Legislative Testimony
Hearing before the Pennsylvania Senate Democratic Policy Committee
Hydrogen Hubs and Climate Change
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Good day, Chairman Muth, Senator Comitta, and members of the Senate Democratic Policy Committee. Thank you for allowing me to speak today about Pennsylvania's hydrogen hubs and some of the challenges they present.

I am Sean O'Leary, a senior researcher at the Ohio River Valley Institute. ORVI is a not-for-profit public policy think tank focused on issues of effective, equitable, and sustainable economic development in Appalachian Pennsylvania, Ohio, West Virginia, and Kentucky. My work at ORVI includes a series of reports on the economic impacts of the Appalachian natural gas boom, examinations of the cost-effectiveness of carbon capture and sequestration and hydrogen technologies, and the analysis and promotion of a model for successful economic development in distressed communities that are traditionally reliant on fossil fuel industries.

<u>Testimony Summary</u>

This past September, ORVI hosted a day-long workshop for Pittsburgh-area journalists on the hydrogen hubs that are proposed for our region. My presentation that day focused on four issues that I hope you will consider as you develop policy concerning the hubs.

- <u>Hydrogen and its companion technology, carbon capture and sequestration, are very, very expensive compared to other means of decarbonization</u>. These technologies will in every application increase costs and, in many cases, they will decrease output as well. In short, hydrogen and carbon capture will be inflationary. Therefore, their use should be limited to only a few industrial applications in which they are either the most cost-effective or the only viable means of decarbonization.

- <u>Hydrogen will deliver fairly minimal reductions in greenhouse gas emissions.</u> Based on the projections supplied by ARCH2, MACH2, and DOE, even if the ARCH2 and MACH2 hubs achieve their announced emission reduction goals of 9 million and 1 million metric tons of CO_2 respectively[1], the participating states of Pennsylvania, Delaware, New Jersey, Ohio, and West Virginia will experience an emissions reduction of only 1.7% below 2021 levels.

[1] U.S. Department of Energy, Office of Clean Energy Demonstrations, "Regional Clean Hydrogen Hubs Selections for Award Negotiations'.
https://www.energy.gov/oced/regional-clean-hydrogen-hubs-selections-award-negotiations

- There is a significant possibility that the hydrogen hubs will never be fully realized and that much of the public funds invested in them will be wasted. Recall the once highly anticipated emergence of an Appalachian petrochemical cluster, which failed when investors determined that anchor projects, including the construction of five world-class ethane crackers, were fundamentally uneconomic. The same fate may befall some and perhaps many hydrogen hub projects that are similarly uneconomic.

- The hydrogen hubs' economic impacts will be minimal and will deliver little if any job growth. That's because many of the businesses that make up the so-called hydrogen economy suffer from the same structural characteristics that prevented the closely related natural gas industry from delivering any measurable increase in jobs and income despite its massive expansion in our region. Also, if hydrogen is deployed in applications for which it is not economic, the result could be an absolute decline in jobs as decarbonization costs rise and more effective, less expensive decarbonization alternatives are crowded out.

For these reasons, the greatest risk facing you as Pennsylvania policymakers isn't that you may provide too little support for the state's hydrogen hubs but rather that you may provide too much. Because, if you do and if hydrogen crowds out more effective and affordable solutions, the result will be reduced economic growth, fewer jobs, and higher utility bills, taxes, and prices for Pennsylvanians, starting almost immediately and continuing for decades to come.

That is why we at ORVI hope members of this committee will help temper financial and regulatory support for the hubs to reflect their actual value and costs. We hope that members will work to ensure that state assistance is limited to the small number of projects and specific applications in which hydrogen is either the most cost-effective or only means of decarbonization. And we hope that, when hydrogen is used, it will be hydrogen made from water and not natural gas, which is both polluting and economically counterproductive.

Hydrogen and Carbon Capture's Exorbitant Cost

As a 2021 analysis by Evolved Energy Research[2] shows, hydrogen is one of the most expensive methods of decarbonization and it can be economically deployed in only a limited number of industrial applications for which other means of decarbonization are impractical.

