Leveling Up Decarbonization:

How Cities, Corporations, and Service Providers Can Leverage Demand-Side Measures for Emissions Reductions

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Research Report

ACEEE

About ACEEE

The **American Council for an Energy-Efficient Economy** (ACEEE), a nonprofit research organization, develops policies to reduce energy waste and combat climate change. Its independent analysis advances investments, programs, and behaviors that use energy more effectively and help build an equitable clean energy future.

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Data and licensing information

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Executive summary

Key findings

- Demand-side management (DSM), which includes energy efficiency and demand response, is crucial for achieving affordable, efficient decarbonization. Optimizing DSM alongside renewable energy in decarbonization planning and procurement decision processes will enable cities and corporations to accelerate progress and reduce the cost of GHG goal attainment.
- Corporations, cities, and other institutions with decarbonization goals have enthusiastically pursued renewable energy solutions (including renewable energy credits, or RECs), in part because of a robust marketplace of supply-side offerings. DSM service providers must remedy the relative lack of similar demand-side offerings so that organizations can employ integrated and optimized energy solutions.
- Decarbonization-committed corporate and city leaders, along with market service providers, should adopt a foundation of *climate-forward efficiency*, which treats DSM as an intentional driver of emissions reductions and a complement to renewable energy procurements and RECs.
- Companies with the most ambitious decarbonization plans are beginning to pursue 24/7 carbon-free electricity, recognizing that annual matching fails to capture the full potential for GHG reductions. Climate-forward efficiency should be integrated into the emerging 24/7 carbon-free electricity framework.

Cities, corporations, and other institutions are increasingly pledging to decarbonize their operations to reduce their energy-related greenhouse gas emissions. Leaders of these organizations have two general approaches at their disposal: demand-side and supply-side. Supply-side options include clean energy purchases from local electric distribution utilities, wholesale acquisition, and the purchase of renewable energy credits without the associated energy. These options are widely used and have standards and market mechanisms built up around them.

Demand-side management, which includes energy efficiency and demand flexibility, is also important, but lacks key market services (e.g., streamlined decarbonization options, access to emissions data) to support cities' and corporations' decarbonization efforts. This is especially true for cases of deep decarbonization, where organizations attempt to lower their energy use and associated emissions on an hourly—as opposed to annual—basis. This report emphasizes the importance of DSM in achieving affordable, efficient decarbonization and offers recommendations for how DSM can be better leveraged to realize greater emissions reductions than are typical under the status quo.

Why decarbonize?

Many corporations claim to be invested in a clean energy economy, with many going so far as to set their own voluntary corporate decarbonization goals. However, for most corporations cost control is a top priority, meaning that they will pursue decarbonization only insofar as it is profitable to do so. By reducing energy use during expensive periods, energy efficiency and demand response often overlap with cost savings and emissions reductions.

However, not all benefits of decarbonization are strictly financial. Some corporations are motivated by a desire to innovate and to be perceived as leaders in moving away from fossil fuels and operating on clean energy. In addition to *being* a clean energy leader, being *perceived as* a leader in clean energy procurement can convey reputational benefits and strengthen a company's public image.

Overcoming barriers

Cities and corporations are generally able to achieve their decarbonization goals more affordably with DSM than without it. Nevertheless, GHG-oriented energy efficiency and demand flexibility face several obstacles to adoption. Integrating DSM into decarbonization efforts can be hindered by its perceived complexity. Energy generation is usually easier to measure than energy conservation; supply-side resources are better characterized within existing tools and accounting frameworks. For example, meeting decarbonization goals through the purchase and retirements of RECs presents a seemingly more straightforward option for organizations than paying for energy audits, new technologies, and installation and maintenance costs of efficient equipment, especially if those more efficient options are perceived as having long payback periods. The demand-side equivalent of RECs, known as demand-side environmental attribute certificates (EACs), remain relatively underutilized.

Additional barriers include siloed structures that separate supply- and demand-side teams within organizations, not incorporating demand-side measures into decarbonization goals, and the absence of external standards that recognize deep decarbonization actions.

Solutions

For organizations that are interested in decarbonization, a variety of solutions can facilitate leveraging DSM to achieve their carbon emissions targets. In addition to roles for city and corporate leaders, roles also exist for market service providers like energy service companies (ESCOs), REC/EAC traders, and those who set decarbonization standards.

First, standard-setting organizations should establish a standard for decarbonization akin to the *annual matching* framework that in 2015 established what it means for an organization to run on 100% renewable energy. Second, more service providers should offer climate-forward efficiency[1] services aligned with those standards to clients, similar to how others offer renewable energy procurement services on the supply side. This would involve offering more granular demand-side audits of an organization's energy use and GHG emissions, streamlining planning processes required to incorporate GHG reductions into demand-side projects, appealing to as many motivations for decarbonization as possible, and encouraging organizations' supply- and demand-side teams to work toward holistic solutions. Those organizations should then be able to identify and prioritize demand-side investments as part of a coordinated strategy for achieving their decarbonization targets.

Third, just as organizations can use RECs to purchase the environmental attributes of clean energy that they are unable to procure directly, environmental attribute certificates (EACs) that do essentially the

[1] Climate-forward actions include treating EE as an intentional driver of GHG reduction; prioritizing EE investments based on their time, seasonal, and geographic impacts; and prioritizing investments across fuels (e.g., electricity, gas), systems, and sectors, particularly through electrification. See "Introduction" for more details.

same thing on the demand-side should be used more widely. Development of transparent, standardized measurement and verification (M&V) protocols by standard-setting organizations would help build trust in demand-side EACs. To gain widespread adoption, this M&V should be inexpensive and quick to execute. Who owns the EAC when multiple parties are involved will need to be clarified.

Together, these three steps will enable organizations unable to further reduce their own demand to financially support other buildings to do so, delivering efficiency where it might not otherwise be accessible while simultaneously conferring an environmental benefit to the organization purchasing the demand-side EAC.

Higher resolution understanding of energy usage and emission factors would help to target efficiency and load flexibility measures toward the times when carbon intensity is highest. These data can be obtained directly from the utility, acquired via direct metering, or purchased from third-party providers. From there, robust automation systems can help buildings react to real-time grid conditions and optimize their energy use. Governments should continue to support carbon-free electricity by setting or strengthening statewide climate targets, stipulating that ratepayer funds can be used to support electrification and other climate-forward efficiency measures, and clarifying regulatory responsibilities so that regulators are authorized and encouraged to consider the need to decarbonize when making decisions.

