Decarb Infra Invest Toolkit

BACKGROUND:

On September 19-21, Decarb Connect will host Decarb Infra Invest, an in-person conference in Pittsburgh to advance the deployment of "large-scale decarbonization projects"—namely, blue hydrogen and carbon capture hubs. The event will host 30+ speakers and 200+ attendees from project developers, industrials, investors and government representatives to "explore different business models, partnerships and financing structures for large scale projects and assess the benefits and challenges of developing industrial hub and cluster projects at scale." Click here to view the conference agenda.

Research from the Ohio River Valley Institute shows that methane-based blue hydrogen projects equipped with carbon capture technology are false climate solutions & economic boondoggles. These technologies harm communities, cost billions, and do little to reduce climate-warming emissions.

Keep reading to learn more about the risks of blue hydrogen and carbon capture development and the promise of alternative models of economic development.

CONTENTS:

[Click to jump]

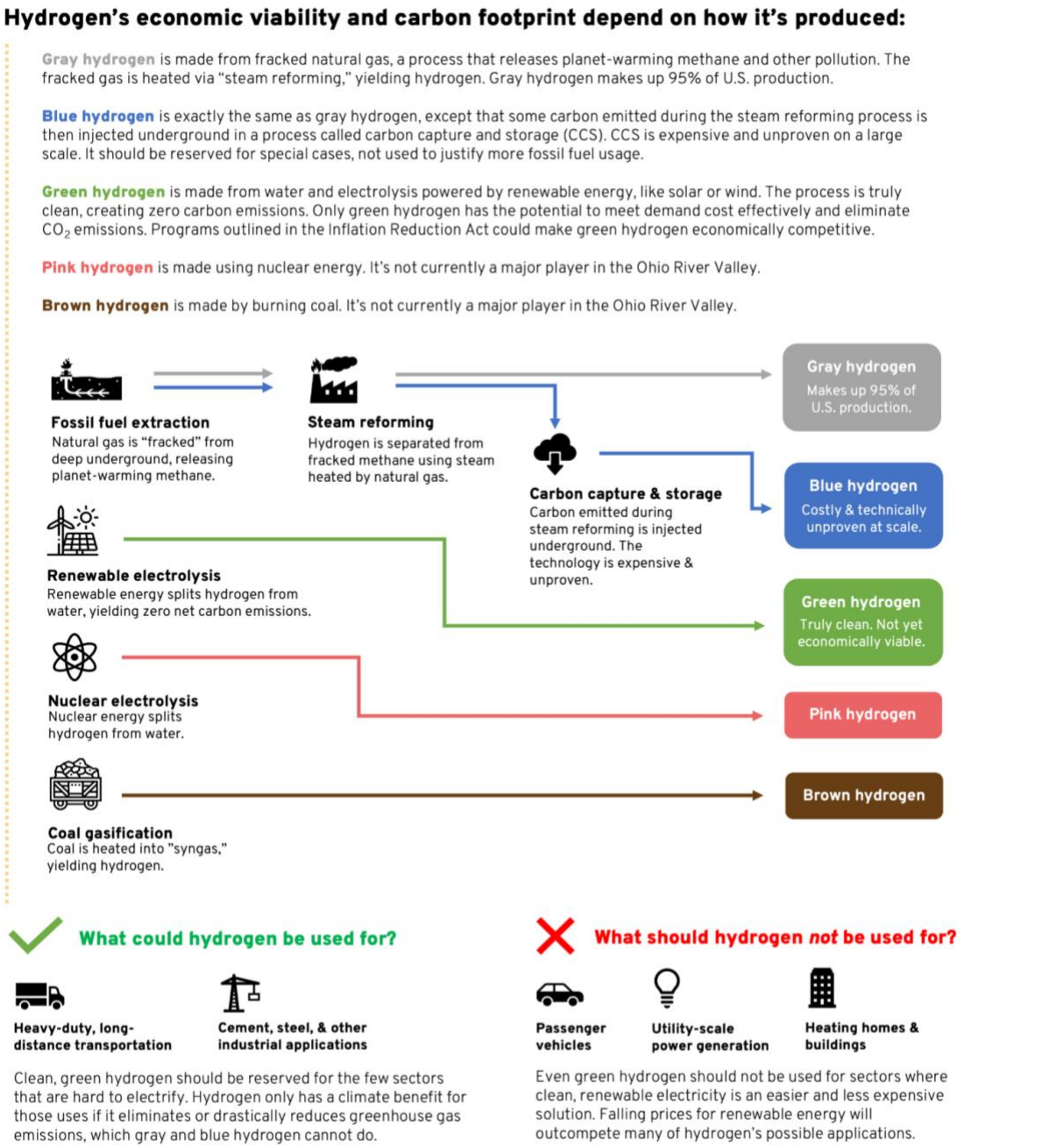
WHAT IS A HYDROGEN 'HUB'?

A hydrogen hub is a proposed network of hydrogen producers and consumers, but this vision is unlikely to come to fruition due to high costs and operational challenges.

The Bipartisan Infrastructure Law set aside $7 billion to build 6 to 10 regional hydrogen hubs across the United States. Each "hub" would create a regional network of pipelines and other industrial infrastructure to produce, transport and use hydrogen. While each hub proposal is unique, the hubs proposed for our region are likely to include large industrial sites, manufacturing facilities, and power plants connected to hydrogen producers and carbon storage sites via a large system of pipelines. Both of the hydrogen hubs in Appalachia have plants to cover dozens of counties in Ohio, Pennsylvania, and West Virginia, meaning many communities in our region could be impacted in a variety of ways.