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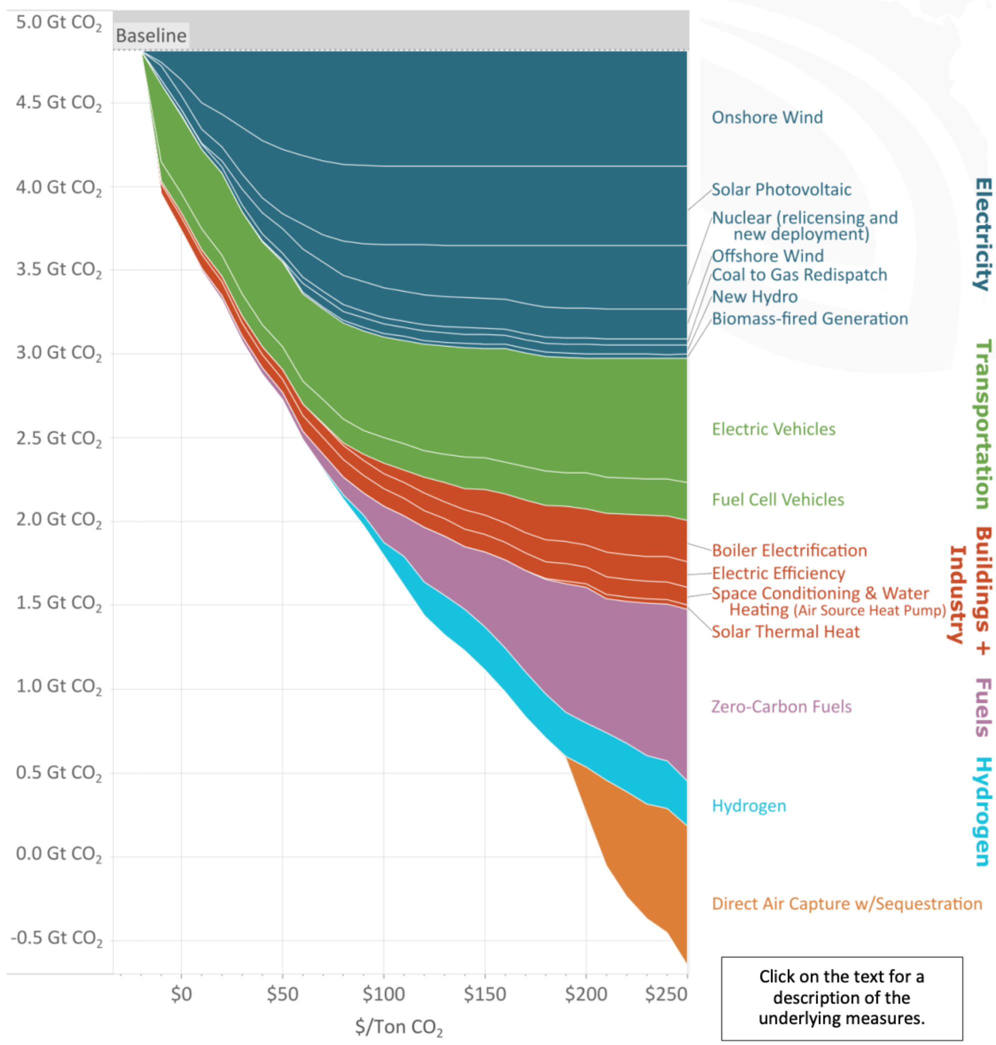
[2] Evolved Energy Research, "Marginal Abatement Cost Curves for U.S. Net-Zero Energy Systems A Systems Approach"
https://www.edf.org/sites/default/files/documents/MACC_2.0%20report_Evolved_EDF.pdf

Figure 1 – A 2050 MAC curve developed using the new approach, shows annual reductions from measures for U.S. energy and industry CO_2, where reductions are relative to 2050 emissions for a baseline scenario. Each segment represents an individual measure, and colors correspond to related groupings of measures.



Because of hydrogen’s high cost, even after taking into account likely federal subsidies, its adoption will increase capital and operating costs for most of the industries in which it is deployed. And, in some cases it will also reduce output. This effect is neatly illustrated by Lazard’s 2023 analysis of the levelized cost of electricity[3] for a variety of generating resources, including combined cycle natural gas with a 20% blend of hydrogen.

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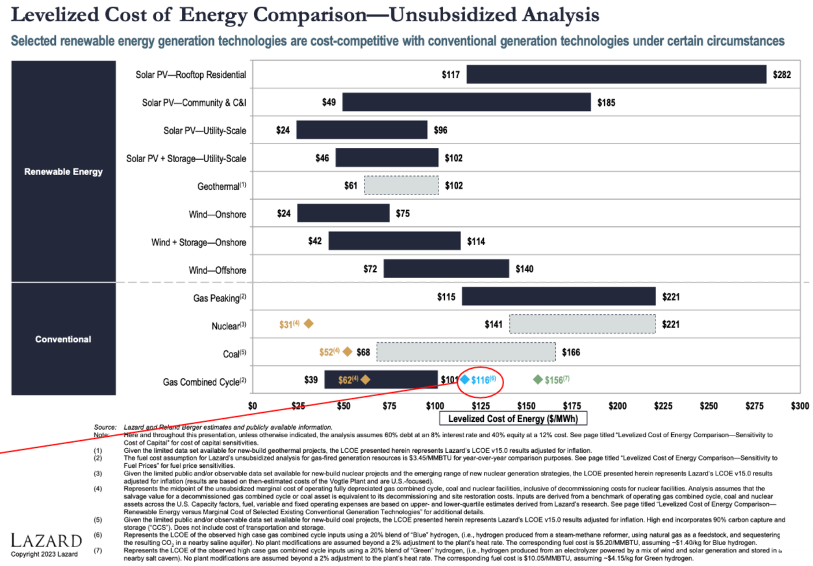
[3] Lazard, “Levelized Cost of Energy +”, April 2023. https://www.lazard.com/research-insights/2023-levelized-cost-of-energyplus/

A mere 20% blend of blue hydrogen in combined cycle gas-fired generation causes the fuel cost to rise by 50% and the total levelized cost of energy to increase by 92%, from $62/MWh to $119/MWh.

