Request for Information on Barriers and Pathways to Integrating Onsite Clean Energy Technologies in the Industrial Sector

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About ACEEE

The American Council for an Energy-Efficient Economy (ACEEE), a nonprofit research organization, develops transformative policies to reduce energy waste and combat climate change. With our independent analysis, we aim to build a vibrant and equitable economy – one that uses energy more productively, reduces costs, protects the environment, and promotes the health, safety, and well-being of everyone. ACEEE has been a leader for four decades in industrial energy policy, programs, and technologies. The comments provided below highlight key information gathered by ACEEE staff while researching paths for variable renewable energy (e.g., wind and solar) to increasingly be used by industrial facilities as a route

to reduce GHG emissions and energy use while aiding beneficial electrification[1]. Perspectives gained by ACEEE staff while serving as the primary research lead for development of DOE's *Industrial Decarbonization Roadmap*[2] also support our response to this RFI.

Introductory Remarks

Industry is currently responsible for more than one quarter of U.S. greenhouse gas emissions (GHGs)[3]. To reach climate stabilization goals it is crucial that deep GHG reductions be made, with electrification being one of the major pathways as identified in DOE's Roadmap. For industrial electrification to be beneficial, however, the energy that powers newly electrified processes must come from low-carbon or carbon-free sources, such as nuclear, hydroelectric, wind, or solar power. Prospects for new nuclear and hydroelectric supply, however, appear limited in the near future. As a result, most new non-fossil fuel power will come from wind and solar, which by their nature are "variable" or "intermittent" power sources. Strategies, capabilities, and tools that create flexibility for industrial facilities to increase their power use as desired when power is readily available and advantaged, and to decrease power use when supply is limited or disadvantageous (e.g., demand responsive loads) will be instrumental to the effective utilization of increased variable power on the grid.

Summary and Recommendations

In our research, onsite or near-site clean energy and storage technologies (distributed energy resources) that improve the ability of industry to flexibly use renewable electricity (RE) have emerged as key toolsets for catalyzing beneficial electrification, increasing the ability of industry to manage electric demand and load,

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[1] Rightor, E., A. Whitlock, and R. N. Elliott. 2020. *Beneficial Electrification in Industry*. Washington, DC: American Council for an Energy-Efficient Economy. https://www.aceee.org/sites/default/files/pdfs/ie2002.pdf.

[2] https://www.energy.gov/sites/default/files/2022-09/Industrial%20Decarbonization%20Roadmap.pdf

[3] https://www.eia.gov/energyexplained/energy-and-the-environment/where-greenhouse-gases-come-from.php

and substantially reduce industrial GHG emissions. Since most of the additional renewable energy supply in the U.S. will come from wind or solar, which produces energy intermittently or variably, building flexibility into power management strategies is necessary. While there are certainly economic, financial, infrastructure and regulatory barriers to the rapid deployment of these technologies, we focus our responses primarily on the informational barriers as being most effectively addressed by DOE efforts.

In general, we suggest that DOE can provide:

1) Translational support between industry and third-party solutions providers or financers. Also, assistance in navigating relationships and identifying opportunities within the broader grid ecosystem players, including regulated utilities, ISOs/RTOs, utility regulators, NERC, and FERC.
2) Decision-making guidance for industrial facilities when it comes to navigating the broad landscape of decarbonization solutions and, in particular, routes for pursuing electrification where variable renewable electricity is directly used at facilities and selecting the best-fit/ first steps for assembling RE solutions.
3) Support for regionally targeted demonstration projects and coalition-building initiatives that serve as hands-on learning and convening spaces to help users gain confidence in new technologies and energy management strategies associated with integration of RE with industrial processes, as well as further supporting peer-to-peer sharing of information and experience.
4) Holistic planning and management support for incorporating thermal storage into ongoing industrial processes. Focused efforts to support storage alternatives to large-scale batteries are needed: primarily thermal storage, but also mechanical or chemical storage solutions.

