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June 24, 2024

U.S. Department of Energy
Industrial Efficiency and Decarbonization Office

RE: Transforming Industry: Strategies for Decarbonization

The Combined Heat and Power Alliance (CHP Alliance) appreciates the opportunity to submit feedback to the Industrial Efficiency and Decarbonization Office (IEDO) on issues related to industrial decarbonization pathways. Combined heat and power (CHP) technologies can enable significant emissions reductions across the industrial sector, critical to achieving the goal of net zero emissions by 2050. CHP systems are currently installed at over 4,000 facilities in the U.S. – with deployments in the chemical, petroleum refining, and pulp & paper sectors accounting for more than half of deployments – leading to 200 million tons of avoided emissions.[1] There remains an enormous un-tapped opportunity to increase the number of CHP deployments, further lowering fuel use and driving down emissions of the industrial sector.

About the CHP Alliance

The CHP Alliance is a diverse coalition with more than 70 members including equipment manufacturers and distributors, engineers, utilities, labor, contractors, non-profit organizations, and educational institutions.[2] Our members come together with the common purpose to educate all Americans about CHP and waste heat to power (WHP), and how CHP and WHP can make America's manufacturers and other businesses more competitive, reduce energy costs, enhance grid reliability, and reduce emissions.

Question 1B.1: What are the most impactful cross-cutting and systems-wide strategies to decarbonize industry and why?

DOE's four cross-cutting industrial decarbonization pathways fail to examine a more important and cross-cutting pathway – the route to decarbonizing combustion in the industrial sector. Today, industry uses high-emitting fuels to produce electricity and heat

[1] DOE, "CHP Installation Database," 2024, https://doe.icfwebservices.com/chp.
[2] The Combined Heat and Power Alliance, "Who We Are," accessed May 24, 2022, https://chpalliance.org/who-we-are/.

needed in manufacturing but will transition over time to combusting Low-Carbon Fuels, Feedstocks, and Energy Sources (LCFFES) or natural gas with Carbon Capture, Utilization, and Storage (CCUS). But DOE currently disaggregates LCFFES and CCUS into separate pathways. Industry needs integrated guidance from DOE about how and when the combustion transition will occur. In the absence of that guidance, industry is hesitant about acting.

The Combined Heat and Power Alliance recommends DOE analyze and build out a comprehensive picture of the pathway to decarbonizing industrial combustion. To develop the Industrial Decarbonization Combustion Pathway, DOE should include four key measures.

Combined Heat and Power Should be at the Center of the Combustion Pathway

First, to lower costs and maximize carbon reductions, Combined Heat and Power, the most efficient method to combust fuels, should play a central role in the combustion pathway. CHP is a proven and highly efficient technology that can reduce emissions using traditional fuels and can reduce emissions even further using emerging renewable and lower-carbon fuel technologies. CHP is already widely deployed at industrial sites and familiar to the industry.

Properly designed CHP systems typically operate with an overall efficiency of 75-85%, compared to 50-55% for separate thermal and electricity generation.[3] CHP achieves these high efficiencies by recovering the waste heat byproduct of electricity generation as useful thermal energy for heating and cooling, a process that is particularly beneficial for energy-intensive industrial sectors. CHP's ultra-high efficiency uses 40 to 60% less fuel per megawatt hour (MWh) generated than any non-renewable resource on the grid, reducing all types of emissions including greenhouse gases, criteria pollutants, and hazardous air pollutants.

CHP systems produce substantial immediate and longer-term emissions reductions and lead to greater emissions reductions than grid electricity. A typical 15 MW industrial

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[3] EPA, "CHP Benefits" accessed May 24, 2024, https://www.epa.gov/chp/chp-benefits.

CHP installation has a net electric emissions rate of 515 lbs CO_2 per MWh,[4] far lower than the marginal emissions rate in every region of the country (Figure 2).

CHP systems are the most efficient way to use Low-Carbon Fuels, Feedstocks, and Energy Sources (LCFFES) and CCUS, requiring less fuel inputs for the same energy outputs compared to other generation units and thereby limiting the impact of the barriers to entry for these fuels such as availability and high costs. Because of these benefits, DOE should encourage combustion of low carbon fuels and fuels in combination with CCUS in a CHP unit wherever possible.

In addition, DOE should include Waste Heat to Power (WHP) as part of its combustion pathway. Waste heat to power (WHP), also known as "bottoming-cycle CHP," uses waste heat from industrial processes to generate electricity with no additional fuel and no incremental emissions. In a WHP system, fuel is used to produce useful thermal energy for an industrial process. The heat not used for that process, the "waste heat," is then utilized to produce electricity. No additional fuel is used to produce the electricity, meaning that there are no incremental emissions associated with the electricity production.