And for that near doubling of cost, you get only a 7% reduction in greenhouse gas emissions.



Natural Gas / Hydrogen Blend

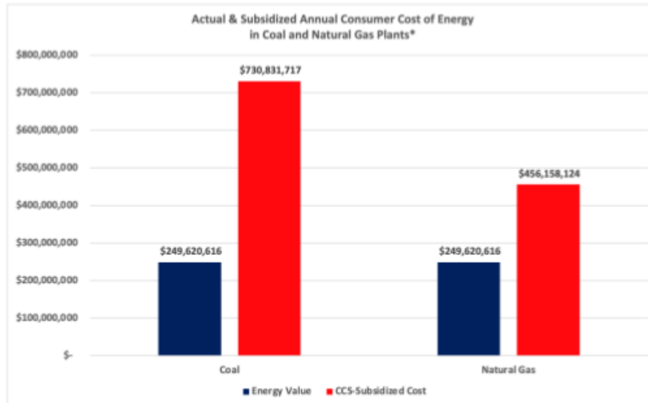
The cost increase owes to the fact that, while natural gas prices are expected to be in the $3-$3.50/mmbtu range for some time to come, even at the U.S. Department of Energy's goal price of $1/kg, hydrogen will cost $8.71/mmbtu. The reason emissions are reduced by only 7% despite a 20% blend is that, by volume, hydrogen is only 35% as dense as methane. In short, hydrogen is both costly and inefficient as a means of decarbonization.

That is why hydrogen's potential as a decarbonization technology is limited to a few niche industrial applications and why it has never been and will not ever be cost-competitive for mass consumption applications such as power generation, home heating, and light transportation, including cars and light trucks. Worryingly, some of the projects announced by ARCH2 involve these applications.

A companion technology, Carbon Capture and Sequestration (CCS), which would be required for the production of blue hydrogen from natural gas and which could, in theory, also be applied directly to other applications, such as gas and coal-fired power plants, is similarly costly and inefficient for all but a few niche industrial applications. At a cost of $85/mtCO2, which is set forth in the Inflation Reduction Act, the use of CCS in power generation would nearly double the cost of generating electricity in gas-fired power plants and almost triple the cost in coal-fired plants.

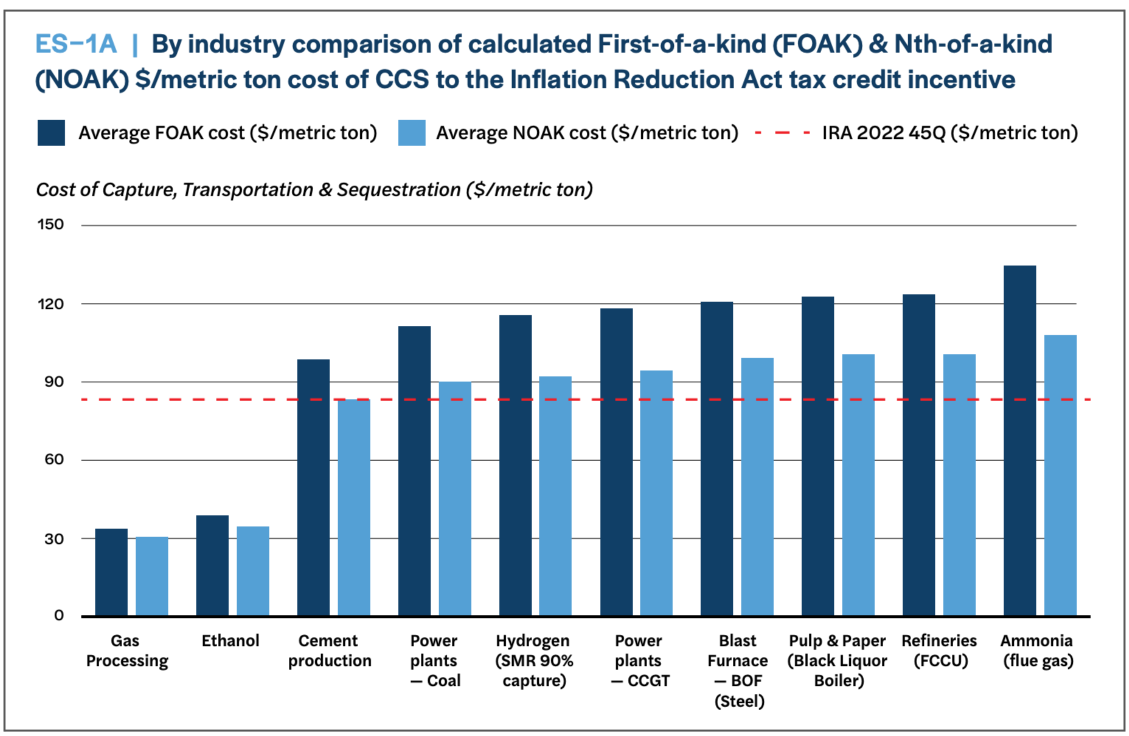
Carbon capture would nearly double the cost of electricity from natural gas and nearly triple the cost from coal.