It's also important to point out that while onsite renewable power generation and use is a pathway forward, it represents a small subset of the larger opportunity space. A broader approach that considers a variety of "non-wires alternatives"[4] would accelerate greater

[4] Frick, N., S. Price, L. Schwartz, N. Hanus, and B. Shapiro. 2021. *Locational Value of Distributed Energy Resources*. DE-AC02-05CH11231. Lawrence Berkeley National Laboratory. https://doi.org/10.2172/1765585.

impact. There are a limited number of companies (typically smaller facilities) that have sufficient land to house renewable generation facilities on-site with enough power to meet their needs. Many mid-sized and larger facilities have power requirements for which electrification could be appropriate but for which onsite renewable power generation would be totally inadequate. Examples of top industrial electrification opportunities include replacement of existing plant low- and medium-pressure boiler and hot water systems[5]. Also, not all industrial facilities are located in regions where either wind or solar is climatically favored, making it more difficult to maximize returns from installations. By limiting the scope of DOE outreach to only onsite generation, DOE may tap only a limited potential for GHG reduction via electrification, by supporting only select industrial energy uses with renewable power.

[5] Rightor, E., A. Whitlock, and R. N. Elliott. 2020. *Beneficial Electrification in Industry*. Washington, DC: American Council for an Energy-Efficient Economy. https://www.aceee.org/sites/default/files/pdfs/ie2002.pdf.

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Responses to Questions

Category 1: Current state of uptake by industrial energy users of onsite clean energy technologies

C1.1 What level of interest is there from industrial energy users in installing onsite clean energy technologies, and what is driving that interest?

A substantial interest in installing onsite clean energy technologies exists from industrial energy users. Prominent industrial players from across the economy and from every subsector are taking steps to reduce their carbon emissions. This interest is being driven by sustainability and economic goals, but also investor, public, and internal demand to reduce emissions. While many companies are approaching these goals through power purchase agreements (PPAs) of renewable electricity, others are beginning to look for additional solutions. Onsite renewable energy generation is one commercially ready, major emissions-reducing pathway.

C1.6 Provide any additional information relevant to the current state of uptake of onsite clean energy technologies by industry that does not fit in the previous sections in this category

There's a need to describe the availability of resource options within a local region in a way that allows for easy comparison across fuel sources.

- For example, how does geographic location impact the availability of biofuels by type, seasonality, and volume? Similarly for renewable electricity, what is the available capacity by time of day, quantity, and amount that's typically in excess of demand. And, how does the availability of transmission & distribution infrastructure impact the potential for local growth?
- Simulation and modeling tools from DOE could help industry, resource aggregators, and others understand the magnitude of the potential resources and risks associated with its availability. This type of tool could support planning for how to best integrate energy storage to minimize risks.

Category 2: Opportunities and barriers for onsite clean energy generation and storage technology integration at industrial facilities

C2.2 What aspects of manufacturing processes or facility operations face the greatest challenges or barriers to using onsite clean energy technologies?

Many energy-intensive industrial processes:

- Are highly integrated, which means they will require substantial cross-system retrofitting to be compatible with electrified systems. Cement, pulp and paper, refining, and chemical manufacturing are particularly highly integrated. Integration may require additional steps for effectively, reliably, and safely using RE.
- Have high temperature needs for process heat, which are not easily electrifiable. Approximately one third of the energy consumed in petrochemical facilities and refineries is above 1,000°C and an even higher proportion is in this range for primary metal manufacturing.
- Are uninterruptible and have limited potential for modularity. Many steelmaking, chemicals, cement, glass, refining, and food production processes are uninterruptible without adverse effects to finished product quality, effective use of resources, and emissions.

