Subnational Policies for Industrial Decarbonization: How States and Utilities Can Play a Key Role

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ABSTRACT

Industrial decarbonization requires a multi-layered, multi-stakeholder approach. While policy interventions and investments from the federal government are foundational, given the complex nature of industrial decarbonization and the need to address potential barriers at the state and local levels, sub-national policies and planning are becoming a key focus in the drive to decarbonize industry. Many U.S. states have nascent efforts in the industrial sector, but the challenges ahead are enormous and complex. We present options for approaches to advance decarbonization for state policymakers, utilities, and industrial stakeholders.

We survey key needs and barriers to industrial decarbonization in the six industries that together produce 80% of emissions in this sector: chemicals, petroleum refining, iron and steel, cement, forest products, and food and beverage. We highlight more than 100 efforts underway in leading states and present options for states seeking to expand or accelerate their industrial decarbonization efforts. There are five main pillars of industrial decarbonization: efficiency—a crucial first step toward making the other pillars affordable and feasible; electrification; low-carbon fuels and feedstocks; carbon capture, utilization, and storage (CCUS); and procurement of low-carbon materials and products. Policy actions in these pillar groupings (e.g., planning and governance, RD&D, carbon pricing, incentives, and standards) can set states on the path to net-zero greenhouse gas (GHG) emissions for most industrial activities.

Additionally, we show how utilities can work with state policymakers to advance industrial decarbonization. Approaches will need to be tailored to each utility's customer needs, energy prices, region, and other factors. Important areas of consideration include small- to medium-size manufacturers, greening the grid, transmission and distribution infrastructure upgrades, and ensuring reliability and resilience for industrial users.

Introduction

In 2020, the industrial sector was responsible for almost a quarter of U.S. direct greenhouse gas (GHG) emissions, and almost a third when including indirect emissions from the use of electricity (EPA 2022). Without new technology and policy interventions, the sector is projected to become the largest source of emissions by 2030. Therefore, industrial decarbonization is critical to mitigating some of the worst effects of climate change. However, the emissions from this sector are hard to abate, as processes are highly integrated, involving many complex interactions and technologies supported by interrelated supply chains. The industrial sector is also economically critical, employing more than 12.6 million workers and accounting for 11% of national gross domestic product (NAM 2019). Thus, it is crucial to pursue a low-carbon transition that manages complexities, supports workforce capabilities, promotes

equity, and maintains competitiveness, while also offering a diverse portfolio of pathways that overcome barriers inherent to the sector.

There is growing recognition that industrial decarbonization cannot just be directed from a national-level perspective using a top-down approach. Industrial decarbonization needs vary by region and by state policy concerns. Instead, it needs to be mediated at a sub-national level by state-level and regionally based stakeholders to ensure approaches and solutions are tailored to the specific and unique contexts in each state and take into account important differences that might otherwise be missed if considering solutions from only a national-level perspective.

Guidance for state policy makers and utility and industry stakeholders is urgently needed to best leverage available technologies, proven foundational pathways, such as energy efficiency, and federal policies and incentives. This paper is not intended to serve as a comprehensive or exhaustive treatment of the subject. Instead, we focus on three key stakeholder groups—state policymakers, utilities, and industry—and provide examples of approaches for these groups for each industrial sector in the unique context of their region or state.

Barriers and Solutions

Given some significant initial barriers, such as the complexity of pathways available, and the unique actions required in different states and regions, it is essential to understand how federal policy, state policy, local action, utility programs, and private activities should all be encouraged, leveraged, and combined to best motivate industrial decarbonization, and how they differ by subsector and regionality. Additionally, some decarbonization pathways are cross-cutting, and some need to be tailored specifically to individual processes/applications. This paper includes suggestions on comprehensive policy levers and policy sequencing within groups of decarbonization policy pathways to address these barriers and enable stakeholders to make progress in planning for change.

The main approaches for state policymakers fall into one of five categories, or pillars, which are introduced below. States can use these approaches to tailor how they mitigate industrial emissions and to compare best practices. These approaches can pair with other efforts (especially federal funding, with emerging clarity in mechanism) to more holistically decarbonize carbon-intensive, hard-to abate subsectors. Approaches for utilities include opportunities for successfully collaborating with state policymakers, energy commissions, and other regulatory bodies to set and meet decarbonization targets through policies and programs aimed toward the industrial sector. Approaches for industry stakeholders largely fall in the realm of working with both state policymakers and utilities to enable decarbonization and leverage the options and incentives available to them.

Decarbonization Approaches, Timeline, and Potential for Industry

Multiple sector-wide roadmaps and decarbonization studies have identified high-level pillars and pathways for cross-cutting industrial decarbonization efforts[1]. The pillar organization is useful for investigating possible avenues for state policy as well as how utilities can support those state policies.

