eligible captured emissions.[21] The bills currently under consideration would further open the subsidy flood gates by:

- Increasing the value of credits to a level equal to or greater than the actual cost of implementation and operation.
- Converting the tax credit, for which the taxpayer must have sufficient tax liability, into a direct payment, for which companies and facilities would be eligible regardless of tax status.
- Allowing corporate partnership arrangements that provide significant tax benefits and assist in the acquisition of financing.
- Increasing the period during which a facility is eligible for the tax credit or direct payment from the current 12 years to 20 years and perhaps longer.

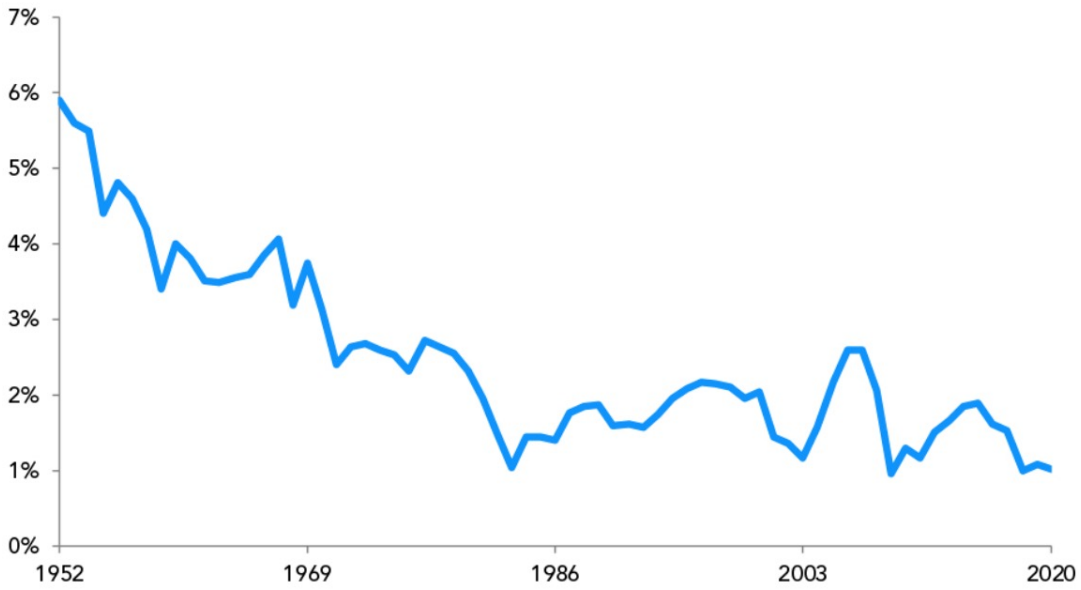
As is currently the case, subsidy values would be indexed to inflation, essentially guaranteeing that, as costs increase, it will be taxpayers and not the industry that picks up the tab. Also, it should be noted that the annual $100 billion cited above as the potential cost of the subsidy may be an understatement. Some of the proposals in Congress would provide more generous amounts than the figures of $56 and $85 per ton of captured carbon assumed above. The Center on Global Energy Policy at Columbia University SIPA recently developed a model that examines the impact of enhancements to section 45Q of the tax code and found that, "…to reduce investment risks and attract private capital to finance CCUS projects, the 45Q credit value would need to be further enhanced to between $60 to $110 per metric ton, or combined with revenue treatments such as production tax credits or contracts for differences."[22]

Financing CCUS through the federal tax system would also result in states whose energy systems are the least carbon-intensive subsidizing states whose systems are the most carbon-intensive. And, because high carbon intensity states tend to be among those most dependent on federal funds, their dependency would be deepened while low carbon intensity states, whose contributions to the federal government tend to exceed the amount of federal spending they receive, would see that discrepancy increase.

20. U.S. Environmental Protection Agency (EPA). "Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2019." *EPA*. Accessed September 2021. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.
21. U.S. Congress. "H.R. 1892 – Bipartisan Budget Act of 2018." *U.S. Congress*. February 2018. https://www.congress.gov/bill/115th-congress/house-bill/1892/text.
22. Ochu, Emeka. "Proposed 45Q Tax Credit Reform Could Give a Big Boost to Carbon Capture Projects." *The Center on Global Energy Policy at Columbia University*. May 2021. https://www.energypolicy.columbia.edu/research/op-ed/proposed-45q-tax-credit-reform-could-give-big-boost-carbon-capture-projects

Also, although this report focuses on the power system, it should be noted that the same provisions would hold for other industries that implement CCUS technology, which would increase taxpayer costs even more.