Federal officials and many of the companies involved characterize hydrogen as a low- to no-emission energy source, for use by energy-intensive industries like steel, cement or aviation. States and companies throughout the country, including in Appalachia, have teamed up to submit hub proposals to the U.S. Department of Energy, which is expected to start awarding money later this year.

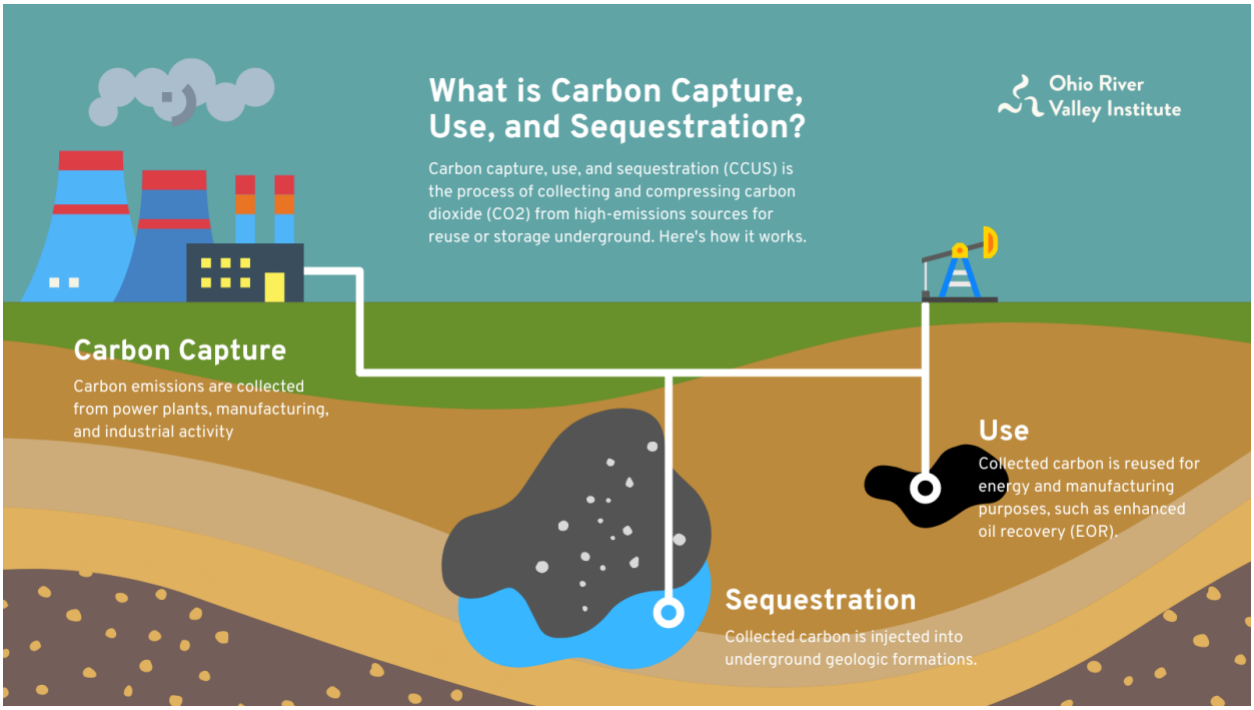
More than 95% of hydrogen produced today is dirty, made from climate-warming methane using fracked gas. Truly clean, "green" hydrogen could play an important role in a decarbonized economy, but it's not yet market-ready. Ultimately, the carbon footprint of hydrogen depends on how it's produced:



The hubs proposed for Appalachia would primarily make blue hydrogen from fracked methane gas, meaning that developing a hub would perpetuate and could even increase fracking pollution. These plans have largely been developed without public notice or community input, despite the wide range of impacts these plans could have on communities in the region.

These hubs also depend on carbon capture and storage, or CCS, technology to remove carbon dioxide emissions. However, CCS technology is largely unproven at scale and CCS projects have been unable to

demonstrate consistently high rates of carbon capture, often performing well below targets. Even though the technology has been explored since the 1970s, billions of dollars in investment and subsidies would be needed to capture significant carbon emissions. Even if CCS did work, it does not address the other air, water, and ground pollutants caused by generating power from coal and natural gas or potential threats to water resources when carbon is stored underground.



WHAT WOULD BLUE HYDROGEN HUBS MEAN FOR OUR REGION?

- **More fracking.** Carbon capture and hydrogen mean more drilling, more compressor stations, more trucking, and more fracking waste. Blue hydrogen is made from fracked methane gas. Increasing hydrogen production, especially through the development of regional hydrogen 'hubs,' will likely expand fracking operations in our region.

- **Higher prices.** A regional hydrogen and carbon capture hub would be wildly expensive, and the cost would fall largely on taxpayers or ratepayers. According to federal estimates, hydrogen hubs could cost as much as $230 billion just to construct. And retrofitting just the nation's coal and gas-fired power plants with carbon capture and storage technology would add about $100 billion per year—$1 trillion over 10 years—to Americans' electric bills, an increase of 25%.

- **Few new jobs.** Hydrogen and carbon capture development would not stimulate major job growth or prosperity and would lock in a fossil fuel economy that has caused the region to shed jobs and population. Except for a temporary blip in construction jobs, the hub would do nothing

to create new permanent employment.

- **Dangerous pipelines.** Carbon pipelines are leak-prone and dangerous. Existing natural gas pipelines cannot safely transport carbon dioxide. New pipelines will have to be constructed to carry captured CO2 emissions to storage caverns. These pipelines are volatile and unsafe: condensed CO2 can corrode steel, particularly if exposed to water, increasing the risk of dangerous leaks, ruptures, and explosions. A carbon pipeline rupture in Satartia, MS in 2020 released a noxious, green fog that poisoned dozens in their cars and homes, leaving many hospitalized and some with permanent injuries.