[1] Including the DOE Industrial Decarbonization Roadmap

Decarbonization Pillars

The five crosscutting decarbonization pillars, which can be applied across all manufacturing sectors, include the following:

Energy efficiency. Energy efficiency (EE), the strategies and technologies that reduce the amount of energy use necessary in industrial processes, is foundational for other decarbonization approaches. It is also the most cost-effective option for reducing emissions in the near term. EE reduces energy and resource demand, making it a vital component of longer-term decarbonization transformation and enabling the use of other costly technologies and those with potential implementation barriers, such as electrification[2]. The current rate of EE improvement in industry is 0.5-1% per year, but this rate can more than triple according to several decarbonization projections (IEA 2021). EE encompasses measures such as materials efficiency, strategic energy management, waste heat recovery, and intelligent efficiency. Intelligent efficiency is one area of EE that is rapidly increasing in scope, applicability, and potential energy savings. Information, automation, real-time data collection, and communication technologies such as sensors offer end-users the ability to reduce energy use and waste, while newly created interconnections between disparate processes enable holistic, systems-level decarbonization. One barrier limiting the savings potential of information, communication technologies (ICT) and intelligent efficiency is the lack of standard attribution protocols for emissions reductions. However, there are emerging carbon accounting methodologies, including the "carbon handprint" approach (Elliott, Srinivasan, Hoffmeister 2022).

Electrification. There are multiple opportunities for industry to increase its use of low-carbon electricity to reduce carbon emissions, including process heat, which accounts for 61% of the on-site energy used in manufacturing. Electricity provides less than 5% of this energy. In terms of temperature, 44% of the process heat used in industry is below 200° C, while more than 50% is below 300° C (Rightor et al. 2022). Currently available or rapidly developing electric technologies, including industrial heat pumps, can provide heat at and below those temperatures, reducing reliance on fossil fuel-generated heat and improving EE, while also offering non-energy benefits such as minimizing the need for natural gas infrastructure, saving water, and more.

Low-carbon fuels and feedstocks (LCFF). Industry uses a variety of energy sources that are currently dominated by fossil fuels. However, low-carbon sources of energy can replace them in increasing quantities in fuels and feedstocks used in many industrial processes. Low-carbon options include biomass, low-carbon hydrogen, and direct use of low-carbon energy sources such as wind, solar, and hydro. Fuel applications can include combustion in furnaces, boilers, or direct-fired applications to generate process heat. Potential applications include kilns in metals refining, cement, chemicals, and refining.

Mitigation strategies. There are many additional strategies and emerging technologies for mitigating GHG emissions at industrial facilities. Carbon capture, utilization and storage (CCUS) is the most recognized and developed technology. Direct air capture (DAC) is also gaining

[2] For example, high transmission and distribution build out needs to match demand.

visibility. Other strategies to remove GHGs that are already present in the atmosphere include land use approaches such as ecosystem preservation, reforestation, and expansion.

Driving low-carbon product demand. Some materials, such as cement and steel, can be produced with significantly less carbon intensity, or embodied carbon. Large purchasers of goods, especially the federal and state governments, have the power to increasingly request and specify materials with lower embodied carbon for infrastructure projects. This helps create market-pull for low-embodied-carbon materials, while demonstrating viable market opportunities for increased manufacturing and the market's ability to compensate for the additional cost of producing such goods and materials. Examples of demand-side policies include the Federal Buy Clean Initiative and Buy Clean legislation passed or being considered in various states, including California, Washington, and Minnesota.

Decarbonization Implementation Timeline

The pillars, and the decarbonization technologies and approaches they encapsulate, have varying degrees of dependence on short-term capital investments, technology development, and supporting infrastructure, and will therefore differ in terms of most effective sequencing. Energy efficiency measures, for example, are typically well positioned to be deployed quickly and are well established in the marketplace without significant capital expenditure (capex) investments. Low-carbon fuels and feedstocks will require higher capex investments and infrastructure investments that may require multi-stakeholder approval. These impacts and timing predictions are illustrated in figure 1.

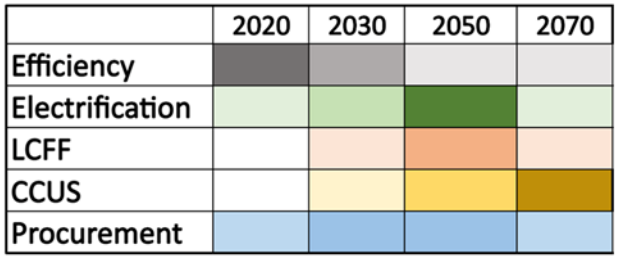

Figure 1. Timing of Major Pillar Impacts. The Darker Shades Within a Color Signify Greater Impact. (*Source*: USCA 2022).