Introduction

Cities and corporations are increasingly pledging to decarbonize their operations in service of reducing greenhouse gas (GHG) emissions. To meet their goals quickly and affordably, they are looking for practical technical strategies that they can implement right away.

City and corporate leaders have two general approaches at their disposal: demand-side and supply-side. Demand-side interventions reduce the amount of energy needed to operate buildings, run factories, and perform other work. Demand-side management (DSM) includes both energy efficiency, which reduces overall demand, and load flexibility, which shifts when or where electricity is consumed to reduce its GHG impact. Supply-side interventions meet growing demand by procuring lower carbon energy. For organizations with decarbonization goals, this usually involves zero-carbon renewable energy procurement, in which an organization voluntarily purchases renewable electricity through market-based mechanisms, usually providing less carbon-intensive power than the organization's distribution utility offers via its standard electric service.

Public and private sector leaders have also relied heavily on renewable energy credits (RECs) to offset the carbon emissions of their fossil-fueled energy consumption, particularly since 2015 when the Greenhouse Gas Protocol established standards to allow electricity consumers to claim 100% of their load was met in this way by renewable energy sources (Sotos 2015). In prioritizing this approach, they have at best underused and at worst ignored the power of demand-side solutions to lower overall energy needs and reach decarbonization targets more affordably, quickly, and efficiently than with supply-side solutions alone.

As a nationally recognized leader in energy efficiency for 45 years, ACEEE endorses the full deployment of DSM strategies. Supply-side renewable energy has an important role, but as a complement to—not a replacement for—DSM. Entities that perceive an either/or choice rather than as a both/and opportunity are making their climb to net zero that much steeper and harder. Moreover, they are making it more expensive. The purpose of this report is to illustrate why and how DSM is the key to an affordable, efficient, and achievable decarbonization strategy, whether the city/corporation is just beginning its decarbonization efforts or is a cutting-edge leader.

This report has two main audiences. The first is corporate and city leaders who need to meet decarbonization targets. Our central argument to these entities is that if they fail to fully deploy DSM in their plans and investment decisions, decarbonization will be more expensive, take longer and be harder to achieve. The reverse is true for those who proactively pursue DSM: Their decarbonization journeys will be faster and cheaper. A subset of this audience is a small group of highly ambitious companies pursuing 24/7 carbon-free electricity, for whom DSM is also essential.

The second audience is DSM and decarbonization market service providers, including planners, energy service companies (ESCOs), and traders of RECs and environmental attribute certificates. Our argument to these entities is that if they are not providing DSM optimization services (planning, procurement, and certificates) to decarbonization-focused clients, they are missing an important market opportunity and making their clients' path to decarbonization more expensive, slower, and less likely to succeed. To expand market services to include DSM, service providers should look to the successful strategies used by companies providing renewable energy to decarbonization-committed entities—particularly around procurement, policy change, and RECs.

ACEEE's leadership on climate-forward efficiency

At the end of 2021, ACEEE published *The Need for Climate-Forward Efficiency* (Specian and Gold 2021). Climate-forward efficiency recognizes that not all kilowatt-hours are created equal, and that electricity savings during higher grid carbon intensity hours are more valuable than those in less carbon intense hours. For example, climate-forward efficiency programs might favor HVAC and envelope measures that preferentially reduce load during peak periods, which tend to be the most carbon intensive periods of the year. Just as the 2021 report argued that energy efficiency (EE) programs must evolve to prioritize GHG reductions, this report argues that decarbonization-committed corporate and city leaders, along with market service providers, must evolve to reprioritize DSM not just as a complement to renewable energy procurement and RECs but as the foundation of their decarbonization programs. Failure to optimize the potential of demand-side measures leaves money on the table and makes the goal of decarbonization more difficult to achieve. In the absence of demand-side energy-saving interventions, organizations will be required to purchase more energy and pay higher demand charges to serve unnecessarily large loads. This increases both operational costs and incremental emissions. Having more efficient loads can also enable organizations to downsize their equipment (e.g., HVAC systems), which lowers upfront costs and ensures that the equipment that serves loads is right sized for the application.

Climate-forward actions do the following:

- Treat EE as an intentional driver of GHG reduction
- Prioritize EE investments based on their time, seasonal, and geographic impacts
- Scale according to the magnitude of decarbonization goals in policy and corporate commitments
- Leverage EE to adapt to the impacts of climate change
- Prioritize investments across fuels (e.g., electricity, gas), systems, and sectors, particularly through electrification

This paper will clarify what motivates organizations to decarbonize, the challenges they face, and the solutions that can help take GHG reduction to the next level

The first section of this paper, "Who Is Decarbonizing and Why?," details the motivations that compel cities and corporations to pursue decarbonization as an organizational goal. Next, the section "Next-Level Decarbonization in Corporations and Cities" explains how matching loads with clean energy on an hourly basis can achieve deeper decarbonization than conventional frameworks, serving as a gold standard for decarbonization-oriented entities. The section "Challenges to Climate-Forward Efficiency" explains the barriers for both kinds of organizations to reaching decarbonization goals. We conclude with the "Solutions" section, which offers recommendations to cities, corporations, DSM service providers, and others who have roles to play in maximizing use of demand-side measures for efficient decarbonization.

Who is decarbonizing and why?

Companies and cities have a variety of motivations that drive their energy policy and procurement decisions, including cost savings, decarbonization, reliability, and reputational enhancement through environmental leadership, just to name a few. Energy service providers we interviewed for this report emphasized that while these actors are generally driven by multiple goals, cost savings is usually a top priority. Understanding these motivations is key to advancing widespread acceptance of demand-side solutions as viable decarbonization tools.

Keeping costs low for corporations

Most corporate energy decisions are cost driven, meaning that companies will likely only adopt measures that reduce their energy costs or provide a clear return on investment. Even though energy efficiency offers multiple non-energy benefits like reliability, ease of operation, and decarbonization, corporations see these as ancillary benefits and pursue them only when they do not increase costs.