- **Continued pollution.** The hydrogen and carbon capture hub likely won't address other hazardous air pollutants from carbon-emitting facilities. Depending on the type of carbon capture technology that is used, power plants and industrial facilities could continue to spew nitrogen oxide, volatile organic compounds, and other health-endangering pollutants into the air. The demand for methane that new blue hydrogen facilities would create would also mean more air and water pollution from fracking operations.

- **Climate inaction.** The hydrogen hub would do a poor job of capturing climate-warming carbon. For one, carbon capture does nothing to reduce the "upstream" emissions that are produced when natural gas is extracted and transported. Frack pads and compressor stations release huge amounts of methane into the atmosphere. And, carbon capture technologies are only expected to capture a maximum of 90% of plant and factory emissions. Existing pilot projects often capture far less than that. Transitioning to renewable energy is a far cheaper and more effective way of decarbonizing our region's economy.

- **Economic stagnation.** Developing a hydrogen hub would increase demand for natural gas, expanding and prolonging a fracking-based economy that has seen declining jobs and population since the beginning of the shale gas boom in 2008. The natural gas industry is structurally incapable of creating local economic prosperity—we can't afford to bail it out for decades to come. Worse, investing in hydrogen and carbon capture technologies would stall progress on real climate solutions, like the renewables that are cheaper than ever and can actually help mitigate carbon emissions while creating thousands of jobs.

Learn more at www.appalachiahydrogenfacts.org.

WHAT WE KNOW ABOUT BLUE HYDROGEN HUB PLANS

Regional blue hydrogen hub projects DNA H2Hub & ARCH2 — recently listed by Rystad Energy as one of the "top ten" hub proposals most likely to win federal funding — have received encouragement notifications from the US Department of Energy. The Ohio River Valley Institute & partners have identified serious economic, environmental, and public health concerns with these projects, both of

which would deploy an interstate network of carbon capture and storage infrastructure to support various blue hydrogen production facilities across the region.

- Click here to learn more about the DNA H2Hub and ARCH2 projects.

A CLEAN ENERGY PATHWAY FOR SOUTHWESTERN PENNSYLVANIA

A December 2022 report published by Strategen and ORVI describes a clean energy pathway for the 10-county region of southwestern Pennsylvania.

Due to its abundance of fossil fuel resources, the region has a long history of substantial energy production, often at the expense of local environmental quality and economic diversity. A transition to clean energy provides a compelling opportunity to transform the local energy profile, while ending the region's overreliance on fossil fuels, to reduce emissions and pursue a path of sustainable growth.

In contrast to expensive, unproven blue hydrogen and carbon capture technologies, our analysis outlines an alternative focused on zero emissions resources, energy efficiency, increased electrification, and leveraging clean energy imports from outside the region, while minimizing the local need for fossil fuels.

The Clean Energy Pathway is 13% less expensive than blue hydrogen- and carbon capture-based pathways, and it cuts 97% of the region's climate-warming power sector emissions by 2050.

- Check out our report summary below to learn more, and read the full report at https://ohiorivervalleyinstitute.org/a-clean-energy-pathway-for-southwestern-pennsylvania/.

A Clean Energy Pathway for Southwestern Pennsylvania

Ohio River Valley Institute

A new report from Strategen and the Ohio River Valley Institute sketches a pathway for clean energy transition in Southwestern Pennsylvania. The pathway cuts polluting emissions, creates lasting job growth, and lowers costs for families. Here's how it works:

Curbing harmful, polluting fossil fuels.

The Clean Energy Pathway phases out coal energy and most natural gas energy in the region by 2050. cutting our power grid's planet-warming CO2 emissions by 97% and saving nearly $2.7 billion per year in environmental and health costs.

Investing in wind, solar, and hydropower.

Southwestern Pennsylvania has lots of opportunity for wind and hydropower energy. Renewable energy is now cheaper than ever. It's the most effective way to cut our region's carbon footprint.

Electrifying cars, trucks, and buildings.

Heating our homes and powering our vehicles with clean energy reduces CO2 emissions. It also saves the region an extra $1.5 billion in environmental and health benefits.

Making our homes, stores, and workplaces more energy efficient.

Energy efficiency upgrades—things like improving insulation, updating appliances, and repairing HVAC systems—cut down on energy use and save families money on their utility bills. They will also create 15,000 local, good-paying jobs by 2050.

Sharing renewable resources with the region.

Nearby states also have great potential for wind, solar, and hydropower energy. Sharing resources allows us all to reduce our carbon output.

Learn more:

By the Numbers

Why the Clean Energy Pathway is the best choice for Southwestern Pennsylvania:

It's cheaper for Pennsylvania families.

The fossil fuel industry wants to use natural gas & carbon capture technology to make blue hydrogen. The problem? The technologies are expensive, and they would raise taxes or utility rates. Altogether, hydrogen and carbon capture could cost Pennsylvania families upwards of $1,000 per year.

13%

The Clean Energy Pathway is **13% less expensive** than competing natural gas and carbon capture pathways.

92%

The Clean Energy Pathway **reduces power sector CO2 emissions by 92%** by 2035.

It does a better job of lowering CO2 emissions.

More natural gas means more emissions. Making hydrogen with natural gas and carbon capture is a step backward for the climate. The Clean energy pathway allows us to meet our climate goals.

It creates more jobs.

The natural gas industry hasn't grown jobs in the Ohio River Valley since the beginning of the fracking boom. Doubling down on more gas production is a dead end. Renewable energy and energy efficiency investments are proven job creators.