Industrial Sector Decarbonization Potential

Six industrial subsectors account for 80% of industrial emissions: chemicals, petroleum refining, iron and steel, cement, pulp and paper, and food and beverage. It is necessary to establish the context of each of these industries and likely emissions reduction pathways before considering state- and utility-level policies and programs aimed toward decarbonization.

Chemicals industry. This is the largest industrial consumer of fossil fuel, with two-thirds for feedstock and one-third for non-feedstock uses. The chemicals industry is also a major consumer of electric power, much of which is self-generated as the largest user of combined heat and power (CHP). Estimates suggest that 20–5% of current fuel use could be replaced by

electrification of process heating applications under 200º C. Biomass-based feedstocks may be able to replace 5–20% of petrochemical feedstocks.

Petroleum refining industry. This is already undergoing a transition in anticipation of reduced demand for fossil fuels in other parts of the economy. Refineries self-generate two-thirds of the fuels they consume and, like the chemicals industry, are a large user of CHP. Refineries are major consumers of hydrogen as a process feedstock, with a large amount produced from byproduct gasses or natural gas.

Iron and steel industry. The iron and steel industry is composed of two distinct sub-industries based on how steel is manufactured: primary iron and steel that converts iron ore into metal and secondary steel that is based on remelting scrap steel in electric arc furnaces (EAF). We anticipate that both sub-industries will increase their use of electricity dramatically, creating opportunities to use low-cost, low-carbon hydrogen in both direct iron reduction processes and in reheating furnaces replacing natural gas.

Cement industry. This industry uses fossil fuels for heat in operations, which creates in 50% of cement-related emissions. While the industry has used energy efficiency effectively, some additional opportunities remain, including material efficiency, kiln electrification, and onsite generation of renewables. CCUS offers an opportunity to manage emissions but will use a large amount of energy if fully implemented across the sector.

Pulp and paper industry. The pulp and paper industry is unique in that it uses a large volume of biomass as an energy resource for process heat and electricity self-generation, usually through CHP, with the balance of energy requirements satisfied by fossil fuels. Most of the biomass is a byproduct of the production processes. The industry has significant potential to shift from fossil fuels to more-efficient electric drying technologies, increased heat recovery, and increased efficiency.

Food and beverage industry. This industry uses fossil fuels to provide process heat directly or through steam for heat in ovens, fryers, and furnaces, and to provide hot water for plant operations. Most of these process heating requirements are at relatively low temperatures (i.e., below 93ºC), which makes these applications ideal for industrial heat pumps and efficiency improvements, including waste reduction.

Next, we consider policy options available to different groups of stakeholders involved in industrial decarbonization.

Options for State Policymaker Stakeholders

When considering valuable approaches for state policymakers, it is important to understand state-level considerations that feed into their industrial emissions, policy, and decision-making environment. This includes considerations for policy design to mitigate emissions, key resources to leverage, and depictions of policy initiatives from leading states.

State Policy Environment

Twenty-four states and the District of Columbia have set various types of GHG reduction goals. While the levels of reduction, time period, and authorities vary, 15 of those states have established net-zero by mid-century goals, and 10 are actively developing or deploying action plans to meet those aims. Figure 2 depicts state-based goals by policy type (C2ES 2022).

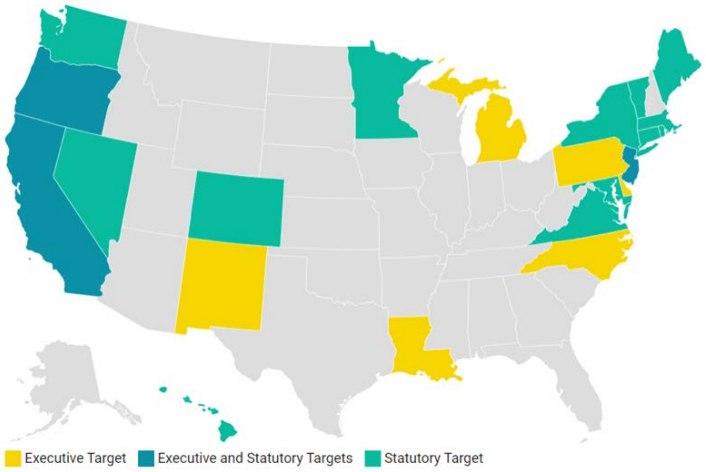

Figure 2. States with GHG Reduction Targets, and Target Authorities (Source: C2ES 2022).

In addition to these goals, 10 states have targets that pertain specifically to industrial decarbonization or clean heat standards (Subramanian et al. 2022). Among these ambitious targets and various action plans, the question often remains: What are the most effective, economical, and timely ways to meet these goals, while maintaining competitiveness, retaining or creating jobs, and not precluding any future transformational technologies that may emerge? Dividing decarbonization strategies into the five high-level pillars above (consistent with those defined in other decarbonization roadmaps and studies, including the DOE roadmap on industrial decarbonization) offers a way to drill down on possible approaches and enables analysis of which approaches need to be facilitated by additional state support, and which strategies are being used or considered by states across the country.