With renewable resources, storage, energy efficiency and demand-side resources competing with and often undercutting the cost of natural gas in power generation, there is no sound rationale for subsidizing CCS-equipped fossil fuel generation, which would cost far more and be only partially effective at reducing emissions.



Coal and Natural Gas plants are assumed to have 1,000 MW capacities, operating at capacity factor of 70%.
Energy value is based on the $40.62/MWh average wholesale price of energy in the PJM market, January 1 through August 22, 2023.
Subsidized costs are based on the 45Q subsidy of $85/Metric Ton of CO2.

If CCS were to find its way into the power generating sector, we would literally pay power plants as much or more for exhuming, recapturing, and sequestering carbon than we would for generating electricity. And the figures cited above are likely to be an underestimate of the actual cost. The Energy Futures Initiative, headed by former Energy Secretary, Ernest Moniz, recently found that the $85/mtCO2 subsidy is insufficient to motivate most industries to embrace CCS, including for the production of hydrogen[4]. That is why state legislatures are being pressured to add state subsidies to those provided by the federal government.

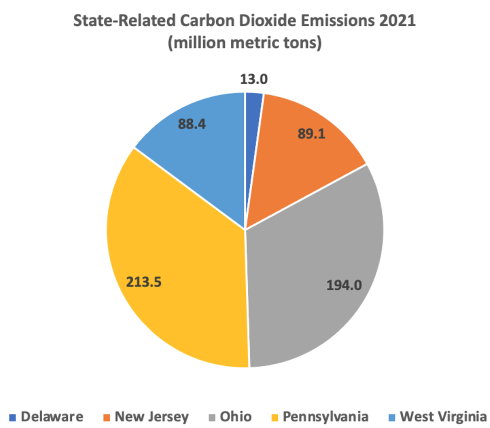


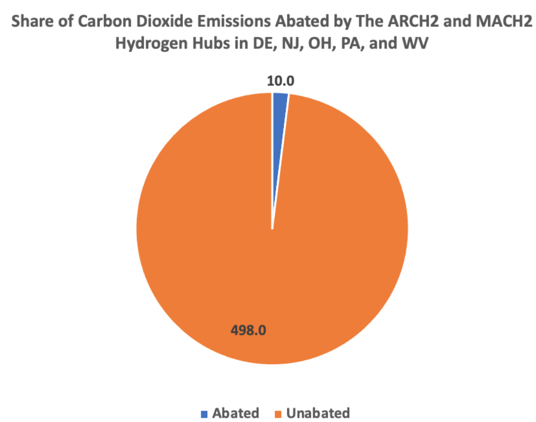
[4] Energy Futures Initiative, “Turning CCS projects in heavy industry & power into blue chip financial investments”, February 2023. https://energyfuturesinitiative.org/wp-content/uploads/sites/2/2023/02/20230212-CCS-Final_Full-copy.pdf

Hydrogen's Limited Emission Reduction Potential

Others who testify today will speak to local dangers and the threat of exacerbating global warming posed by the manufacture, transportation, and use of hydrogen, particularly blue hydrogen, which is derived from natural gas. And they will call into question whether the share of emissions that DOE and ARCH2 claim can be captured and sequestered is realistic. However, for the purpose of my testimony, we will generously assume that DOE's and ARCH2's anticipated rate of carbon capture can be attained and that the two hubs can reduce emissions by the amounts claimed.

When DOE announced the selection of the ARCH2 and MACH2 hubs for funding, it said that the ARCH2 hub would eventually deliver annual savings of 9 million metric tons of carbon emissions and the MACH2 hub would deliver savings of 1 million tons. In 2021, the five states participating in the ARCH2 and MACH2 hubs emitted a combined 598 million tons of CO_2. Therefore, the combined 10 million tons in anticipated savings from the two hubs amounts to just 1.7% of that total for the five states.





Author's calculation from EIA data.