12,416

Investing in efficiency and renewables **supports 12,416 total jobs by 2035.**

It makes the region a better place to live.

More natural gas means more emissions. Making hydrogen with natural gas and carbon capture is a big step backward for the climate and the environment. A clean energy pathway would allow the region to meet our climate goals.

THE CENTRALIA MODEL FOR ECONOMIC TRANSITION

A new economic development model centering high-multiplier investments in energy efficiency, weatherization, distributed generation, and education could help struggling Appalachian communities spark job, population, and income growth, according to a forthcoming study from the Ohio State University's Swank Program in Rural-Urban Policy.

- Click here to view a summary and the full report (available Wednesday, Sept. 20).

The report, "A Bigger Bang Approach to Economic Development: An Application to Rural Appalachian Ohio Energy Boomtowns," uses a 'synthetic control' approach to demonstrate how the once-struggling coal town of Centralia, WA leveraged economic transition funding to achieve job and economic growth double the national average.

After two decades of zero job growth, the Centralia micropolitan statistical area, which includes surrounding Lewis County, looked to be on the verge of a downward "death spiral" when the town's local coal mine and coal-fired power plant, the two largest employers in the area, announced plans to shut down operations. As the mine and power plant started shedding workers, Centralia negotiated a $55 million Coal Transition Grant Program with the facilities' owner, TransAlta, to invest in clean energy, energy efficiency, and education, with a particular focus on construction, small businesses, and firm startups.

The results have been "remarkable." Since the program started distributing grant funding in 2016, Lewis County's declining economy has rebounded, adding new jobs at twice the rate of the nation and triggering wage growth 50% greater than the national average.

The study's "synthetic control" demonstrates a causal link between the Centralia Model's investment priorities, first outlined by a 2021 Ohio River Valley Institute report, and Lewis County's remarkable economic reversal. Ohio State researchers constructed a counterfactual synthetic control variable using aggregate data from nearby communities with demographics and economies similar to Centralia's. In the years immediately following grant distribution, Lewis County grew jobs and personal incomes nearly 2% faster than the synthetic control county.

Because their economies are very similar to Centralia's in its pre-boom era, struggling energy communities across the Ohio River Valley may be able to replicate Lewis County's economic turnaround by implementing the Centralia Model, the report finds.

According to federal economic data, many communities in the region, and particularly those with a history of resource extraction, have fallen behind the nation in job, population, and income growth. Since the beginning of the shale gas boom in 2008, the largest gas-producing counties in Ohio, Pennsylvania, and West Virginia have lost more than 10,000 net jobs and nearly 47,000 residents, according to new research from the Ohio River Valley Institute. Efforts to spark a petrochemical

renaissance with the region's abundant natural gas reserves have similarly produced poor economic outcomes. After Pennsylvania invested $1.6 billion in public subsidies to launch the Shell Polymers Monaca petrochemical complex, research shows surrounding Beaver County has fallen behind the nation in nearly every indicator of economic activity.

"A Bigger Bang Approach to Economic Development" explains that oil and gas development produces relatively small "multiplier effects," or spillovers of positive economic activity. New economic activity generally triggers a ripple of job growth as supply chains form or expand to meet the needs of new industry or as new workers spend their wages in the local economy. But compared to other industries, few jobs are created to help support the oil & gas supply chain, and few local jobs are created as a result of oil & gas worker spending, the report shows.

Conversely, the industries targeted by the Centralia Model trigger relatively large multiplier effects. Centralia's transition grant funding invests in highly labor-intensive local economic activity, such as energy efficiency and weatherization work conducted by local contractors and construction companies. These investments create local jobs, generate additional monthly utility savings, and increased property values. Other uses of the funds include investments in quality-of-life amenities in the area, local business improvement, and attracting additional outside dollars from partners to fund novel start-ups and research into how Centralia can capitalize on technological changes in the new energy economy.

Now, money is on the table to help distressed communities across northern Appalachia replicate Centralia's economic turnaround. The Inflation Reduction Act's Greenhouse Gas Reduction Fund sets aside $27 billion to help low-income and disadvantaged communities deploy zero-emission technology and make homes and buildings more energy efficient. By utilizing funding from these and other sources wisely, and creating partnerships to leverage funding, distressed communities across the Ohio River Valley can build stronger, more diverse, and resilient economies that leverage local residents' skills and improve health, incomes and employment, and quality of life.

GREEN STEEL IN THE OHIO RIVER VALLEY

For more than a century, steel has played an important role in the economy and culture of the Ohio River Valley. But the traditional method of making steel, known as BF-BOF (blast furnace-blast oxygen furnace), requires lots of energy and produces lots of climate-warming emissions. The iron and steel sector is currently responsible for about 7% of global greenhouse gas (GHG) emissions, according to the International Energy Agency.

Shifting to "green" steelmaking could reduce greenhouse gas emissions, boost jobs, and grow the region's economy. Fossil fuel-free DRI-EAF (direct reduced iron-electric arc furnace) steelmaking uses green hydrogen—created with wind and solar energy—to make steel with nearly zero climate-warming emissions.

Investing in fossil fuel-free steelmaking is a win for the climate and the economy. An April 2023 report from the Ohio River Valley Institute looks at Mon Valley Works, a steelmaking facility in southwestern Pennsylvania, as a model for transitioning from carbon-intensive BF-BOF steelmaking to fossil fuel-free DRI-EAF steelmaking.

Click here to view and download the full report.

Key Takeaways:

- A transition to fossil fuel-free steelmaking could grow total jobs supported by steelmaking in the region by 27% to 43% by 2031, forestalling projected job losses. Regional jobs supported by traditional steelmaking are expected to fall by 30% in the same period, data show.