State Policy Options

State governments and state energy offices can pull various policy levers to effect meaningful decarbonization of regional, economically vital, and hard-to-abate industrial subsectors via each of the high-level pathways identified in the pillars. These policies fit broadly into five additional categories: incentives, carbon pricing, standards, RD&D, and supporting policies. Figure 3 depicts the relationship between the policy landscape within those categories and the five pillars described in this paper.

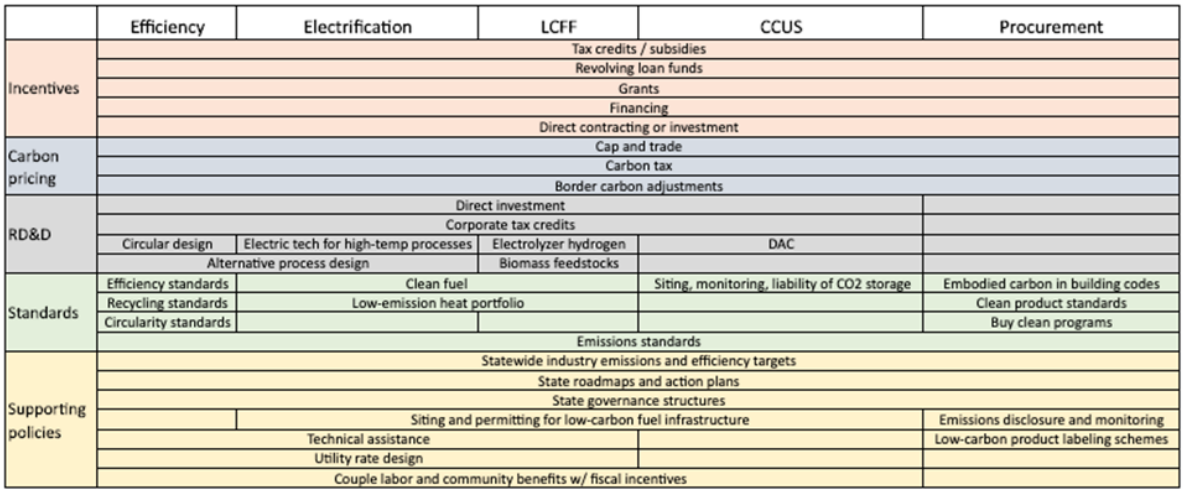

Figure 3. Interaction of Policy Landscape and Decarbonization Pillars. (Source: USCA 2022).

The leading states in guiding industrial decarbonization in their jurisdictions have used various policy avenues, navigating the chart in figure 3 to fit their particular economy and geography. Many of these states have worked, and will continue to work, with utilities and balance the need for immediate action with long-term planning. These states and the others that have lagged behind will need to continue to coordinate with partners in their industrial sectors to align priorities (especially on workforce and diversity, equity, inclusion, and justice (DEIJ) concerns), find and remove barriers, and leverage emerging federal resources to ensure a just transition to a lower-carbon future. The leading states include those with passed legislation, established standards, and/or dedicated funds to industrial decarbonization efforts, such as California (Buy Clean California Act, Just Transition Fund, low-carbon fuel standards), Colorado (Buy Clean Colorado, Greenhouse Gas Emissions and Energy Management for Manufacturing (GEMM), Just Transition Action Plan), New York (buy clean for concrete, clean hydrogen hub) and Washington State (buy clean and buy fair pilot projects, clean fuel standard, Climate Commitment Act) (USCA 2022). Leading states also include those that are still in the planning phase of policy action, like Louisiana, which has laid out a detailed statewide roadmap for upcoming efforts, including developing a buy clean policy, net-zero industry wide standards, GHG monitoring, electrification, and more (Louisiana Climate Initiatives Task Force 2022).

Opportunities for Policy Development

It is important to acknowledge where essential policy work has already been done and where best examples can be leveraged for use in states where decarbonization plans need to be made.

Figure 4 organizes the existing landscape of more than 80 state policies connected to accelerating industrial decarbonization into the pillars defined above and a further categorization of five groupings of policy types. This figure illustrates a numerical count of policies in each category; it is not intended to illustrate the impact of any one decarbonization and policy avenue. It depicts where current and emerging state policies are focused and, considering the holistic action needed in all decarbonization pillars and policy types, where there are gaps in the existing framework.

State government entities should look to the work being done around the United States for examples of best practices for decarbonizing specific sub-industries and efforts toward transitioning economies to low-carbon futures. What is still needed are cross-cutting efforts to overcome remaining barriers, support for emerging technologies, and close collaboration with utilities to ensure resource adequacy and policy support best suited to unique needs.