Fig. 8: Corporate Income Tax Revenue (% of GDP)
Revenue from corporate income taxes has decreased since the 1950s



Source: Peter G. Peterson Foundation

A final benefit to industry is that, if the federal government funds CCUS through direct payments, the added $100 billion annual cost won't show up on customers' electric bills. Instead, it will be collected through the taxes we pay. That's beneficial to industry because, according to the Peter G. Peterson Foundation, over the last quarter-century the share of revenue that the corporate sector pays in federal income taxes has fallen to its lowest level in more than 60 years (Fig. 8).[23]

While corporate income taxes once contributed 35% of federal revenues, the share has dropped to just 7%, meaning that the burden for the subsidies provided by a modified section 45Q would fall overwhelmingly on individual taxpayers.

In short, the public and not the industry will eat the vast majority of the cost. The situation may be somewhat ameliorated by the Biden administration's efforts to increase corporate taxes domestically and in concert with other developed nations,[24] but the change, if enacted, would still result in the vast majority of the burden falling on individuals.

Active bills that would modify 45Q

The bills in the table on the following page are currently being considered by Congress, as is the $3.5 trillion reconciliation bill, which is expected to include additional funding for CCUS.

In addition, Delaware Senator Chris Coons has introduced the SCALE Act (S. 799),[25] which would not amend Section Q45, but would devote significant federal resources to the construction of new carbon capture, transportation, and storage infrastructure.

23. Peter G. Peterson Foundation. "Six Charts That Show How Low Corporate Tax Revenues Are In The United States Right Now." *Peter G. Peterson Foundation.* April 2021. https://www.pgpf.org/blog/2021/04/six-charts-that-show-how-low-corporate-tax-revenues-are-in-the-united-states-right-now
24. The White House. "Statement by President Joe Biden on Today's Agreement of 130 Countries to Support a Global Minimum Tax for the World's Largest Corporations." *The White House.* July 2021. https://www.whitehouse.gov/briefing-room/statements-releases/2021/07/01/statement-by-president-joe-biden-on-todays-agreement-of-130-countries-to-support-a-global-minimum-tax-for-the-worlds-largest-corporations/.
25. U.S. Congress. "S. 799 – SCALE Act." *U.S. Congress.* March 2021. https://www.congress.gov/bill/117th-congress/senate-bill/799/text.

Bill & Sponsors				Modifications to Section 45Q				
Bill	Title	Date	Key Sponsors	Increases Per-Ton Value	Creates Direct Pay Option	Lowers Qualifying Standards	Offers Publicly Traded Partnership Structure	Extends Duration
H.R. 5205	NET Zero Act of 2021	9/10	Rep. Donald Beyer, Jr. [D-VA]	X		X		X
H. R. 5194	Carbon Capture & Sequestration Expansion Act	9/7	Rep. Terri Sewell [D-AL]			X		X
S. 2230	A bill to amend the Internal Revenue Code of 1986 to enhance the carbon oxide sequestration credit	6/24	Sen. Ben Ray Lujan [D-NM]	X				
H.R. 4153	Clean Energy Future Through Innovation Act of 2021	6/24	Rep. David McKinley [R-WV]	X			X	X
H.R. 3538	Coordinated Action to Capture Harmful Emissions Act	5/25	Rep. Tim Ryan [D-OH]	X				
S. 1298	Clean Energy for America Act	4/22	Sen. Ron Wyden [D-OR]	X	X			
H.R. 2633	To amend the Internal Revenue Code of 1986 to increase and expand the credit for carbon oxide sequestration	4/16	Rep. David Schweikert [R-AZ]	X		X		X
S. 1034 H.R. 2291	Financing Our Energy Future Act	3/25 3/29	Sen Christopher Coons [D-DE] Rep. Mike Thompson [D-CA]				X	
S. 986	Carbon Capture, Utilization & Storage Tax Credit Amendments Act	3/25	Sen. Tina Smith [D-MN]	X	X	X		X
S. 1034	Financing Our Energy Future Act	3/25	Sen. Christopher Coons [D-DE]				X	
S. 985	Save America's Clean Energy Jobs Act	3/25	Sen. Thomas Carper [D-DE]		X			
S. 661 H.R. 1760	Carbon Capture Modernization Act	3/10 3/10	Sen. John Hoeven [R-ND] Rep. David McKinley [R-WV]			X		
H.R. 1062	ACCESS 45Q Act	2/15	Rep. David McKinley [R-WV]		X			X

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