As of 2016, there were 469 megawatts (MW) of existing WHP capacity at 75 sites across the U.S., mostly used in primary metals and refining applications.[5] In addition, as of 2016, WHP's technical potential is estimated to be 7.6 GW across all facility types, with petroleum, metal, and non-metallic mineral markets having the highest amount of technical potential.[6]

Rapidly Deploy Natural Gas-Fired CHP in Industry Now

Second, DOE should seek every opportunity to rapidly deploy new natural gas-fired CHP units at industrial sites. New CHP units installed today are substantially cleaner than the grid in every region of the country and deliver significant carbon emissions. In almost all regions of the U.S., CHP units installed through 2035 and operating through

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[4] 515 lbs CO2 per MWh is based on a 15 MW GT & fired HRSG system offsetting 82% efficient NG packaged boilers with an unfired power to heat ratio of 0.794, an overall efficiency (including fired steam) of 78.7%.
[5] U.S. Department of Energy, "Combined Heat and Power (CHP) Technical Potential in the United States," p. 18.
[6] U.S. Department of Energy, "Combined Heat and Power (CHP) Technical Potential in the United States," p. 28.

2050 using natural gas are expected to cause a net reduction in carbon emissions over their system life by reducing demand for marginal grid resources.[7]

For all states in the continental U.S., fossil fuel generators are used as marginal electric grid resources to serve incremental loads. But CHP reduces demand for these marginal resources and avoids their emissions.

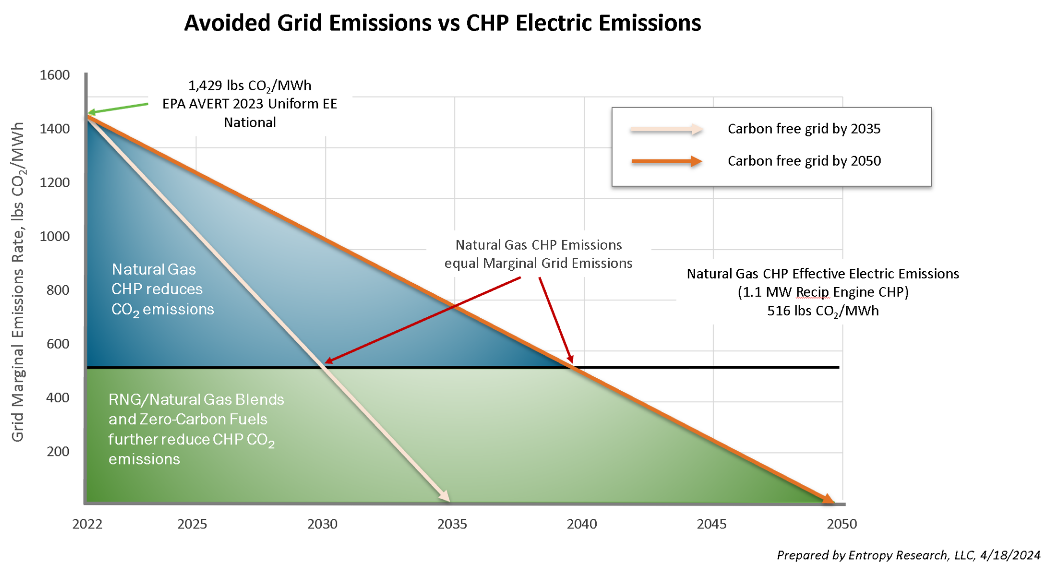

Figure 1: Grid emissions in New England compared to CHP.

As Figure 1 indicates, a natural gas-fired CHP unit in the Northeast delivers substantial immediate emission reductions relative to the grid today and can make industrial sites zero emission when clean hydrogen and CCUS become widely available.

[7] In all regions except New York and California. "Combined Heat and Power Potential for Carbon Emission Reductions: National Assessment 2020-2050," ICF, July 2020, p. 4, http://consortia.myescenter.com/CHP/ESC_CHP_Emissions-Full_Study-ICF-071320.pdf.

Figure 2 shows that the average marginal grid emissions in every region of the country is substantially dirtier than a natural gas-fired CHP unit. In other words, new natural gas-fired CHP can immediately reduce emissions in every region of the country.

Avoided CO_2 Rate (lb. per MWh)	*Uniform EE*
National Weighted Average	1,429
California	1,037
Carolinas	1,511
Central	1,740
Florida	1,044
Mid-Atlantic	1,363
Midwest	1,712
New England	1,065
New York	1,048
Northwest	1,604
Rocky Mountains	1,840
Southeast	1,446
Southwest	1,342
Tennessee	1,338
Texas	1,294

Figure 2: Marginal emissions rate by region (Data Source: AVERT 2023).

As Figure 3 demonstrates, the high efficiency and high annual capacity factor of a 15 MW CHP system can reduce the same greenhouse gas emissions in eight years as the same capacity of zero-carbon solar photovoltaic does in 25 years.