- Transitioning to fossil fuel-free steelmaking will cut Pennsylvania's industrial sector emissions by 4 million metric tons of CO2e per year, improving quality of life and saving the state $380 million in health, community, and environmental costs.

- The Ohio River Valley is uniquely positioned to become a decarbonized industrial hub. A skilled workforce with applicable manufacturing experience, ready access to water and iron ore, and high potential for solar, wind, and green hydrogen development situate the region to lead a growing green manufacturing industry.

- Billions in federal funding from the Bipartisan Infrastructure Law, the Inflation Reduction Act, and the CHIPS and Science Act will boost demand for American-made steel while supporting worker retraining programs, hydrogen infrastructure, and renewable energy development.

ADDITIONAL RESOURCES

Hydrogen Hub Proposals: The State of Play

- **Appalachia Hydrogen Facts** | ORVI, Jun. 2023
    - A public-facing repository of information on carbon capture and hydrogen hubs—what they entail, where they come from, and how they stand to impact the region's public health, environment, and economy.

- **Hydrogen Hubs: Get to Know the Encouraged Applicants** | RFF, Feb. 2023
    - RFF analysts discuss the profiles of encouraged applicants for federal Regional Clean Hydrogen Hubs funding, including feedstocks, end uses, and partners.

- **Regional Clean Hydrogen Hub Funding Opportunity Announcement** | US Dept. of Energy, Sep. 2022

- This document outlines the parameters of the Regional Clean Hydrogen Hub program, including program goals, application requirements, and other information for applicants.

- **Community Benefits Plan Guidance** | US Dept. of Energy, Oct. 2022
  - This supplement to the FOA is intended to support applicants in developing the community benefits plans required in the application for hydrogen hub funding.

- **H2Hubs Applicant Informational Webinar** | US Dept. of Energy, Jan. 2023
  - This webinar was hosted by the Office of Clean Energy Demonstrations and was intended to provide information to prospective applicants regarding the Regional Clean Hydrogen Hubs program, the funding application, and the community benefits plan.

- **Regional Clean Hydrogen Hubs Notifications** | US Dept. of Energy, Apr. 2023
  - In December 2022, the US Department of Energy's Office of Clean Energy Demonstrations gave encouragement or discouragement notifications to Concept Papers submitted for the Regional Clean Hydrogen Hubs program. This page outlines the assessment process and includes Frequently Asked Questions about the program structure.

Clean Hydrogen

- **How green is blue hydrogen?** | Robert Howarth and Mark Jacobson, Aug. 2021
  - A peer-reviewed study of blue hydrogen's lifecycle greenhouse gas emissions accounting for emissions of both carbon dioxide and unburned fugitive methane. The analysis finds that the greenhouse gas footprint of blue hydrogen is more than 20% greater than burning natural gas or coal for heat and some 60% greater than burning diesel oil for heat. Blue hydrogen's total carbon dioxide equivalent emissions are 9%-12% lower than gray hydrogen's, though fugitive methane emissions for blue hydrogen are higher than for gray hydrogen because of an increased use of natural gas to power the carbon capture.

- **Fact-checking PA Politicians' Blue Hydrogen Hype in the Wake of House Bill 1059** | ORVI, Nov. 2022
  - This blog breaks down Pennsylvania's billion dollar blue hydrogen subsidy and fact checks claims regarding blue hydrogen's economic viability, impacts, and role in decarbonization.

- **System Design to Enable True Green Hydrogen** | ORVI, Apr. 2023
  - This brief sidebar from ORVI's *Green Steel in the Ohio River Valley* report outlines the conditions needed to ensure that green hydrogen maximizes its climate reduction

potential, including additionality, regionality, and time-matching — the three pillars of green hydrogen.

- **Clean Hydrogen Production Standard** | U.S. Dept. of Energy, Jun. 2023
    - This guidance document establishes a target of 4.0 kgCO2e/kgH2 for life cycle greenhouse emissions associated with hydrogen production. The Clean Hydrogen Production Standard is an essential element of the Regional Clean Hydrogen Hub program.

- **Feedback to the Proposed Clean Hydrogen Production Standard** | ORVI, Nov. 2022
    - This comment outlines recommendations for developing the standard, including region-specific considerations for the DOE regarding the carbon intensity of the grid in the Ohio River Valley, the need to weigh decisions based on alternatives to blue hydrogen production, and how best to calculate lifecycle emissions reductions.

- **Request for Comments on 45V Hydrogen Production Tax Credit** | Internal Revenue Service, Nov. 2022
    - This document requests feedback from the public to support the development of guidance for implementing the 45V hydrogen production tax credit, including defining clean hydrogen and reporting requirements.

Decarbonization, Permitting, and Environmental Justice

- **Carbon capture's methane problem** | IEEFA, Aug. 2022
    - Enchant Energy's San Juan Generating Station in New Mexico is a case study of the real-world carbon mitigation potential of carbon capture technology on coal-fired power plants. Including the substantial "upstream" methane emissions from the coal mine that supplies fuel to the station, IEEFA analysis finds that the project's effective carbon capture rate would be no more than 72%, not the 90% that Enchant claims. The problem of associated methane emissions is endemic to all coal and natural gas plants with proposed carbon capture retrofits, as well as the blue hydrogen hubs seeking state & federal subsidies.

- **Industry is Misleading the Public on Carbon Capture, Internal Documents Show** | ORVI, Oct. 2022
    - Fossil fuel companies are misleading the public about carbon capture technology, according to internal documents unearthed as part of the US House Committee on Oversight and Reform investigation into fossil fuel company misinformation. Private conversations between top employees of major oil and gas corporations reveal that the industry is pushing carbon capture as a climate solution, despite private acknowledgement that the technology is meant primarily to prolong and expand oil and

gas drilling.