	Decarbonization Pillar				
Policy Type	**Efficiency**	**LCFF**	**Electrification**	**CCUS**	**Procurement**
Financial / Tech Assistance	28	12	14	0	3
State Planning & C markets	10	13	9	9	4
Standards	5	7	4	7	3
Embodied carbon	0	0	0	0	10
RD&D	4	6	5	7	0

Figure 4. Number of State Policies Connected to Industrial Decarbonization (*Source*: USCA 2022).

Steps for State Policymakers

There is a lot to consider among these pathways to determine the most effective actions and multiple areas where policy can make a substantial difference. Given the complexity of the industrial sector, in which processes and integration of those processes differ by facility, outlining initial steps is useful. Please note that the approach in any one state will depend on specific needs and economic and geographic considerations. The steps detailed below offer a starting point for shaping discussion and action.

1. Assess current energy and GHG footprint of industry as well as existing state goals and timing for energy and GHG reductions. Initiate planning and strategy discussions.
2. Form partnerships and connections with key stakeholder groups.
3. Identify reduction options that best align with needs and goals.
4. Explore levers to best enable the reduction options and evaluate the prospects of pursuing the best levers.
5. Discuss options with stakeholders, develop a plan, cycle on feedback.
6. Identify funding and resource needs to support the plan. Get approval for the plan.
7. Pursue the plan with stakeholders, collect feedback, and modify plan based on an agile learning approach.

By progressing through these steps, states can shape policy for decarbonizing the industrial sector while maintaining competitiveness and increasing the capable workforce.

Options for Utility Stakeholders

Utilities represent another key group of stakeholders who can play a pivotal role in industrial decarbonization. This is especially the case as the energy needs of industry shift. As industry decarbonizes through pathways such as electrification, utility capacity and infrastructure must be significantly scaled up to meet resource adequacy concerns. These efforts will have to be

paired with grid decarbonization measures to ensure net emissions reductions. This section outlines the actions that utilities can take and examples of what leading utilities have done to help effect meaningful industrial decarbonization. Utilities can operate in conjunction with state policymakers, federal funds, and state energy offices to ensure that decarbonization programs and policies reach industrial customers of all sectors and sizes, and that adequate resources are being deployed to that end. Utilities have a vested interest in decarbonization and in offering programs to help decarbonize industry. This is the case because of their goals to defer transmission and distribution (T&D) infrastructure and additional capacity buildout, keep energy prices low, ensure reliability and resilience, and promote equity in underserved communities. Many factors influence utility decarbonization program development, including state regulations, whether the utility is investor-owned, whether the utility provides electricity, natural gas, or both, whether the utility operates in traditionally regulated or a restructured energy market, and more. Utilities should consider these factors when determining how best to structure effective programming to decarbonize industry.

Key Roles for Utilities in Industrial Decarbonization

Offering utility-sponsored programs. By offering industrial customers programs related to decarbonization pathways, including performance incentives, support for strategic energy management (SEM) program growth, fostering the deployment of key technologies in each of the pathways above (through cost-sharing, financial incentives, technical assistance, and implementation support), and ratepayer energy efficiency programs.

Engaging in decarbonization pillars. By decarbonizing energy sources and grid operations through such efforts as reducing line losses and optimizing voltage delivered to customers. By engaging in the five decarbonization pillars defined above, utilities can support the use of hydrogen and low-carbon fuels, electrification, energy efficiency, renewable energy and variable power, and circular economy through infrastructure upgrades, incentive rates, and other business models.

Providing input to policymakers. By working with communities, state and other policymakers. Utilities can provide input to state energy offices, governors' offices, legislators, and public utility commissions (PUC), among other entities. This input is often essential for the development of effective regulatory policy.

Enabling state energy policy. By working with states on energy efficiency resource standards, renewable portfolio standards, binding standards, and rate-making efforts, and contributing to green energy funds.

Enabling economic development. By enabling economic development by engaging with state-based workforce programs, providing technical assistance, education, and energy audit programs to industrials.

These utility roles in the context of technology and policy lenses can be seen in Figure 5.