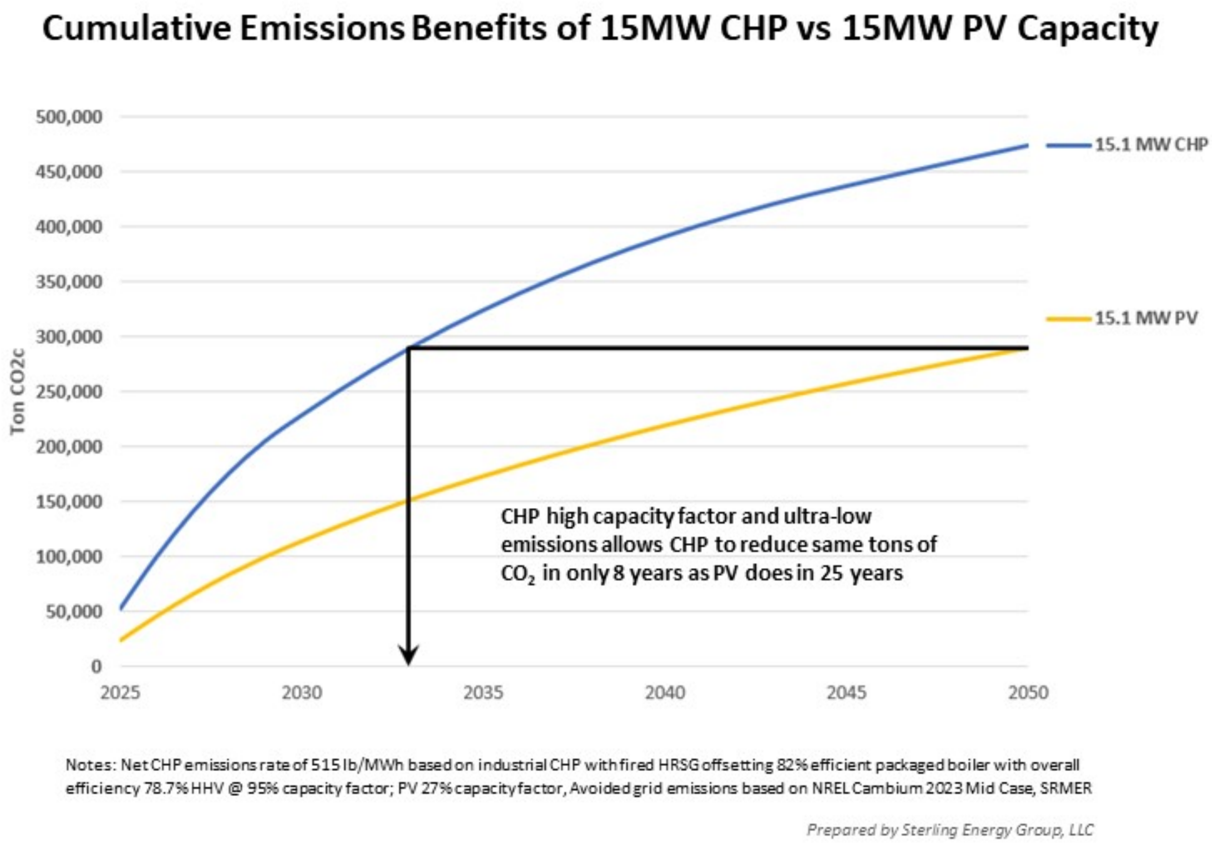

Figure 3: Emissions benefits of CHP compared to solar.

Manufacturers are already leading the way by installing new CHP units and DOE should encourage and accelerate this trend, as CHP can help to decarbonize even the hardest to abate sectors. Within the last four years, the pulp and paper and chemical sectors led the way in new CHP capacity brought online, with over 5 GW and 3.5 GW installed respectively. Looking to the future, DOE's own analysis has identified more than 73 GW of remaining CHP technical potential capacity at over 50,000 industrial sites nationwide, including:

- Chemicals – 24.2 GW.
- Petroleum – 10.6 GW.