Nonetheless, corporations do not always choose to procure demand-side measures, despite their proven track record as a least-cost energy resource. Even in the data center industry, where large technology companies routinely spend billions of dollars per year on new facilities and hundreds of millions of dollars on energy, monetary savings alone are sometimes insufficient motivation. Many energy efficiency opportunities in data centers involving IT equipment such as servers, network, and storage remain untapped (Bashroush and Lawrence 2020). These unrealized benefits are so significant that in 2023 the German parliament passed the Energy Efficiency Act (EnEfG), which requires data centers to implement energy efficiency measures to use power effectively and to avoid unnecessary waste heat.

Factors that complicate the straightforward least-cost energy approach include the perception that demand-side measures are too complex to install, a lack of technical expertise to do installations, and a short-term focused business mindset that demands quick returns on investment given potential changes in management, strategy, or market conditions.

Keeping costs low for cities

Cities are also highly motivated to keep costs low, but their direct purview in this regard generally only extends to buildings under municipal administration. Municipal buildings (e.g., schools, courthouses, administrative buildings) usually have long lifespans, and their operations can consume a significant portion of a municipal budget. Moreover, these buildings typically provide necessary community services year over year, which makes addressing potential energy waste through demand-side measures a pressing need. In the absence of DSM, cities often have to direct additional tax revenue toward energy purchases.

Because they have large portfolios of fixed infrastructure that they will most likely need to operate for many years, municipalities typically have a greater tolerance for extended payback periods on energy-related measures than corporations. For them, long-term contracts bring a form of stability.

Cities interested in energy or decarbonization solutions will generally issue a *request for proposals* (RFP), seeking solicitations to provide those services. A service provider capable of meeting the city's minimum requirements in a way that provides financial savings is overwhelmingly likely to be selected, which again speaks to the power of being able to achieve cost reductions. Alternative proposals that achieve other energy-related goals without cost savings typically have a diminished chance of success.[2]

[2] According to experts interviewed for this report, most organizations when presented with a proposal that would deliver cost savings through energy-related measures tend to accept those proposals. Universities were identified as the one group that is sometimes an exception to this rule.

Reputational enhancement through environmental leadership

Some corporations are motivated by a desire to innovate and to be perceived as leaders in decarbonization. In addition, these companies may be motivated by pressure from peers, clients, and rating agencies, which further compels action. They value the opportunity to drive innovation in energy procurement and energy systems management, differentiating themselves from others in the market. Beyond internal objectives, advancing clean energy and decarbonization goals offers the chance to influence the larger energy system and support industry-wide decarbonization. Corporate leaders can be influence multipliers, helping to drive change beyond the company's own operations.

In addition to *being* a clean energy leader, being *perceived as* a leader in clean energy procurement can convey reputational benefits and strengthen a company's public image. These benefits are sometimes facilitated by nongovernmental organizations such as CDP (formerly the Climate Disclosure Project), RE100, and the Science Based Targets initiative (SBTi), all of which play a significant role in motivating companies by creating structured frameworks and public accountability systems. Initially, advocacy began with shaming tactics (e.g., Greenpeace targeting major tech companies), but it has since evolved into collaborative initiatives that offer companies marketing benefits and public recognition for their efforts.

Once companies publicly commit to goals like RE100 or Science Based Targets, these become internal corporate objectives, driving action without the need for continued external pressure. Public recognition, such as being listed in annual reports or gaining certification logos, acts as a powerful motivator to maintain corporate reputation and market trust.

Some companies and organizations pursue decarbonization goals due to corporate sustainability mandates or to meet environmental, social, and governance (ESG) targets. Companies may also pursue decarbonization initiatives due to external pressures from stakeholders. Increasingly, retail customers have high expectations for the environmental and sustainability goals of the companies they patronize. Companies like Amazon and Target have set public decarbonization goals, often motivated by customer expectations and brand reputation.

Pressure to pursue environmental sustainability is also exerted by corporations' clients. Many business-to-business (B2B) companies have large clients that demand sustainable practices. Such companies may act because large customers demand emissions reductions across their supply chains. Now suppliers are increasingly being asked to demonstrate their contributions to corporate clients' decarbonization targets.

Decarbonization in cities

Cities are more likely than corporations to pursue decarbonization as an end in itself. As public entities, cities are moved by and beholden to political pressure (and legislative mandates to decarbonize) rather than customers, though concerns over cost are certainly still a factor.

For example, young activists in Ithaca, New York, inspired by the Green New Deal played a significant role in pushing the city to adopt its net zero by 2030 goal. The city aims to become a leader in climate action by setting ambitious decarbonization goals and by serving as an example for other municipalities through showcasing innovative decarbonization strategies (L. Aguirre-Torres, pers. comm. July 19, 2024).

In Boulder, Colorado, citizens have long been committed to environmental protection and conservation. Residents are highly engaged in city planning, policy advocacy, and sustainability initiatives, driven by a collective desire to address climate change. Boulder has a history of being a pioneer in sustainability policies, such as implementing one of the first climate action taxes in 2007. More recently, Boulder has set clear, ambitious targets, including 24/7 zero-emission electricity by 2030 and broader economy-wide decarbonization by 2035 (M. Lehrman, pers. comm., July 17, 2024).

Next-level decarbonization in corporations and cities

While the findings and recommendations in this report are targeted toward organizations with annual decarbonization commitments, the lessons from considering deeper decarbonization frameworks can inform long-term goals too. In this section, we summarize the 24/7 carbon-free electricity framework, which aims to decarbonize electricity *every hour* of the year, as opposed to netting out to zero emissions over the course of an entire year. While the number of organizations currently pursuing 24/7 carbon-free electricity is quite small, understanding its features and barriers to expansion can help us sketch out an idealized version of a decarbonization ecosystem and identify what is lacking in current decarbonization efforts.

Scope 1, 2, and 3 emissions

GHG emissions attributable to an organization's activities are typically categorized based on their *scope*, or source. Scope 1 emissions are those emitted from sources directly controlled by an organization, such as a natural gas boiler. Scope 2 emissions are those from purchased or acquired electricity, stream, heat, and cooling. For those reliant on grid-supplied electricity, these emissions are mostly determined by the carbon intensity of utility-supplied electricity and the timing of the organization's loads. However, in some regions organizations may voluntarily enter into power purchase agreements (PPAs) that give them access to more low-carbon electricity than a standard utility customer. Scope 3 emissions are the indirect emissions caused by other elements of an organization's value chain, such as those embodied within products used in the organization's operations.