- **PA Health and Environment Study** | University of Pittsburgh, Pennsylvania Department of Health, Aug. 2023
    - Children who lived closer to natural gas wells in Pennsylvania fracking counties were more likely to develop lymphoma, a relatively rare form of cancer, and nearby residents of all ages had an increased chance of severe asthma reactions, according to this series of major health studies first announced by former Pennsylvania Gov. Tom Wolf in 2019. The studies were prompted by years of community advocacy in rural Southwestern Pennsylvania, where shale gas companies have drilled more than 3,500 wells since 2008 and dozens of children and young adults have been diagnosed with Ewing sarcoma and other forms of cancer.

- **The Gassing of Satartia** | HuffPost, Aug. 2021
    - Journalist Dan Zegart depicts the February 2020 carbon pipeline rupture in Satartia, MS that hospitalized nearly fifty people and forced hundreds to evacuate their homes. Scaling carbon transportation infrastructure could place more communities at risk of similar disasters.

- **Carbon Dioxide Pipelines: Dangerous and Under-Regulated** | Pipeline Safety Trust, 2023
    - Accufacts Inc. prepared this report on behalf of Pipeline Safety Trust and identified significant gaps in regulations for pipeline transport of carbon dioxide. The report outlines critical health and environmental risks associated with this practice and includes recommendations for federal policymakers.

- **PHMSA Failure Investigation Report - Denbury Gulf Coast Pipelines, LLC** | US Department of Transportation, Pipeline and Hazardous Materials Safety Administration, Office of Pipeline Safety, May 2022
    - This report was issued by regulators alongside plans to revise carbon pipeline standards and provides key facts regarding the circumstances surrounding the 2020 pipeline failure in Satartia, Mississippi. The report identified necessary improvements to operator practices and emergency preparedness.

- **Class VI Permitting Report to Congress** | Environmental Protection Agency
    - This 2022 report to Congress outlines agency recommendations to improve Class VI permitting and includes a summary of stakeholder feedback.

- **Class VI Letter to Governors** | Environmental Protection Agency
    - This 2022 letter from EPA Administrator Michael Regan to state governors outlines the agency's priorities regarding the Class VI carbon injection well program, including the need for stronger protections, environmental justice measures, and robust public

participation.

- **Norway's Sleipner and Snøhvit CCS: Industry models or cautionary tales?** | Institute for Energy Economics and Financial Analysis
    - IEEFA researched two 'model' carbon sequestration projects in one of the most-studied geological fields in the world. Their findings reflect the dynamic and uncertain nature of long term geologic storage of carbon dioxide and highlight the regulatory oversight needed for these projects.

- **Liability transfer and unitization statute survey and background** | ORVI, Sep. 2023
    - This resource is a survey of statutes across the country pertaining to unitization of pore space and the transfer of long term liability for carbon dioxide geologic sequestration projects. Information is also provided regarding relevant legislative efforts in the Ohio River Valley.

- **The DOE and the Justice40 Initiative** | US Dept. of Energy, Jan. 2022
    - This page includes resources and information about the DOE's approach to Justice40, including eight policy priorities intended to guide DOE's implementation as identified by the Office of Economic Impact and Diversity.

- **Final Recommendations** | White House Environmental Justice Advisory Council May 2021
    - This report from the WHEJAC reflects their recommendations to the Council of Environmental Quality and to the Biden-Harris Administration regarding Justice40 and related efforts, including examples of projects which should and should not be thought of as benefiting communities.

Cost & Economic Impacts

- **2023 Levelized Cost of Energy+** | Lazard, Apr. 2023
    - Lazard's analysis pegs the cost of generating electricity with hydrogen at $116/MWh, compared to $62/MWh for unabated natural gas and $20-$40/MWh for renewables and natural gas-fired generation. Lazard's pricing scenario assumes hydrogen makes up just 20% of the fuel mix, with natural gas accounting for the rest. According to ORVI researcher Sean O'Leary's analysis, "in other words, replacing just 20% of the natural gas feedstock with hydrogen causes the price of electricity to jump by a frightening 87%. And worse, emissions are reduced by just 7%. This is why making electricity with hydrogen, even in a minor supporting role, is stupidly expensive."

- **Carbon Capture, Use, and Sequestration Would Decarbonize the Electric System…in the Worst Possible Way** | ORVI, Oct. 2021

- A research brief on the economics of CCUS implementation in the national power system, including analysis of the 45Q tax credit and proposed expansions. With a price tag of $100 billion/year, widespread adoption of CCUS in our electric system would spark outrage if its cost showed up in our monthly bills or federal taxes.

- **CCS for power yet to stack up against alternatives** | IEEFA, Mar. 2023
  - The cost of carbon capture and storage (CCS) remains unclear as no known new power plants have been built with the technology installed and operating at commercial scale. Thermal power generation with CCS has a levelized cost of electricity of at least 1.5-2 times above current alternatives, such as renewable energy plus storage. In Australia, if CCS is applied with all costs borne by increasing electricity prices, annual volume weighted average wholesale prices could climb by 95% to 175%.

- **Energy Department should only spend public funds on hydrogen hub projects that are practicable** | IEEFA, Apr. 2023
  - The US Department of Energy must decide if proposed production methods and uses for H2Hub proposals are safe, protect the environment, and are economically competitive, IEEFA's Suzanne Mattei writes. A DOE failure to exercise its ability to determine which hydrogen production methods are practicable could result in a substantial waste of tax dollars.