That is not to say that hydrogen and CCS should never be used to abate emissions, because there are some industrial applications for which no practical alternatives exist. However, these applications, principally in steel and cement making, the manufacture of fertilizer, and some forms of heavy transportation, are few in number and they should be the only ones for which we resort to hydrogen as a means of decarbonization.

Will the ARCH2 and MACH2 Hubs be Fully Realized? Maybe Not.

While the combined $1.675 billion allocated by DOE for the ARCH2 and MACH2 hydrogen hubs sounds like a great deal of money, it barely scratches the surface – probably less than 5% – of the capital investments that will be required to fund the various projects that make up the two hubs. States may kick in some supplemental funding, but the vast majority of funds will have to come from the private sector. And, as we saw in the aforementioned case of the Appalachian petrochemical cluster, markets can and will refuse to underwrite ventures that they conclude are fundamentally uneconomic. That's especially true of projects whose economics are dependent on tax credits, which are scheduled to sunset in ten to twelve years with no assurance they will be extended or replaced. Some and perhaps many ARCH2 and MACH2 projects may fall into that category.

To put the relative value of the DOE allocations and the criticality of private capital to fund the hydrogen hubs in context, consider the announced economics of the Fidelis Mountaineer GigaSystem[5], an ARCH2 project located in Mason County, West Virginia. At full capacity the proposed facility would produce 234,000 metric tons of blue hydrogen annually, which is about 2.4% of DOE's production goal of 10 million tons annually from the seven hubs. However, the project's $2 billion capital cost is equivalent to more than a quarter of the entire $7 billion DOE recently allocated to developing the Regional Hydrogen Hub program. And it's more than the total combined DOE grants to the ARCH2 and MACH2 hubs.

In all, the funds that Fidelis expects to receive from DOE via ARCH2 and from the state of West Virginia, which recently approved a $62.5 million forgivable loan, come to just over $110 million, which is less than 6% of the capital cost. 90% or more of the remainder will have to come from private investors.

The equivalent of more than 40 Fidelis Mountaineer GigaSystems, with similar funding requirements, will be required to achieve DOE's hydrogen production goal for the hubs. And that doesn't include the many more billions of dollars that will be required just in ARCH2 and MACH2 to transport hydrogen and captured carbon and to equip mills, factories, and power plants to use hydrogen and/or capture their own greenhouse gas emissions.

The point is that neither recently announced DOE allocations for ARCH2 and MACH2 nor enhanced IRA tax credits make the realization of the hubs or their individual project a "done deal". Therefore, policymakers should carefully consider the allocation of additional state funds to projects, which may fail to attract sufficient private investment.

Just a few years ago the Department of Energy and many policymakers – including many who are now promoting the hydrogen hubs – were touting the creation of an Appalachian petrochemical cluster. It was called "Shale Crescent USA[6]" and some said that it could rival in size the Gulf Coast petrochemical cluster. The Department of Energy[7] embraced a 2017 American Chemistry Council economic impact study[8], which anticipated the construction of five world class ethane crackers in Appalachia along with four other major infrastructure elements.

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[5] Fidelis Mountaineer GigaSystem website, https://fidelisinfra.com/project/mountaineer-gigasystem/
[6] Shale Crescent USA website, https://shalecrescentusa.com/
[7] U.S. Department of Energy, "Appalachian Energy and Petrochemical Renaissance", July 1, 2020. https://www.energy.gov/articles/appalachian-energy-and-petrochemical-renaissance-report-stakeholder-statements
[8] American Chemistry Council, "Appalachian Region Could Become a Petrochemicals & Plastics Manufacturing Hub", May 2017. https://www.americanchemistry.com/better-policy-regulation/energy/resources/appalachian-region-could-become-a-petrochemicals-plastics-manufacturing-hub

The prediction was that, between these nine major projects and an accompanying burst in downstream manufacturing activity, the region could see the creation of 100,000 jobs by 2025. Apart from the Shell cracker, which provides about 400 jobs after receiving the largest subsidy in Pennsylvania history[9], none of it ever happened.

We can't afford to be seduced again into throwing money at projects that may be fundamentally uneconomic and of which investors will conclude that the risks are too great. Even in a "best case" scenario, the hubs will entail a vast expenditure of funds with only modest emission reductions in return. But there is a worst case scenario in which, despite major DOE funding, a significant number of hydrogen projects fail to come to fruition and any supplemental funding provided by the Commonwealth becomes good money chasing bad.