In addition to these specific subsector barriers, on-site renewable energy is also challenged more broadly by regulatory and informational barriers, sources of general market uncertainty, and geographic limitations:

- General informational constraints include a workforce that lacks experience and training in new systems and limited technical support for navigating issues with new technology. Vendors of renewable technologies must support planning for integration of new technologies into pre-existing industrial processes and be available for continued support years down the line
- Delays occur when utility approval is required for siting of onsite generation and the construction of power generating infrastructure. Requirements for additional transmission and distribution infrastructure can slow projects or inhibit the flexible use of new technologies. For example, generators of RE can be new entities that are not traditional utilities and there are hurdles for their power to cross public rights of way (e.g., some state statues may require the entities register as a utility), inhibiting deployment of these technologies by industry. These regulatory barriers need to be addressed for industry to incorporate onsite renewable energy rapidly and economically.
- Uncertainty arises based on the inherent availability restrictions of some renewable energy. Available space and local wind and solar potential can limit the capacity of onsite renewable energy generation at many industrial sites. Incorporating renewable power generation into a broader and more holistic

energy management strategy may mitigate some concerns over investing in onsite generation when it is only one small "piece of the puzzle" for a facility.

Much needed implementation assistance for industry can come from DOE support for:

- Testing and certification facilities that can standardize comparisons and mitigate regulatory hurdles.
- Tools or expert-led, customized guidance and technical assistance to facilitate comparisons between technology model options. This could be supported through the Industrial Efficiency and Decarbonization Office (IEDO), under the Technical Assistance and Workforce Development priority.
- Physical, to-scale demonstrations of how different RE tools and approaches can apply to different industrial applications. This could be supported under the Advanced Materials and Manufacturing Technologies Office (AMMTO), to address the goals of accelerating RD&D.
- Financing support, especially for smaller or medium-sized companies which lack the ability or staff time to apply for complex, competitive grants. The DOE Loan Programs Office (LPO) can continue to support this type of work.

C2.3 What industrial subsectors have the greatest opportunity for integrating the following onsite clean energy technologies?

The subsectors with the highest potential for onsite clean energy technologies are those with large amounts of low to medium grade process heat demands. Potential is also greater for those subsectors that are interruptible, are not highly integrated and are co-located where there is already high renewable integration into the electric grid. For example, the largest, best prospects for RE supplied industrial process heat is likely in chemical manufacturing, pulp and paper manufacturing, and food and beverage manufacturing, as these subsectors have large process heat demands that are currently being met by conventional boilers and combined heat and power (CHP).

Other subsector advantages include those that:

- have readily electrifiable heating loads/ applications
- have high potential for internet-communications technology implementation to manage energy demand, shift loads, and optimize energy use

Some industrial facilities are better positioned to incorporate renewable energy technologies into their processes because of the work that they have already done to save energy and reduce emissions. Those facilities may:

- have already implemented other energy efficiency practices, such as through the implementation of strategic energy management or third-party energy audits and implementation practices
- have already implemented smart manufacturing technologies to reduce peak energy demand, shift loads, and optimize energy use
- have already deployed other supportive distributed energy resources (e.g., thermal energy storage) that may be used to support onsite renewable generation

C2.5 Provide any additional information relevant to how the energy needs of industry are evolving and the opportunities that presents for onsite clean energy resources that does not fit in the previous questions in this category.

There are some broader, systemic issues that need to be addressed to expand the opportunity space for industrial onsite clean energy and storage:

- The slow and complicated nature of permitting in regulated energy markets of on-site installations can be discouraging for industrial facilities. Lack of net metering or sell-back tariff options in some markets also disincentivize onsite clean energy installations, unless clients have onsite storage to maximize utilization of onsite energy generation. DOE could develop tools and communications vehicles that help convey the level of renewable energy available, and where constraints are evident due to generation, transmission, or distribution to point out these challenges to PUCs, utilities, and others.
- Supply chain constraints and price limit the ability of industry to use 'drop in' battery solutions to store excess generated energy. Other forms of energy storage (e.g., thermal storage, storage of industrial gases such as oxygen and hydrogen) may be a better fit for many facilities. These alternative storage options require a shift in facility energy management strategy and entail more complex decision-making, despite greater potential for long-term feasibility and affordability compared with traditional batteries. Assistance in the form of regionally distributed demonstration projects, feasibility modeling and technical assistance support for holistically rethinking industrial energy system

design could help make storage options more viable, in the context of the full project life cycle from generation to supply to use to recovery and reuse.