- **Frackalachia Update: Peak Natural Gas and the Economic Implications for Appalachia** | ORVI, Aug. 2023
  - The largest gas-producing counties in Ohio, Pennsylvania, and West Virginia have underperformed the state and the nation since the dawn of the Appalachian fracking boom. In all, these "Frackalachian" counties lost 10,339 jobs and 47,652 residents from 2008 through 2021, data show. As Appalachian gas production begins to plateau, it looks increasingly unlikely that new natural gas development will deliver economic prosperity to the region.

- **'Hydrogen unlikely to play major role in road transport, even for heavy trucks': Fraunhofer** | Recharge, Feb. 2022
  - Hydrogen fuel-cell vehicles have lost their one-time advantages of range and fast-charging, and are likely to remain uncompetitive with battery EVs, according to research from an independent German research institute.

- **Regardless of what they say, green hydrogen will be cleaner, cheaper, and it's around the corner** | ORVI, May 2023
  - Subsidies aside, by 2030, renewable-powered green hydrogen is expected to become cheaper than gray or blue hydrogen as capital and operational costs continue to fall. Meanwhile, the price of natural gas—used to create methane, the feedstock for gray

and blue hydrogen—remains volatile and unpredictable.

- **Stupid Ways to Make Electricity (Hint: To do it really stupidly, you need hydrogen)** | ORVI, Jun. 2023
    - Hydrogen is 2.5 to 4 times more expensive than natural gas as a power generating feedstock. In fact, for hydrogen to be cost-competitive with natural gas, its cost would have to be $.40/kg, less than half the price DOE aims to achieve by 2030. Hydrogen is "stupidly expensive," O'Leary explains, which is why it will never economically serve as a 'base load' resource for generating electricity, nor is it likely to be sensible or affordable as a 'peaking' resource or even as a means of balancing load in an increasingly renewables-based power system.

- **The Clean Hydrogen Ladder (version 4.1)** | Michael Liebreich, Aug. 2021
    - A ranking of the possible applications for clean hydrogen based on efficiency, cost, and market standing.

- **The Energy Department's hydrogen gamble: Putting the cart before the horse** | IEEFA, Feb. 2023
    - The US Department of Energy is "putting the cart before the horse" by advancing decisions on methane-based blue hydrogen hubs without knowing whether such hubs will be clean enough to qualify—reliably and over the long term—for Bipartisan Infrastructure Law funding, IEEFA analysts write. Even before considering upstream methane emissions and downstream carbon emissions, no carbon capture and sequestration system has achieved a consistent 95% annual average carbon capture rate on a commercial scale over the long-term.

- **The Ohio River Valley Hydrogen Hub: A Boondoggle in the Making** | ORVI, Mar. 2022
    - Constructing a blue hydrogen hub would raise costs for ratepayers and taxpayers, it would be largely uneconomic without substantial federal subsidies, it would saddle the nation with significant unabated emissions and the Ohio River Valley with continued local air and water pollution, and, even if it were built, it wouldn't stimulate major job growth or prosperity, according to this analysis by Senior Researcher Sean O'Leary. And, it's not the first time the industry has sold the region on grandiose visions that were ultimately left unfulfilled or went terribly wrong.

- **Top economists tell OH, PA, WV governors petrochemical boom is a non-starter** | ORVI, Jun. 2020
    - On June 15, 2020, a group of seven prominent economists and policy analysts from leading universities in Ohio, Pennsylvania, and West Virginia and a former Pennsylvania Secretary of Environmental Protection wrote a public letter to the governors of the three states warning them that economic development strategies based on a massive buildout of the region's petrochemical industry are infeasible. The letter recommends

that the governors and other policymakers explore more viable and sustainable strategies.

- **What A Pennsylvania Hydrogen and Carbon Capture Hub Would Cost** | ORVI, Jun. 2022
    - A full-scale hydrogen and carbon capture hub would add $1,000 to $3,000 or more per year to Western Pennsylvanians' taxes, utility bills, or a combination of both, research shows.

- **The Section 45Q Tax Credit for Carbon Sequestration** | Congressional Research Service, Aug. 2023
    - This fact sheet, originally issued in March 2020 but updated in 2023, outlines the legislative and regulatory background for the 45Q tax credit and provides cost projects pertaining to its use.

- **Investigation into misuse of 45Q tax credit** | Treasury Inspector General for Tax Administration
    - This report details an investigation initiated by Sen. Bob Menendez (D-NJ), a senior member of the Senate Finance Committee, which found that fossil fuel companies improperly claimed nearly $1 billion through the 45Q carbon sequestration tax credit. Following enforcement action from the IRS, approximately $531 million of those credits were revoked, totaling 59% of the credits claimed between 2010 and 2019. The 45Q tax credit was later increased through the Inflation Reduction Act.

Alternative Economic Development Opportunities

- **The Centralia Model for Economic Transition in Distressed Communities** | ORVI, Jul. 2021
    - A real-life model of successful economic and clean energy transition in a chronically distressed coal town that faced the closures of a coal mine and a power plant, the town's largest employers. Centralia established a $55 million transition fund for investments in clean energy, energy efficiency, and education that spurred local job growth, drove complementary investment, provided utility bill savings, increased disposable incomes, and improved quality of life. Despite the closing of the mine and impending retirement of the power plant, Centralia's transition formula, which can be replicated in similarly challenged places, led to economic and job growth that was twice that of the nation's in the first four years of grant funding.