The Hydrogen Hubs' Meager Economic Impacts

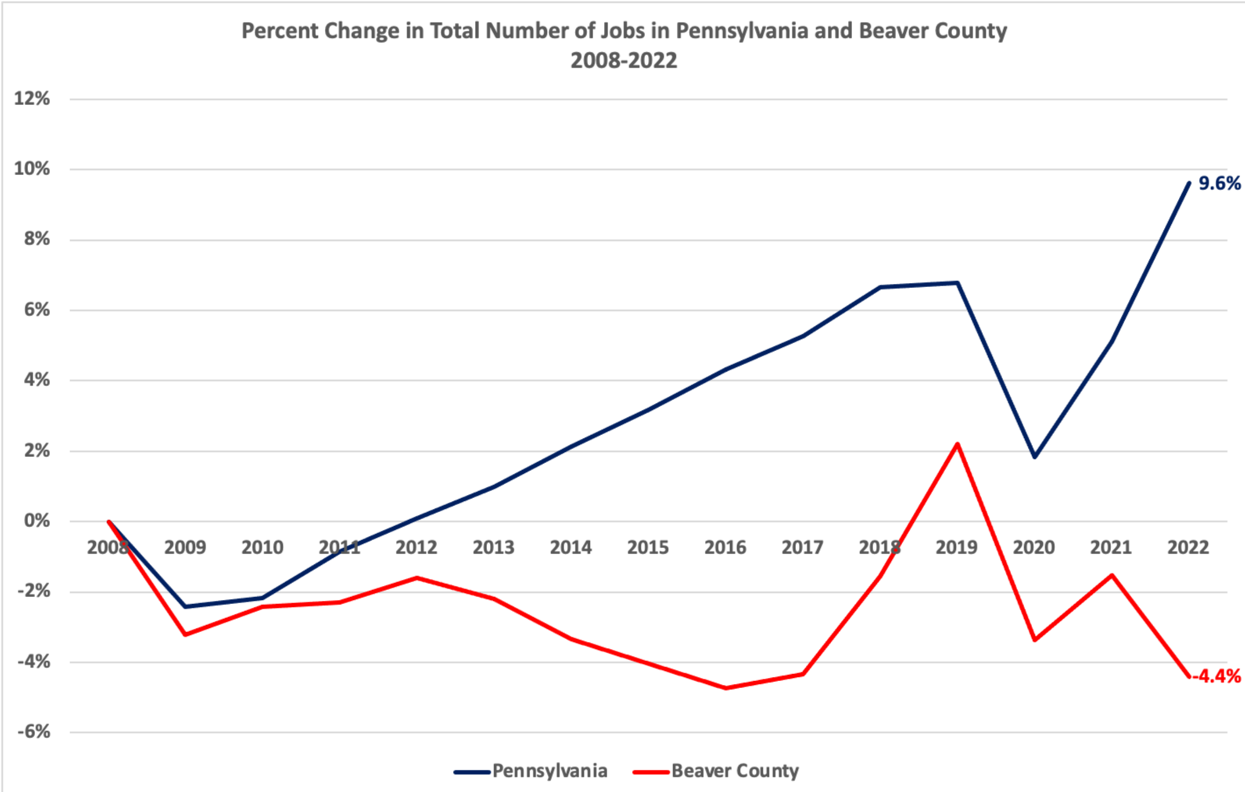
In its announcement[10] that the ARCH2 and MACH2 hubs had been selected for federal funding, DOE indicated that the ARCH2 hub would "create more than 21,000 direct jobs – including more than 18,000 in construction and more than 3,000 permanent jobs" and that the MACH2 hub "anticipates creating 20,800 direct jobs—14,400 in construction jobs and 6,400 permanent jobs".

We don't know the provenance of these figures and they assume that all of the hubs' projects will be realized. Still, it's worth setting aside for the moment any qualms to consider the significance of these figures and what history teaches us about energy-related growth and its effects on jobs, income, and population in local economies. The Shell ethane cracker in Beaver County is a good starting point.

Beaver County had been struggling with job growth for a number of years prior to the start of construction on the Shell cracker. Then, in 2017, as construction got into full swing, we saw a spike in employment. However, as quickly as employment rose, it then declined as construction was completed. Fairly quickly, job growth in Beaver County reverted to its pre-construction baseline, suggesting that cracker operations are now doing little to boost employment.

[9] PennFuture, "Buried Out of Sight: Uncovering Pennsylanvia's Hidden Fossil Fuel Subsidies", February 2021. https://www.pennfuture.org/Files/Admin/PF_FossilFuel_Report_final_2.12.21.pdf

[10] U.S. Department of Energy, Office of Clean Energy Demonstrations, "Regional Clean Hydrogen Hubs Selections for Award Negotiations". https://www.energy.gov/oced/regional-clean-hydrogen-hubs-selections-award-negotiations