- The ability for industry to sell excess power at a fair, just, and equitable price back to the grid, to maximize investment in onsite clean energy generation, could make demand response program participation more appealing to industry. Sensing and controls that provide real-time and forecasted signals to industry about when advantaged power is available need additional development to mitigate risks and provide clarity on where there are benefits to industry participants. These real time pricing and arbitrage programs are not available in all markets. DOE can work with utility providers, leverage international experience, and facilitate learning and information-sharing to accelerate progress on sensing and signaling needs that best support these kinds of programs.
- The way that energy is managed across businesses may also need to evolve, in response to changes in the percentage of renewables on the grid, the potential of utilizing RE, and demand response opportunities. For large customers, and some mid-sized customers, power supply is the domain of an energy department that oversees the distribution of power to manufacturing processes. The manufacturing businesses, although reliant on the energy provided, are not always directly connected to the energy department, and scheduling of production may not reflect the marketplace dynamics of power availability and power source. The interaction between RE and utility demand response programs, in the context of increasing grid renewables, has the potential to lead to a more dynamic connection between energy supply and manufacturing operations. DOE could develop data sharing models, scenario planning tools, and document demonstrations and case studies to allow companies to work through the challenges of implementing these new energy management systems.

Finally, if local transmission and distribution upgrades are required to provide reliability support for large onsite installations, this work is a further barrier to industrial use of clean energy. In particular, the recovery of required T&D upgrades can pose a financial barrier to project implementation. DOE can help identify regional needs for transformation of high voltage supply to reliable power at the level that industry can use it via substations/busbars, feeders, etc. DOE can also work

with utilities and utility regulators to develop planning and tariff models for T&D upgrades that ensure timely availability of service and manageable cost recovery.

Category 3: Existing technical assistance and resources available to industrial energy users interested in implementing onsite clean energy generation and storage technologies

C3.1 Which types of facilities are more likely to have the resources required to implement onsite clean energy projects?

Large, well-resourced, global companies are most likely to have access to capital, are more likely to have made sustainability or emissions commitments, and likely have staff expertise, internally or through existing outside consultant to manage and plan these energy strategies. Smaller companies are more likely to lack expertise and access to capital, making it more complicated to evaluate investments in clean energy, even if they could lead rapidly to energy and money savings.

Category 4: Accelerating the adoption of onsite clean energy generation and storage technologies

C4.1 What educational and training resources do industrial energy users need to accelerate the adoption of onsite clean energy technologies?

There is a need for information-sharing and inter- and intra-organizational communications support between energy stakeholders, as well as help navigating the specific, regional logistics of onsite clean energy technology adoption:

- Bridging the gap that exists between industry and clean energy technology vendors. DOE could potentially fill this gap by being a neutral educational resource to help industry better differentiate between their technology and financial contracting options.
- Many industrial customers are unfamiliar with the contracting and financing options for renewable energy installations. Providing regionalized support around identifying potential vendors and evaluating full life cycle costs, given the local regulatory and market conditions, could help with industrial clean energy adoption. Given variation in energy costs and markets in different regions, different options may make more sense depending (for example) on

the relative price of gas and electric and presence of a competitive wholesale market or RTO.

C4.2 What software and analysis tools do industrial energy users need to accelerate the adoption of onsite clean energy technologies?

Software and analysis tools that help support decision-making around different available clean energy options:

- Calculators that estimate localized life cycle costs/GHG impacts and allow users to weigh the outcomes and financial and non-financial benefits of different approaches. Being ultimately cost-effective, however, is not reason enough for businesses to make large changes; support for building a business case for investing in clean energy technology is necessary.