Annual matching

Goals surrounding demand-side resources and renewable energy are both conventionally set on an annual timescale. The most common energy efficiency goals take the form of energy efficiency resource standards (EERS), which stipulate a minimum amount of load that must be reduced via energy efficiency by a utility or EE program administrator, usually within a calendar year.

Likewise, corporate accomplishments in renewable energy are often recognized using an annual framework. Until recently, residential and commercial electric ratepayers had limited control over their Scope 2 emissions. Most electricity was generated through fossil-based sources with far less variability in carbon intensity compared to today. In the 1990s electricity deregulation opened up wholesale electricity markets, allowing for competition between generating resources, paving the way for electric ratepayers to choose their generating resources.

Then in 2015 the Greenhouse Gas Protocol established standards that allow electricity consumers to claim 100% of their load was met by renewable energy sources (Sotos 2015). The Protocol introduced a GHG accounting method distinguishing between location-based emissions (i.e., the average emissions intensity of electricity at the location where consumption occurred) and market-based emissions (i.e., the emissions that an electric consumer could claim credit for based on their electricity purchases).

The 2015 Scope 2 Guidance to the GHG Protocol effectively standardized a process by which electricity customers (largely corporations) could voluntarily procure enough renewable energy to offset all of their annual load. Purchases could take the form of power purchase agreements (PPAs), in which customers agreed via a long-term contract to purchase clean electricity for a specified rate and duration. Or purchases could take the form of RECs, which represent the environmental attributes of a unit of clean electricity.[3] By purchasing and retiring another actor's RECs, an electricity consumer could lay unique claim to clean generation and count it toward their total annual generation.

If a corporation purchases an amount of clean electricity over the course of a year—either through standard utility purchases, PPAs, or RECs—equal to its annual load, the company earns the right under the GHG Protocol to claim they ran on 100% renewable energy. The 2015 Scope 2 Guidance catalyzed a remarkable growth in the procurement of renewable energy (see figure 1). As of June 2024, energy customers have voluntarily procured 84 GW of clean energy capacity since 2014 (CEBA 2024). In fact, corporate voluntary procurement accounted for about 40% of all renewable energy capacity added between 2012 and 2022 (see figure 2). This Guidance also catalyzed the growth in market support services for renewable energy procurement.

[3] Environmental attributes include renewable fuel type, facility location, project build date, generation vintage, emission rate of the renewable energy resource, and other identifying data.

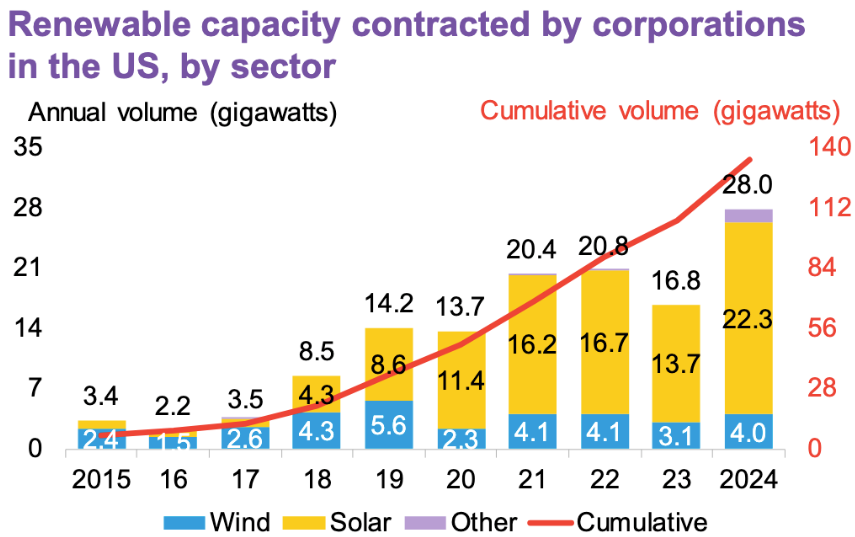

Figure 1. Growth in renewable energy capacity contracted by corporations in the United States since the GHG Protocol update. Source: BloombergNEF (BloombergNEF and The Business Council for Sustainable Energy 2025).

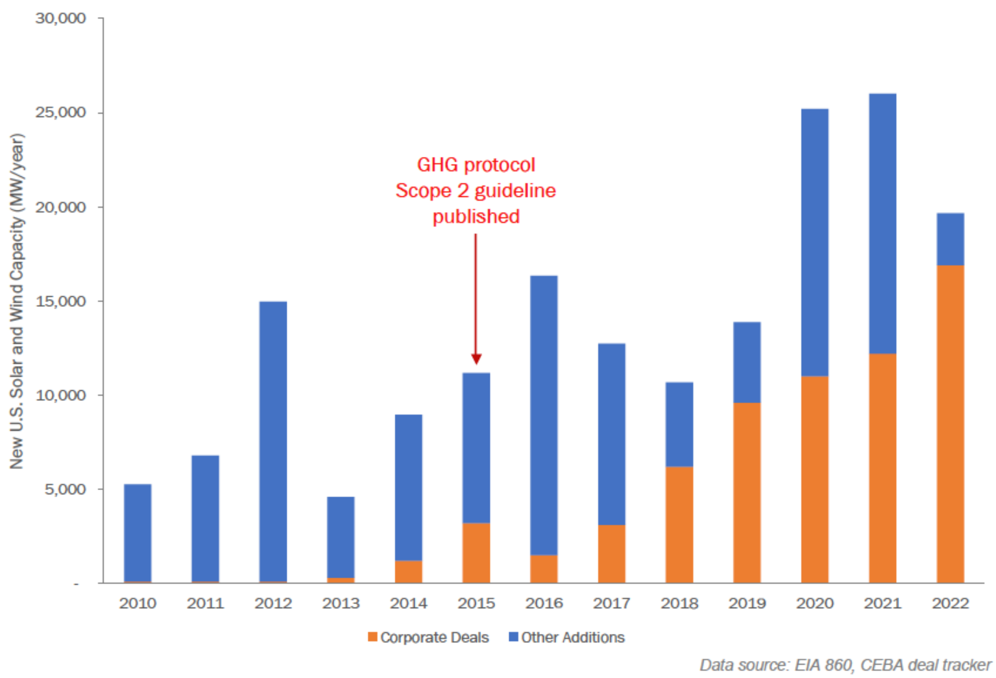

Figure 2. New solar and wind capacity additions in the United States (2010–2022). Approximately 40% of all new additions were the result of voluntary corporate procurement. Source: Hank He in a presentation for Energy Systems Integration Group (ESIG 2023).