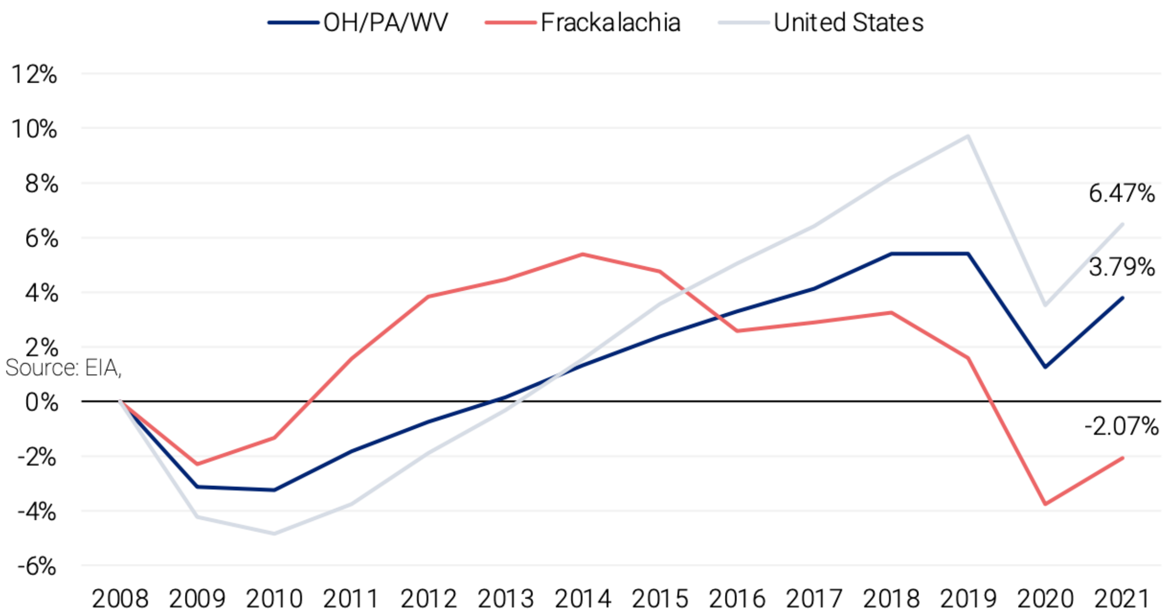


Bureau of Economic Analysis, CAEMP25N Total full-time and part-time employment by NAICS industry

This isn't an isolated phenomenon. We know, for instance, that the same thing happened with the Appalachian natural gas boom. After an initial surge in jobs starting in 2008, by 2013 jobs were in decline in the twenty-two Appalachian counties where gas production is concentrated so that, by the year 2020, there were fewer jobs in major gas producing counties than there were before the start of the natural gas boom[11].

[11] Ohio River Valley Institute, "Frackalachia Update", September 2023. https://ohiorivervalleyinstitute.org/wp-content/uploads/2023/08/Frackalachia-Update-FINAL.pdf

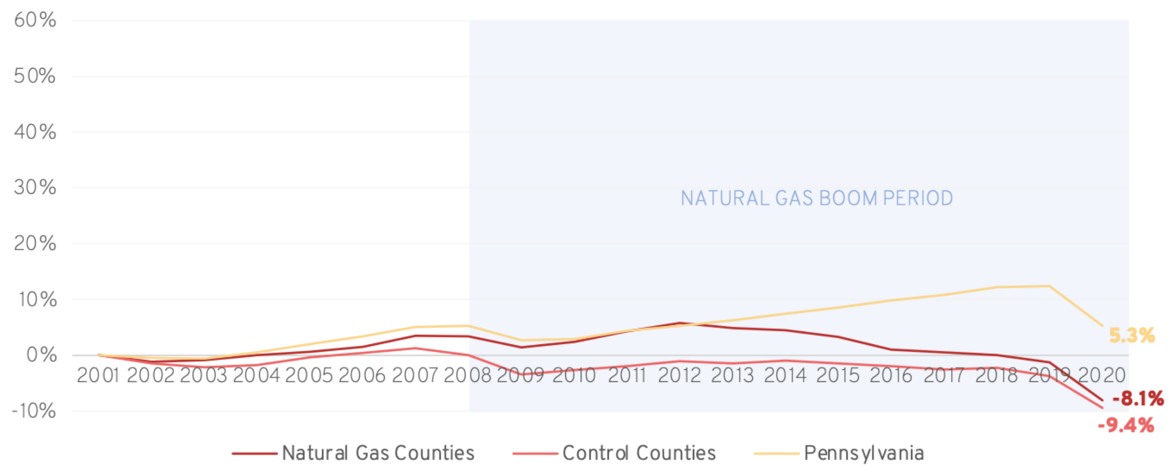
Figure 13: Cumulative Change in Total Employment, 2008-2021



Source: Bureau of Economic Analysis, CAEMP25N Total full-time and part-time employment by NAICS industry