Software tools that support exploring the match between current electrical usage with storage and generation needs for installation, and that also allow users to examine how a combination of energy efficiency strategies could reduce their demand and save money on installations overall.

C4.3 What other forms of technical assistance may industrial energy users need to accelerate the adoption of onsite clean energy technologies?

Regional demonstrations are needed to tailor energy approaches to the varying industrial sector needs, best available renewable energy sources, electricity market structures, and to engage the various industries and supply chain partners to build support across diverse stakeholders. DOE can support the initiation of these regional demonstration projects, convene interested parties, and facilitate shared learning within and across demos nationally to accelerate progress.

- Optimal energy solutions will vary by geography, climate, and policy environment. Industrial sector facilities are often concentrated where there is advantaged proximity to resources, transportation, or customers. For example, chemicals near the Houston ship channel, steel manufacturing near Chicago, or textiles near Dalton, Georgia. Often the concentration, availability, and type of renewable energy does not align with the location of manufacturing clusters.
- Energy storage capabilities and types vary geographically as well. For example, along the Gulf Coast, geologic storage in salt domes is possible,

water resources are abundant, and pipeline infrastructure is well developed (e.g., for storage of H2 from electrolysis, or related energy carriers like ammonia or methanol).

- The structure of electricity markets and regulatory requirements also vary substantially across the country. This will impact which tools and incentives are available and profitable for companies.
- There's a need for a common screening tool and processes to aid the evaluation of opportunities and tailor the approach to the regional demonstrations. This would provide a concrete starting point for projects, saving time, providing clarity, and giving a basis for shared learning. It could also provide a means for collecting and organizing inputs (e.g., availability of renewable power by type, magnitude of power needs by industry, geographic location crossover). DOE has experience building this type of informational tool to help organize information, connect the dots to key data sources, and to develop guides that can provide a starting point, especially for industrial companies or facilities that lack the on-staff support for that kind of decision-making and planning.

C4.4 What types of stakeholder engagement efforts may help to accelerate the adoption of onsite clean energy technologies?

Stakeholder engagement strategies are needed that build collaboration between peers. DOE has experience facilitating and supporting these networks through the Better Plants program, the Industrial Assessment Centers, and other DOE outreach programs. This is also an opportunity to prompt engagement across industry, academia, supply chains, and engineering companies that service the industries, as well as connect renewable power to aggregators and end-users:

- In the U.S., the Renewable Thermal Collaborative (https://www.renewablethermal.org) is an example of a cross- industry group around the use of low-carbon technologies for process heat. Another example is the Clean Energy Buyers Association (https://cebuyers.org). In the energy management space, cohorts are being used to encourage the sharing of practices and approaches in small and medium manufacturers that may not have dedicated energy managers. In Europe, expertise centers are being supported for the development and application of advanced industrial heat pumps, which has provided continuity and progress in addressing additional hurdles that are exposed as technology capabilities advance further.

- DOE can greatly expand international collaborations by sharing learnings from case studies and demonstrations. The experience of advancing low-carbon technologies where a carbon price exists or where there are other strong drivers for adoption (e.g., the natural gas supply constraints in Europe due to the Ukraine war) have accelerated development and adoption of several low-carbon technologies in Europe, Canada, and now some parts of Asia. This provides an opportunity for the U.S. to leverage and share knowledge with trading partners. For example, Europe, Japan, Australia, and S. Korea continued to advance industrial heat pumps in industrial, district heating, and many other applications in the past several decades, whereas RD&D in this area in the U.S. halted in the 1990s. Beneficial electrification has accelerated in Europe in response to reduced gas supplies from Russia. Myriad companies, academic partners, and NGOs are working together in Europe to interface renewable energy sources and storage to supply electricity to industrial processes.