24/7 carbon-free electricity

While annual frameworks are currently the most popular for setting and measuring progress for energy-related goals, it is possible to adopt a more granular framework that takes smaller time periods into account. Such frameworks enable considerations of load and carbon intensity of electricity that occur on hourly (or finer) timescales, opening up pathways for deeper decarbonization. In this section, we summarize how these frameworks operate for both renewable energy and climate-forward efficiency.

Despite the success of voluntary corporate procurements in driving the growth of renewable energy, many leading buyers have begun to realize that the accounting approach codified by the GHG Protocol about a decade ago still leaves a lot of emissions on the table. A leading alternative is *24/7 carbon-free electricity*, or *hourly matching*, in which an electricity customer's load is matched every hour by an equivalent amount of clean electricity in that hour generated in the same geographic region as the load.

In the same way that Passive House is a more ambitious standard than LEED for building decarbonization, 24/7 carbon-free electricity is a more ambitious standard than 100% annual matching for reducing one's carbon footprint.[4] Figure 3 illustrates an example from California that shows how different percentages of hours met by 24/7 carbon-free electricity result in progressively larger GHG reductions relative to a 100% annual matching case.

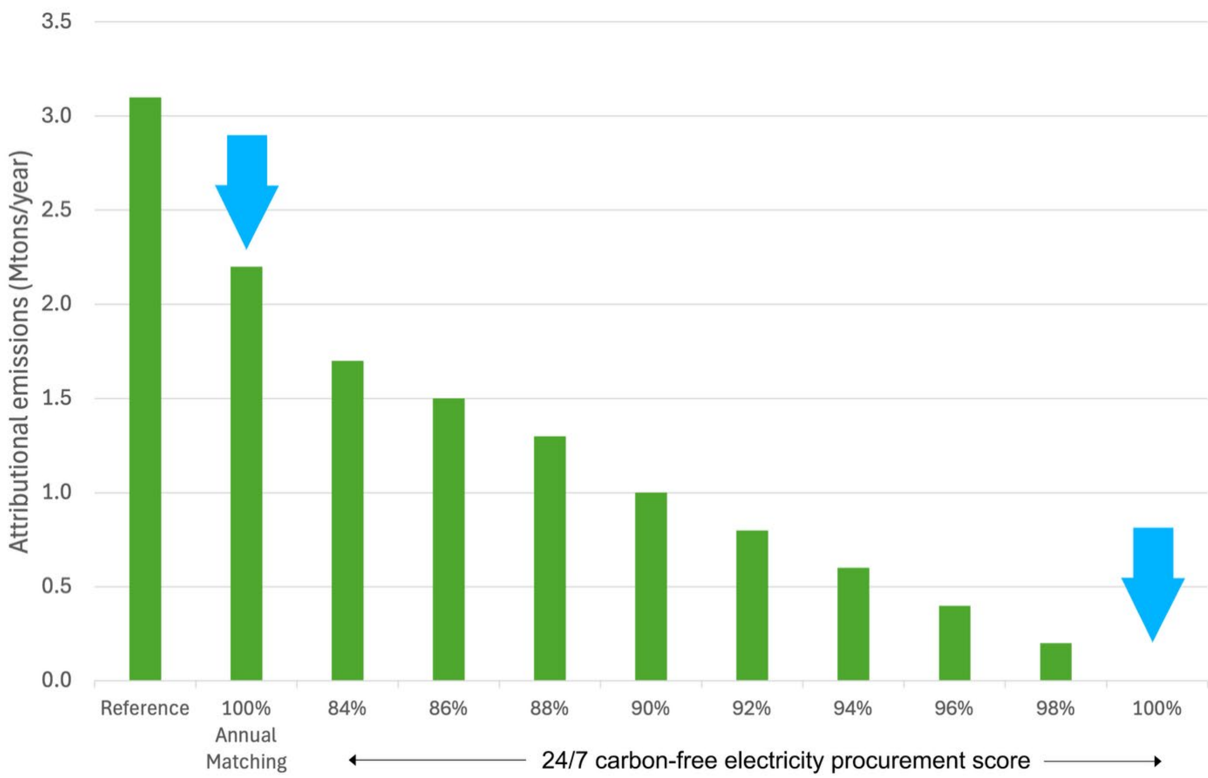

Figure 3. Attributional emissions (emissions consumers' demand is responsible for net of contemporaneous supply) in California (10% commercial and industrial participation) under a 100% annual matching framework (left arrow) and various percentages of hours met by carbon-free electricity. A 100% annual match reduces attributional emissions relative to a reference case by about one-third. As temporal (24/7) matching increases, emissions go down until, at 100% carbon-free electricity, all load is effectively met by behind-the-meter clean electricity, but with the benefits of connection to a broader regional grid. "Reference" and "100% Annual Matching" cases equivalent to carbon-free electricity scores of 70% and 80%, respectively. Source: Jesse Jenkins (Raab Associates 2022).

[4] Leadership in Energy and Environmental Design (LEED) is a global green building certification program.

The 24/7 carbon-free electricity framework recognizes that the timing of renewable energy consumption is of great importance and largely unaddressed by the annual matching framework embedded within the current GHG Protocol. A simple example of the importance of timing is the duck curve,[5] which shows a steep ramp in load that must be met without renewable energy in the evenings as solar generation drops for the day (see figure 4). The difference in carbon intensity of delivered electricity between midday and evening in a region subject to the duck curve can be stark, as can the carbon footprints of loads that run during those hours. This level of temporal granularity is not addressed by annual matching frameworks.