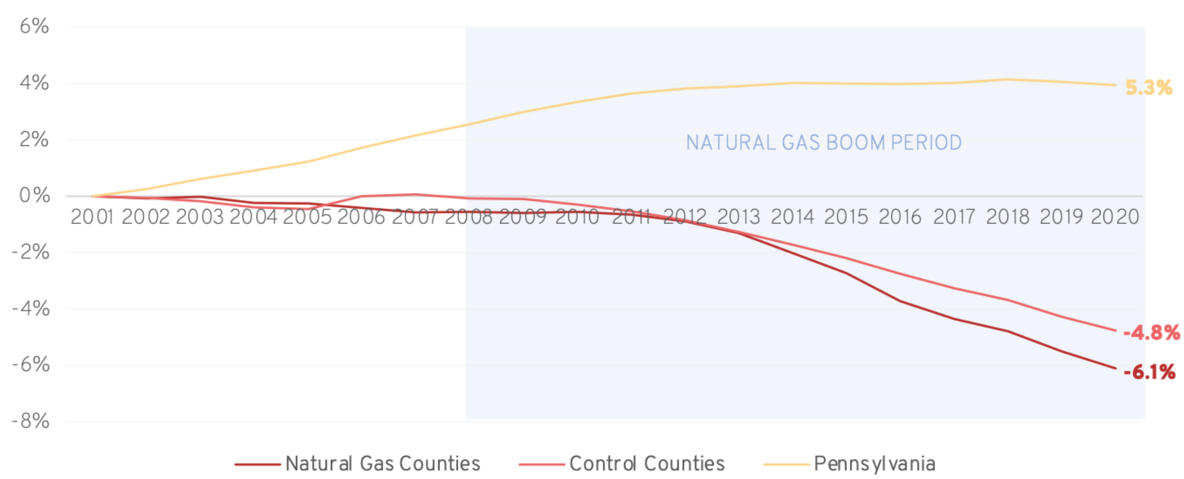
The situation is even worse in rural Pennsylvania counties where the natural gas boom was strongly felt. Not only did these counties experience deeper job losses than non-rural counties, their job losses were nearly as great as other rural counties that were not heavily impacted by the natural gas boom, suggesting that gas production failed to stave off employment decline. And population loss was even greater in the rural natural gas counties than it was in rural counties that weren't gas-impacted.

Figure 4: Change in Total Employment, 2001-2020



Source: Author's calculations using Bureau of Economic Analysis data

Figure 5: Change in Population, 2001-2020



Source: Author's calculations using Bureau of Economic Analysis data

This is all preface to pointing out that most large-scale energy-related development is relatively ineffective in bringing about increases in jobs and economic prosperity. And, as the charts comparing job and population change in rural gas and non-gas counties shows, it's not because failings in other parts of the economy offset the benefits of energy development. It's because the energy sector is one of the least labor-intensive sectors in the U.S. economy. In 2021, ORVI published a report[12] examining the structural issues in the natural gas and energy economy that produced the paradoxical outcome of vast increases in investment and output being accompanied by anemic and, because of negative impacts on quality of life, sometimes negative effects on jobs and population.

These structural reasons explain why, despite the many billions of dollars of investments that would be associated with the ARCH2 and MACH2 hydrogen hubs, their job impacts would be modest. 3,000 permanent jobs in ARCH2 combined with 6,400 in MACH2[13] represent an increase in total jobs of just four one-hundredths of one percent spread out across five states. It's a number too small to be charted.

These figures are particularly relevant in the ARCH2 region, whose footprint more or less overlays the Marcellus and Utica shale fields that gave rise to the Appalachian natural gas boom and where job and population loss are at their worst. The notion that, by promoting the development of blue hydrogen, we would be helping that region economically by boosting its natural gas industry is at best misguided and at worst cruel.

Conclusion

The greatest risk posed by the hydrogen hubs is that overly generous government subsidies will motivate developers to propose applications for hydrogen for which it is fundamentally uneconomic and for which cleaner and less expensive options are available. The imposition of hydrogen in industries such as power generation, home heating, and light transportation would not only increase costs for taxpayers, ratepayers, and customers, it would, to the degree the hydrogen is made from natural gas, worsen the forces driving job and population losses that are being experienced in the major natural gas-producing counties of Pennsylvania, Ohio, and West Virginia.

State legislatures should try to ensure that hydrogen stays in its economic lanes and that economically justifiable needs for hydrogen are met as much as possible with green hydrogen rather than blue. By tailoring incentives and funding to achieve these outcomes, Pennsylvania can get optimum value from the development of hydrogen with the least possible cost and best possible impact on job creation and economic prosperity.

Thank you.

[12] Ohio River Valley Institute, "Destined to Fail: Why the Appalachian Natural Gas Boom Failed to Deliver on Jobs & Prosperity and What it Teaches Us", July 2021.
https://ohiorivervalleyinstitute.org/wp-content/uploads/2021/07/Destined-to-Fail-FINAL.pdf

[13] U.S. Department of Energy, Office of Clean Energy Demonstrations, "Regional Clean Hydrogen Hubs Selections for Award Negotiations".
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