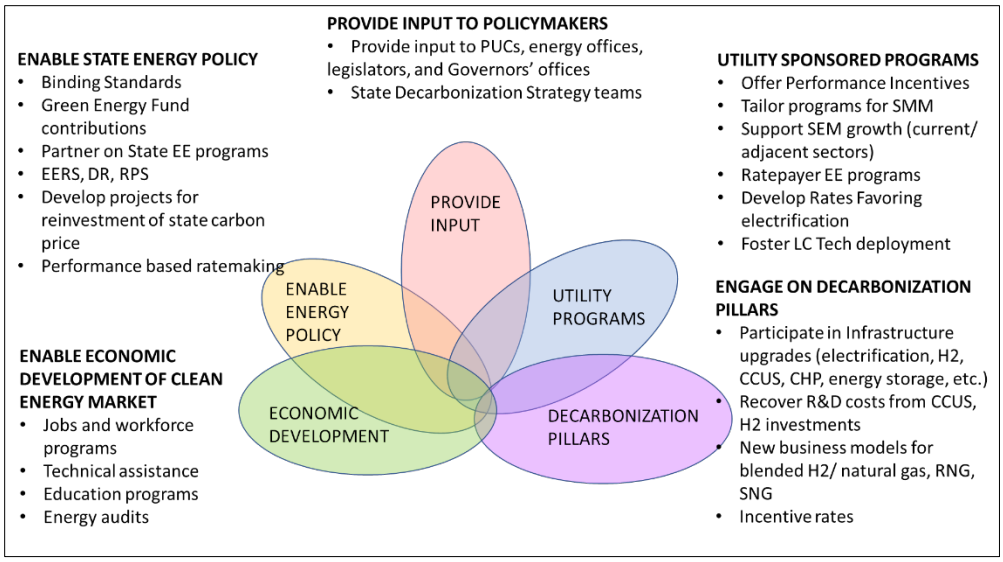

Figure 5. Roles that Utilities Can Play in Industrial Decarbonization. *Source*: ACEEE (Srinivasan et al. 2023)

Utilities can also appreciably accelerate industrial decarbonization by decarbonizing power production while electrifying manufacturing. This pathway includes possibilities such as fuel switching and producing electricity from zero-carbon energy sources.

Roles for the Gas Utility

Gas utilities face a different set of challenges than electric utilities in the transition to a low-carbon future. Unlike electric utilities, which are expected to enable electrification and help build out the necessary infrastructure, gas utilities must focus on low-carbon fuels and feedstocks generation (e.g., hydrogen) and renewable natural gas (RNG). Some states (e.g., California, Washington) have clean fuel standards and RNG mandates. Other states (e.g., New York, Hawaii) have plans for renewable hydrogen programs and/or hubs.

Another key role for the gas utility is to serve as a transitional stage on the way to increased electrification and to keep industry functional in this transition because many industries rely heavily on natural gas to meet their high process heat needs. As industrial gas sales decline over time due to electrification, and as gas distribution infrastructure ages, gas utilities and their regulators will need to make decisions about replacement versus retirement. These are local decisions that are largely influenced by the intensity of use. (Nadel 2022).

Energy Efficiency as a Meeting Ground for Stakeholders

Strategic energy management (SEM) is an effective, low-cost, near-term programmatic pathway for energy use and emissions reductions in industry. There is a clear concentration of utilities with SEM offerings in states with policies promoting and supporting SEM programs, though there are some outliers. Statewide SEM programs often report savings as high as 10% of annual energy spend for participants, while also reaching medium and large customers that have opted out of their utility service provider's energy efficiency riders (in states where that is permissible) (Bernath & Buffum 2017).

Utility SEM programs assist organizations in reducing energy use and emissions beyond the level of regulatory requirements, often reaching and enable significant savings from highly motivated players with more hands-on technical support and collaboration. Large shares of eligible industrial and commercial energy demand customers have not participated in voluntary SEM programs. It will take the combination of state and federal policy as well as utility programs to encourage energy management and the savings it can create through efficiency. Figure 6 identifies the states with policies supporting strategic energy management programs, along with the utilities identified from the 2020 ACEEE Utility Scorecard as those with strategic energy management (SEM) offerings (Relf et al. 2020, Subramanian et al. 2022). Those utilities are represented in figure 6 by power poles at the location of the utility's headquarters.

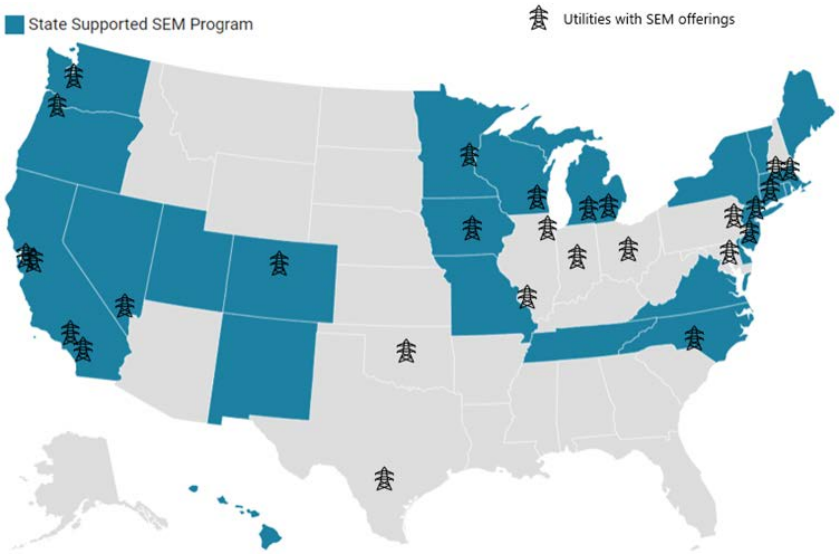

Figure 6. States with SEM Programs and Utilities with SEM Offerings (*Source*: Relf et al., 2020, Subramanian et al. 2022).