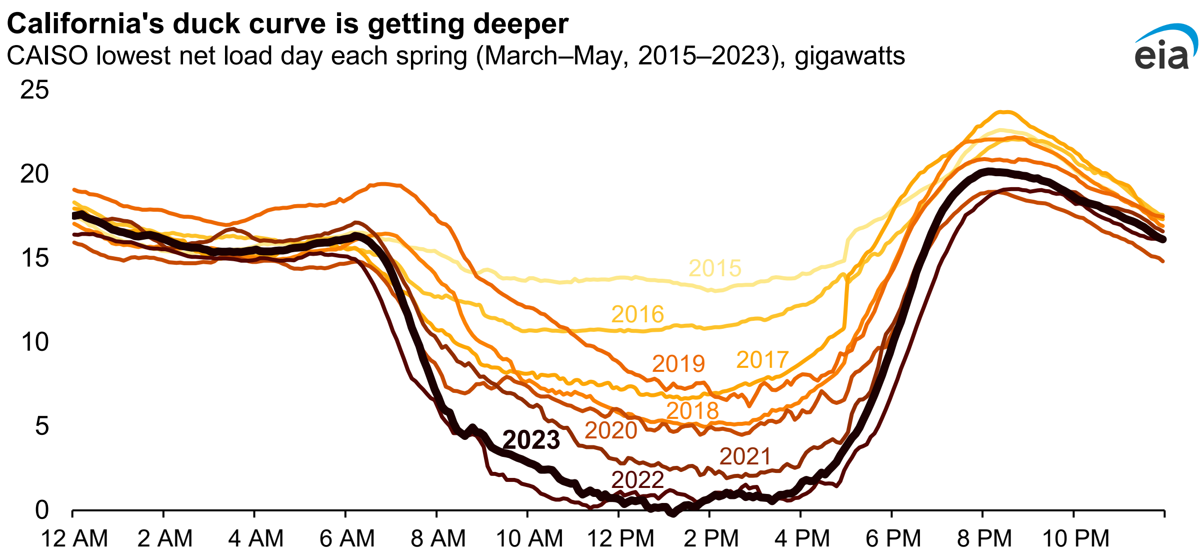

Figure 4. Representation of the duck curve in California. Lines represent the load that must be met after subtracting out variable renewable generation. The dip in the middle of the day is the result of high solar generation, which decreases in the late afternoon into the evening, causing a steep ramp that must be met with other (often fossil) sources of energy. Source: U.S. Energy Information Administration with data sourced from the California Independent System Operator (CAISO) (EIA 2023).

To date, adoption of the 24/7 carbon-free electricity approach for renewable energy procurement has been relatively modest. Its development has been driven by corporations like Google and Microsoft, and adopted by a small handful of city governments (Ithaca, New York; South Lake Tahoe, California; and Des Moines, Waterloo, and Windsor Heights, Iowa) and the federal General Services Administration (GSA). These leaders are setting precedents that others may follow as the economic and technological landscapes evolve. However, critics of 24/7 carbon-free electricity point out that the framework is considerably more complicated than annual matching, requiring more data and more expense for implementation (especially above 98% hourly matching). This presents a practical barrier to adoption for otherwise interested parties, but also introduces opportunities for demand-side interventions to lighten the lift.

[5] The duck curve represents the daily net load on the grid (i.e., demand for power minus supply of renewable energy) as a function of time. It is named because the midday trough and quick rise as the sun goes down vaguely resembles the shape of a duck.

Emissionality

Another emerging approach to clean energy procurement and decarbonization is *emissions first* or *emissionality*. Instead of aligning renewable energy generation with the time and location of energy consumption, emissionality focuses on maximizing avoided emissions, regardless of when and where load occurs. For example, while a California customer pursuing 24/7 carbon-free electricity would be required to procure clean energy locally and in time alignment with their load, a customer pursuing emissionality could prioritize clean energy projects anywhere that would maximally reduce emissions: for example, by procuring renewable energy that displaces coal-based electricity generated in West Virginia.

Another reason for slow adoption of hourly matching is the lack of a formal protocol for its evaluation. Unlike 100% annual matching, which is supported by the 2015 Scope 2 Guidance of the GHG Protocol, hourly matching does not yet have any standardized protocol. As a result, corporations that adopt the more ambitious framework lack a uniform standard by which to measure their progress. However, there have been discussions about including granular data in the GHG Protocol process, with deliberations that provide such a standard for 24/7 carbon-free electricity happening as of this writing (Greenhouse Gas Protocol 2025; Junger 2025).[6]

An earlier section of this report, "Who Is Decarbonizing and Why?," listed several motivations that compel organizations toward decarbonization. In light of 24/7 carbon-free electricity, we can add an additional motivation to that list: future-proofing operations against changes in market conditions and remaining compliant with future standards.

Iron Mountain, a data center and information management service company, is already acting in advance of this change. Iron Mountain realized that as companies set more aggressive decarbonization goals, traditional annual matching would eventually run out of potential savings. As the energy supplier to data centers, Iron Mountain saw an opportunity to fill a market gap with 24/7 carbon-free electricity. And in 2023, across four pilot sites, the company achieved over 97% hourly matching with local clean energy assets, with additional optimization on the horizon. Iron Mountain sees hourly matching as a *safe harbor* approach that offers long-term operational and financial benefits. Moreover, some utilities are already beginning to explore the potential of 24/7 carbon-free electricity tariffs (C. Pennington, pers. comm., July 15, 2024).

[6] The GHG Protocol process is overseen by the World Resources Institute, a U.S.-based environmental NGO, and the World Business Council for Sustainable Development, a Geneva-based organization that brings together leading businesses to accelerate the transition to a sustainable world.

Corporate preference for granular tracking

Companies like Google and Microsoft have emerged as early proponents of 24/7 carbon-free electricity, signing onto collaborations like the 24/7 Carbon-Free Energy Compact (24/7 Carbon-Free Energy Compact 2025). Other companies, like Amazon and Meta, populate the steering committee of the Emissions First Partnership, which supports the emissionality approach (Emissions First Partnership 2025). Regardless of their specific approaches to decarbonization, these and other like-minded companies with ambitious GHG-reduction goals recognize the shortcomings of annual aggregate accounting under the GHG Protocol and see granular energy tracking as a more precise and meaningful way to reduce emissions (Jian Zhang, CFEX, pers. comm., July 25, 2024).

Optimizing supply- and demand-side decarbonization resources

While the current lack of a standardized protocol for 24/7 carbon-free electricity hinders its adoption, it also provides an opportunity. Much of the current discussion around this updated decarbonization framework has focused on the supply-side resources that can meet load with clean energy on an hourly basis. While some studies have looked into the role of storage and demand flexibility, particularly with respect to data centers, the larger role of demand-side measures, including energy efficiency, within the 24/7 carbon-free electricity framework has yet to be established.