- **Green Steel in the Ohio River Valley: The Timing is Right for the Rebirth of a Clean, Green Steel Industry** | ORVI, Apr. 2023
    - A transition from traditional coal-based steelmaking to fossil fuel-free steelmaking powered by green hydrogen could grow total jobs supported by steelmaking in the region by up to 43% by 2031, forestalling projected job losses. Transitioning to fossil fuel-free steelmaking would also cut Pennsylvania's industrial sector emissions by 4

million metric tons of CO2e per year, improving quality of life and saving $380 million in health, community, and environmental costs.

- **A Clean Energy Pathway for Southwestern Pennsylvania** | Strategen/ORVI, Dec. 2022
    - A renewables-based pathway centering energy efficiency & clean energy imports from the PJM market is more cost-effective than continued reliance on fossil fuels in the 10-county region surrounding Pittsburgh, this analysis finds. A strategy focused on natural gas and carbon capture will be 13% more costly than the clean energy pathway, which avoids expensive investments in CCS technologies to reduce emissions, while limiting the region's exposure to fuel price volatility and mitigating the risk of stranded fossil fuel assets. The clean energy pathway also results in a 97% reduction in CO_2 emissions from the power sector by 2050.

- **APPALACHIAN POWER COMPANY and WHEELING POWER COMPANY Application for the issuance of a Certificate of Public Convenience and Necessity for internal modifications at coal fired generating plants necessary to comply with federal environmental regulations, direct testimony by Sean O'Leary** | ORVI, May 2021
    - Sean O'Leary's testimony on the Mitchell coal-fired power plant, in which he argues for the plant's retirement aided by an economic transition plan like the Centralia Model for Economic Transition in Distressed Communities.

Miscellaneous Industry & Government Documents

- **Ohio River Valley Hydrogen and CCS Hub Market Formation** | AFL-CIO, Sep. 2021
    - Summary of a workshop convened by the Labor Energy Partnership (LEP), an initiative of the Energy Futures Initiative (EFI) and the American Federation of Labor and Congress of Industrial Organizations (AFL-CIO), to promote hydrogen and carbon capture and storage development in the Ohio River Valley. Attendees included Senators Joe Manchin and Sherrod Brown, former Energy Secretary Ernest Moniz, White House National Climate Advisor, Gina McCarthy, and AFL-CIO secretary-treasurer, Elizabeth Shuler.

- **The Pathway to Carbon Management Commercial Liftoff** | US Dept. of Energy, Apr. 2023
    - An overview of the US Department of Energy's plan to develop carbon capture, use, and sequestration. The revamped 45Q tax credit for carbon storage and utilization, as well as approximately $12 billion in funding from recent climate and infrastructure legislation, pave the way for "commercial liftoff," according to DOE.

- **The Pathway to Clean Hydrogen Commercial Liftoff** | US Dept. of Energy, Mar. 2023
    - An overview of the US Department of Energy's plan to develop regional hydrogen hubs. In the near-term (2023-2026), $8 billion in DOE funding for Regional Clean Hydrogen Hubs will "advance new networks of shared hydrogen infrastructure," the department

claims.

- **The Potential Economic Benefits of an Appalachian Petrochemical Industry** | American Chemistry Council, May 2017
    - An outline of the petrochemical 'renaissance' envisioned for the Ohio River Valley region, complete with five world-class ethane crackers, two hydrogenation plants, and an Appalachian Storage Hub connected by 500 miles of pipelines. Today, only one of these projects—the Shell ethane cracker in Pennsylvania—has even crossed the starting line. Hydrogen hub plans could be the next industry-led "failed vision."

- **Turning CCS projects in heavy industry & power into blue chip financial investments** | Energy Futures Initiative, Feb. 2023
    - An analysis of the remaining financial challenges for bringing carbon capture technology to full deployment stage after enactment of the Inflation Reduction Act. Even the enhanced 45Q subsidy remains insufficient to spur carbon capture adoption in many industries, including power generation. EFI claims that kickstarting at-scale CCS investment will require addressing two fundamental challenges: application heterogeneity, or the deployment of CO2 capture technologies in new industrial and commercial settings, and value chain complexity, or managing the "four links" that connect a CO2 capturing industrial facility to permanent geologic storage (capture, transport, deep underground injection, and ongoing monitoring).

- **Western Pennsylvania Hub, An Atlas of Carbon Capture and Hydrogen Hubs for United States Decarbonization** | Great Plains Institute, Feb. 2022
    - Industry-associated think tank Great Plains Institute's roadmap of hydrogen hub buildout, with an inset analysis of Western Pennsylvania. According to this analysis, in Appalachian Ohio, Pennsylvania, and West Virginia, the gas and coal power generating sector is responsible for 90% of 45Q-eligible emissions. Everything else amounts to niche applications.

- **White House Council on Environmental Quality Report to Congress on Carbon Capture, Utilization, and Sequestration** | WHCEQ, Jun. 2021
    - WHCEQ's report to Congress on the status of carbon capture use and sequestration in the US economy and steps that can be taken to accelerate its development. The report encourages states to take actions that will raise utility bills and increase taxes to fund subsidies, expanding the field of battle into state legislatures and regulatory bodies such as public service commissions.

- **Carbon Capture and Storage: Actions Needed to Improve DOE Management of Demonstration Projects** | Government Accountability Office, Dec. 2021
    - The GAO found that the DOE's actions increased risks for taxpayer funds and the success of previous carbon capture demonstration projects. The report also outlines a number

of external challenges impacting these projects, challenges that also apply to blue hydrogen projects.

- **Appalachian Hydrogen Infrastructure Analysis** | National Energy Technology Laboratory, Mar. 2022
    - This report outlines NETL's vision for a hydrogen economy in Appalachia and surveys existing resources, barriers, and regulations pertaining to the advancement of hydrogen infrastructure in the region.