Options for Industrial Stakeholders

Industrial companies can also affect state policy development and utility programs through engagement with their co-stakeholders in the industrial decarbonization arena. Many large multinational manufacturers have GHG-reduction goals and science-based targets, with some even aiming for carbon neutrality. Companies need to communicate barriers and technology priorities to state governments and utilities to ensure creation of programs and policies that accelerate their decarbonization and help them meet their goals. Many companies have also pursued International Organization of Standardization (ISO) certifications. This is an important step in the right direction because such standards are agreed upon by international experts and are based on best-practice knowledge of decarbonization measures and energy management approaches. Engagement with policymakers on certification and standardization of protocols can ensure adequate accounting for and attribution of decarbonization measures taken at facilities. Energy audits and technical support can enable identification of potential technology and efficiency improvement opportunities. Industrial stakeholder participation in state planning,

utility program design, and energy opportunity assessments will connect industrial goals with program and policy options and make sure they take the best pathways (Srinivasan et al. 2023).

Cross-cutting Themes and Considerations

Diversity, Equity, Inclusion, and Justice

Diversity, equity, inclusion, and justice (DEIJ) should be considered through all decarbonization approaches. There are pathways to DEIJ improvements at every level of engagement in the industrial decarbonization space. State-level programs geared to workforce development and job creation should include considerations of economic development, local engagement, and availability to underserved communities. Funding should prioritize reskilling and retraining of workers in low-income communities whose jobs may be phased out. Several states have included just transition strategies in their clen energy plans, including North Carolina, New York, New Jersey, Louisiana, Michigan, Nevada, Rhode Island, Wisconsin, and Washington State. Utility efforts should include education programs and low- or no-cost energy audits for underserved subsectors. Manufacturing facilities are typically located in underserved, lower-income communities. Fortunately, decarbonization efforts will accrue benefits for such communities, including improved air and water quality because of less reliance on fossil fuels and fossil fuel-backed infrastructure. Policies and programs should support hiring from within those communities and ensure that electricity prices do not increase for residents as a result of electrification efforts (Srinivasan et al. 2023).

Leading states on industrial DEIJ efforts include Colorado, Massachusetts, and Rhode Island. These states have programs that include commitments to improve workforce diversity and aim to leverage DEIJ efforts with larger climate goals. Examples from these states include Colorado's Environmental Justice Task Force, which provides recommendations on how to address environmental justice inequities, Massachusetts' new environmental justice protections for projects located near vulnerable communities, and Rhode Island's new requirements for an equitable transition to net-zero emissions, including protections for vulnerable communities. Other states should replicate and expand on these efforts to ensure that underserved and threatened communities are protected.

Resilience and Reliability

Resilience and reliability of electricity supply is an essential, cross-cutting resource adequacy concern for many decarbonization pathways (especially energy efficiency and electrification). Many industrial processes are uninterruptible, and therefore absolutely depend on the reliability of their power supply. States can help promote resilience and reliability through policies that help reduce costs for on-site renewable electricity generation at industries, energy storage, technical support programs for such technologies, and funding for utility infrastructure upgrades. Utilities need to continue to update the efficiency and reliability of grid supply through voltage optimization efforts and infrastructure buildout (Srinivasan et al. 2023). For reliability, utilities should consider the future of load growth and how best to meet that growth with low-carbon energy. For resilience, utilities and industry should carefully collaborate on prioritization of infrastructure buildout. Microgrids are one example of a strategy to enhance grid reliability and resilience amid decarbonization.

Small and Medium Manufacturers

Small and medium manufacturers (SMM) make up a significant portion of manufacturers in the United States: More than 90% have fewer than 500 employees (NAM 2019). Many of these companies are critical players in complex, carbon-intensive supply chains, transforming intermediate products to finished products and distributing them. Holistic industrial decarbonization will rely on efforts to reach these entities in addition to the major emitters. However, reducing emissions at SMMs is often difficult because of lack of personnel, capital, knowledge, and infrastructure. State efforts to overcome these barriers should include outreach, energy management programs, involvement in pilots and demonstrations of transformative technologies, and incentives for efforts such as waste reduction, project implementation, and energy assessments. Relatively low-cost, low-complexity technologies and efficiency improvements, such as those recommended by DOE's Industrial Assessment Centers (IAC) to improve productivity or reduce waste is another viable pathway to help SMMs decarbonize. Examples of such technologies include more-efficient belts, occupancy sensors, insulation, and adjustable frequency drive or multiple speed motors. State policy should also expand leverage with utility providers to reach SMMs. Utility programs should include further programs specifically tailored for SMM decarbonization (Srinivasan et al. 2023).