The ideal method for developing a GHG-optimized energy portfolio is to select the combination of supply- and demand-side resources that reduce the most GHG emissions at the lowest cost. The costs of energy-related resources (e.g., renewable energy, storage, building envelope improvements, energy management systems) all differ, so the optimal combination will often require a bespoke analysis of energy prices, up-front technology costs, climate, the carbon intensity of delivered electricity, and other factors.

Meeting annual demand with 100% clean energy becomes more expensive as you approach the 100% mark due to several factors, including the intermittency of renewable energy and the cost of energy storage. Meeting demand with clean energy in 100% *of hours* is harder still. At lower percentages, energy resources like solar, wind, and short-term battery storage are capable of meeting the need. But higher percentages introduce a pressing need for advanced, clean, firm resources like advanced geothermal, small modular nuclear, and long-duration storage.

These needs are especially acute for 24/7 carbon-free electricity. Proponents of the hourly matching framework often point to the market demand 24/7 carbon-free electricity creates for these advanced energy resources. Increased deployment of these technologies in the near term will help accelerate their market readiness, driving down costs for when they will be needed at scale. However, as shown in figure 5, this comes at a cost premium for early movers, increasing the price of achieving 100% hourly carbon-free electricity relative to less ambitious decarbonization goals. This additional cost (and complexity) is one of the reasons corporations and cities have been relatively slow to adopt the 24/7 carbon-free electricity framework.

The exponential increase in cost required to meet the highest levels of hourly matching underscores the importance of utilizing demand-side measures. Energy efficiency remains the lowest-cost resource for utilities (at an average of $20.10/MWh for utility energy efficiency programs), and a great number of demand-side measures will be less expensive than the advanced supply-side technologies that are needed to reach 100% hourly matching without energy efficiency and demand flexibility (ACEEE n.d.; Hoffman et al. 2018; LBNL 2021).

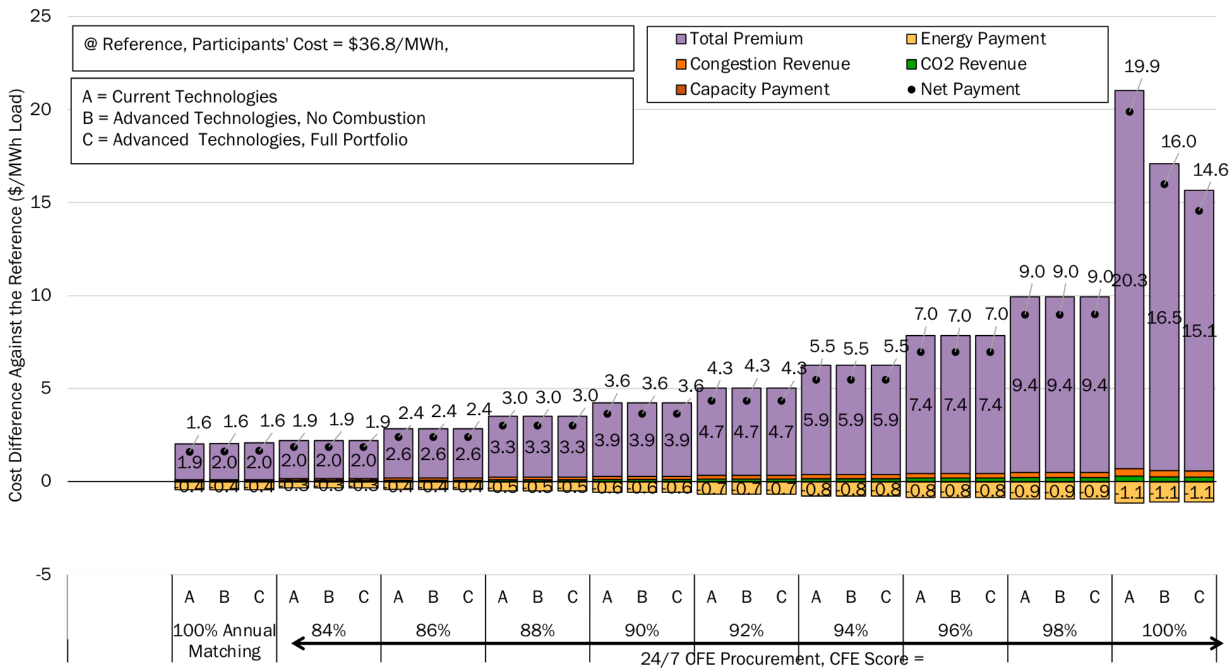

Figure 5. Cost premium to meet high percentages of hours with 24/7 carbon-free electricity. This figure presents a test case in which 100% annual matching comes at a premium of $1.60/MWh, while 100% hourly matching comes at a premium of $15–20/MWh. Early movers (i.e., Portfolio A) end up paying the highest costs to decarbonize, but help drive down costs for those who follow (i.e., Portfolio C). Source: Jesse Jenkins (Raab Associates 2022).

Challenges to climate-forward efficiency

Cities and corporations can achieve their decarbonization goals more affordably with DSM than without it. Nevertheless, GHG-oriented energy efficiency and demand flexibility face several challenges. We divide these challenges into two sets: general decarbonization challenges, which apply to all organizations with a commitment to decarbonization, and 24/7 carbon-free electricity challenges, which apply to organizations pursuing deeper decarbonization along the lines of 24/7 carbon-free electricity.

General decarbonization challenges

- Complexity involved in procuring demand-side solutions from the market
- Underdeveloped market for demand-focused environmental attribute certificates
- Organizational siloes that separate demand- and supply-side solutions
- Lack of standards for entities wanting to set ambitious DSM goals

24/7 carbon-free electricity challenges

- Lack of easy access to necessary data
- Insufficient building automation

- Inadequate presence in legislation, policy, and programs

While the climate-forward efficiency framework was developed primarily in service of the utility sector and its efficiency programs, its principles are valid for corporations, cities, or others seeking to decarbonize. In fact, climate-forward efficiency and 24/7 carbon-free electricity are effectively two sides of the same coin. Each is purposed with enabling deeper decarbonization than conventional frameworks. Both require advancing from annual measures of progress to more granular measures. Each framework attempts to aggressively deploy technologies specifically based on their decarbonization potentials.