- Food – 9.1 GW.
- Pulp and Paper – 7.3 GW.
- Primary Metals – 6.8 GW.
- Lumber – 3.3 GW.
- Other – 11.7 GW. [8]

Convert Existing Industrial CHP Units to LCCFES and CCUS

Third, DOE should seek to convert new and existing CHP units over time to use clean hydrogen or CCUS. DOE's analysis should examine converting the 1,145 existing industrial CHP units to clean hydrogen or CCUS as they become available. CHPA's Clean Hydrogen CHP roadmap finds that existing CHP units can be converted to 100% use of clean hydrogen at low cost and with little disruption as it can occur when the units are out of production for their regularly scheduled overhaul.[9]

These units are large, generating 78% of the electrical power from all CHP units. The chemicals, pulp and paper, and food processing sectors house more than 60% of all industrial CHP units.[10]

Use CHP in New LCFFES and CCUS Wherever Possible

Fourth, as clean hydrogen, other LCFFES, and CCUS become widely available for use in industry, wherever possible, DOE should encourage industry to combust these fuels in CHP units, as this is the most efficient use of these systems. DOE's analysis should identify how these low combustion options for industrial decarbonization will scale up, including identifying the amounts and timetable for their availability. DOE should strongly encourage manufacturers to combust these fuels in CHP units; doing so will lower costs for industry and maximize the carbon reduction benefits of these fuels and CCUS.

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[8] U.S. Department of Energy, "Combined Heat and Power (CHP) Technical Potential in the United States".
[9] Combined Heat and Power Alliance, *Clean Hydrogen and Combined Heat and Power: A Roadmap for Industrial and Commercial Decarbonization*, which can be found at: https://chpalliance.org/resources/publications/clean-hydrogen-and-combined-heat-and-power-a-roadmap-for-industrial-and-commercial-decarbonization/.
[10] U.S. Department of Energy, "CHP Installation Database," accessed May 24, 2024, https://doe.icfwebservices.com/chp.

CHP systems currently operate on 100% hydrogen, but these systems are primarily in Europe due to the high cost of hydrogen compared to natural gas in the U.S.

Question 1B.3: Given the breadth of available and emerging technologies, which cross-cutting technologies are most in need of RD&D funding?

More RD&D on clean fuels and their applications in CHP units is needed. Greening the gas system with high volumes of clean hydrogen can allow CHP systems to use these clean fuels efficiently. CHP manufacturers currently operate units in Europe that use 100% hydrogen. However, in the U.S. the cost of hydrogen compared to natural gas remains prohibitive to its deployment. RD&D funding for methods to reduce the high cost of hydrogen is critical to its deployment.

Supporting RD&D of clean hydrogen in the gas system could help to accelerate decarbonization, with the following considerations:

- **Transportation**: The existing gas pipeline system may provide a cost-effective way to transport clean hydrogen, but additional research is required to determine what quantities of hydrogen can safely be transported or what retrofits may be required.
- **Distributed generation**: Distributed generation technologies such as CHP can be deployed at the point of clean hydrogen production, allowing the use of hydrogen in CHP systems and the realization of corresponding emissions benefits while the development of hydrogen-ready pipelines is still underway.
- **Use**: While research and development of hydrogen-ready CHP technologies is ongoing, technology manufacturers and end users will need support evaluating what amount of hydrogen current equipment can use, identifying the retrofits and upgrades needed to ensure the adjustment of existing equipment for hydrogen use is easy and affordable, and the development and deployment of new equipment as required.

Question 1B.4: Some example barriers to cross-cutting strategies are provided in this section. Are there additional barriers you believe hinder cross-cutting strategy/technology adoption?

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Recent data shows electricity demand is suddenly growing rapidly due to rising demand from data centers and new manufacturing units.[11] As more sectors move to electrify, the grid will face incredible strain from this added load. An analysis of 30 industrial heat pump projects in Europe found loads per heat pump ranging from about 25 kilowatts to 1.25 megawatts. 1.25 megawatts are equivalent to the electricity needs of approximately 350 homes' central air conditioners.[12] Demand for industrial electrification alone may double total U.S. electricity demand.[13]

DOE should analyze how CHP systems and the overall combustion decarbonization pathway can reduce demand on the grid through providing reliable, and low emission, onsite electricity and thermal energy. Natural gas-fired CHP systems combine their high efficiency and high-capacity factors to deliver more net emission reductions than the same MW installed capacity of wind and solar PV systems, which operate at much lower capacity factors.[14]

To cost effectively decarbonize the industrial sector, DOE must implement its "All-Hands-on-Deck" approach by promoting energy efficiency processes and low carbon fuels and feedstocks in addition to industrial electrification.

Respectfully,

David Gardiner
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[11] Grid Strategies, "The Era of Flat Power Demand is Over", December 2023. https://gridstrategiesllc.com/wp-content/uploads/2023/12/National-Load-Growth-Report-2023.pdf
[12] ACEEE, "Coming Electrification will Require the Grid to Evolve," Feb. 10, 2023, https://www.aceee.org/blog-post/2023/02/coming-electrification-will-require-grid-evolve.
[13] Eric Gimon, Energy Innovation, UtilityDive opinion piece.
[14] CHP Alliance, "CHP and a Changing Climate: Reducing Emissions and Improving Resilience," Jan. 14, 2021, https://chpalliance.org/resources/publications/chp-and-a-changing-climate-reducing-emissions-and-improving-resilience/.