Leveraging Federal Funding

The passage of the Energy Act of 2020, Infrastructure Investment and Jobs Act of 2021, and Inflation Reduction Act (IRA) of 2022 provides support for programs in multiple areas that could yield significant GHG reductions in industry. Recent analysis has found that the IRA package as a whole has the potential to reduce net U.S. GHG emissions to 32-42% below 2005 levels in 2030, compared to 24-35% reductions without it (Larsen et al. 2022). With the IRA, industrial emissions are predicted to decrease by 3%, 11%, or 16% in 2030 relative to 2005 in three future emissions scenarios (high, central, and low), compared to +1%, 8%, and 14% without the IRA (Larsen et al. 2022). DOE has funding for a number of new programs and expansion of others to support decarbonization, and there are emerging funds to support decarbonization in collaboration with state energy offices.

How States, Utilities and Industry Can Work Together Effectively

There are several examples that demonstrate complementary efforts of state policymakers, utilities, and industrial entities. These include examples of approaches to overcome barriers, including legislative obstacles like bans on fuel switching, and real-world illustrations of the decarbonization pathways such as energy efficiency and electrification.

Energy Efficiency in the Pacific Northwest

Bonneville Power Administration (BPA), for example, which has more than 120 customer utilities in the Pacific Northwest, encourages and incentivizes energy efficiency as a primary avenue for helping industrial end-users decarbonize. BPA engages with state legislatures and the Northwest Power and Conservation Council, which oversees regional energy efficiency planning and renewable goals. BPA consistently pursues energy efficiency measures across its utilities

and their end-users, working with state policymakers to provide technical support and review savings potential across the region. (BPA 2020)

Energy Efficiency in the Midwest

DTE Energy, which serves millions of customers in Michigan, has interacted with Michigan state policy, including its critical 2008 Energy Waste Reduction standard, which requires all natural gas and electric utility providers in the state to implement programs to reduce energy usage and introduce effective energy saving programs for their large commercial and industrial (C&I) customers. Such programs include energy management controls, retro-commissioning, and prescriptive incentives for energy-efficient industrial equipment. (DTE 2019, 2020)

Electrification, Energy Efficiency, and Gas Utilities

Public Service of Colorado (PSCo), a subsidiary of Xcel Energy, is the major investor-owned utility (IOU) in Colorado for the region's industrial sector. PSCo has interacted with Colorado state policy, including the clean heat standard, which established GHG-reduction goals for natural gas utilities, and a recent Senate bill on how the "Electric Utility [Can] Promote Beneficial Electrification," which requires electric utilities to support all cost-effective electrification to effect decarbonization for their end-users (Colorado General Assembly 2021). To that end, PSCo plans to create 400 MW of battery storage, has established energy efficiency rebates for industrial equipment, and offers a Process Efficiency Program for large industrials that want to direct their utility fees to energy efficiency investments at their facilities. (Xcel 2023)

Conclusions

Industrial decarbonization, which is critical to abating the worst effects of climate change, will require a suite of policies and activities at federal, state, and utility levels. There must be action across the five cross-cutting decarbonization pillars: energy efficiency, electrification, low-carbon fuels, mitigation strategies, and driving product demand. Energy efficiency is a critical first step to accessing these pillars. We also need efforts toward promoting equity and resilience as well as regional, industrial sub-sector-specific policies and programs to ensure decarbonization efforts reach all parts of the sector and along complex supply chains.

State policies are effecting meaningful decarbonization and/or setting market signals that will be essential. It is critical that states continue to develop and refine such policies to help decarbonize the hardest-to-abate sectors in their region. States may need to conduct studies and develop roadmaps to understand the barriers that need to be overcome, which could include workforce and environmental justice concerns, resource adequacy, and more. They will need to simultaneously consider the most effective cross-cutting strategies in the near term to help overcome those barriers, while pairing that action with what will enable longer-term transformation. State policy should complement and leverage federal dollars while also ensuring that important decarbonization pathways and technologies are not overlooked.

Utilities also have the potential to help rapidly accelerate industrial decarbonization. Utility programs should interact with state goals, resources, and policy to ensure that customers have access to the resources necessary to pursue decarbonization measures. Utility action is often required—on top of effective state policy—to accelerate emissions reductions because of

utilities' unique positions to offer technical support, optimize grid management, and provide more-targeted programs than standalone state or federal action.

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