Despite these similarities, an integrated framework that fully optimizes demand-side considerations with 24/7 carbon-free electricity has not been proposed until now. There have been some reports, such as TU Berlin's study showing how load-shifting flexibility can be used to meet high 24/7 carbon-free electricity targets (particularly with respect to data centers), but these examples remain limited (Riepin and Brown 2022).

By surfacing the conditions that would make an integrated framework more viable, we hope to inspire cities, corporations, and others to more aggressively pursue deep decarbonization. Even if those organizations are not ready to take the leap into 24/7 carbon-free electricity, the elements that make an integrated framework more attractive—such as awareness, data access, accounting mechanisms, policies, and standards—can make conventional decarbonization more attainable as well.

In November 2023, ACEEE hosted a one-day workshop at the Energy Efficiency as a Resource (EER) conference in Philadelphia, Pennsylvania. Approximately 75 attendees participated in breakout sessions where they provided feedback on issues surrounding the idea of an integrated framework that merges climate-forward efficiency and 24/7 carbon-free electricity. The agenda for and feedback received from that workshop are included in "Appendix A: Climate-Forward Efficiency Workshop Report."

The remainder of this chapter is devoted to elaborating upon each of the obstacles impeding climate-forward efficiency from being integrated into decarbonization frameworks. In the subsequent section, Solutions, we offer recommendations for overcoming them.

General decarbonization challenges

Complexity

The perceived complexity of integrating demand-side measures into decarbonization efforts can serve as a barrier for organizations. Current market offerings tend to prioritize supply-side procurement over demand-side solutions, largely due to better characterization of supply-side resources in existing tools and accounting frameworks. Existing regulations and utility planning processes are also not fully aligned with innovative demand-side integration strategies.

When organizations have the option of meeting their decarbonization goals through the purchase and retirements of RECs, that presents a seemingly more straightforward option than paying for energy audits, new technologies, and installation and maintenance costs of efficient equipment, especially if those more efficient options are perceived as having long payback periods.

Moreover, for companies, scaling integrated solutions across global operations is complicated by differences in regional policy landscapes, access to energy data, renewable energy availability, energy resource prices, and climate zones. Some business leaders report that the energy software solutions they are familiar with have not done a good enough job characterizing the potential of various demand-side measures, making it difficult to decide what and how many demand-side resources to secure.

Cities do not have to operate globally, but they must still adhere to regulatory processes and policy constraints, and they have limited knowledge of and control over the loads within their jurisdictions. Differences among companies and cities mean that there is no one-size-fits-all approach, necessitating local or specialized solutions, many of which are not being offered by service providers in the market. All these perceptions highlight the importance of understanding and appealing to the motivations of organizations to ensure efficient demand-side solutions are understood for what they are: financially attractive and environmentally responsible options.

Insufficient support from service providers

There is a pressing need for more third-party demand-side service providers to offer climate-forward efficiency decarbonization services to their clients. To understand what is required of such service providers, it is helpful to explore the workings (and weaknesses) of the ESCO model in the context of climate-forward efficiency.

ESCOs typically earn a return based on the energy savings they are able to deliver for their customers, which makes those cost savings a critical component for both the client and the service provider. Projects must deliver financial returns, and clients expect economic benefits to justify investment. Projects worth consideration have two components: proposals and execution.

Before any work takes place, ESCOs typically generate multiple proposals for work that can be done. These proposals are created prior to the contracting phase of work, meaning that ESCOs invest their own resources into proposal creation without a promise that the client will agree to pay for their services. For this reason, a natural incentive exists for proposals to not be too complicated to put together (or else their production cost will rise), yet they must be attractive enough so they are reasonably likely to be selected by the client.

ESCOs usually begin by trying to understand what their clients wish to accomplish. They will then put together a project plan that meets those goals. ESCOs typically present a far more comprehensive project than the client has an appetite for. The client will subsequently shave off the elements of the project that they do not wish to pursue before arriving at a final agreed-upon proposal.

Climate-forward efficiency proposals and those that incorporate carbon-free electricity are likely to be more complicated and expensive to generate relative to traditional energy-focused proposals. To satisfy hourly matching requirements, ESCOs would need to acquire hourly load profiles for all the client's loads, which may not be immediately available.[7] Then they would need to map those loads to likely emissions profiles of any energy consumed by the client, including energy supply by the electric grid or separately procured by the client. For a large site, an investment-grade audit development can cost hundreds of thousands of dollars. The ESCO remains on the hook for those costs with no guarantee of reimbursement unless and until the client signs a contract to do the construction.

The second component of ESCO projects is execution. In the absence of a price on carbon, many decarbonization efforts, such as electrification retrofits, lack immediate financial payback. If there is no clear financial value associated with carbon reduction, there will be no substantial monetary incentive tied directly to emissions savings. This lack of financial return makes projects difficult to justify for both the ESCO and the client. Organizations that have prioritized decarbonization (e.g., Google) are more willing to absorb additional costs, but for other organizations every effort should be made to reduce what amounts to a decarbonization premium.

[7] Hourly matching also requires hourly load profiles, just not disaggregated by end use.

Moreover, most ESCO work today is done in public buildings, not corporate ones. Public buildings often have some sort of decarbonization goal set by the elected officials overseeing them. In practice, however, these goals are often unfunded mandates. Even though public buildings have a goal to decarbonize, their operators still expect the ESCO model to deliver a net benefit to their financial bottom line. While public facilities operators may appreciate the decarbonization benefits offered by an ESCO, in the end the ESCO has to have a financial justification before it can move forward. Without that, projects get canceled—even if they reduce significant amounts of greenhouse gases.

This ESCO model presents something of a chicken-and-egg situation. If a client presents ambitious 24/7 decarbonization goals, the ESCO will readily develop a complementary work plan. But the ESCO is unlikely to develop and present that plan if the client fails to make that overture. And the client may not be informed about 24/7 decarbonization.

Underdeveloped market for demand-side environmental attribute certificates

An organization that has directly procured as much renewable energy as possible and made all of the demand-side improvements at its own facilities that would be economically or technically feasible may still fall short of its decarbonization goals. For example, a data center might have a nighttime load that exceeds the capacity of local available wind or other clean energy resources. If the data center cannot reduce load further or shift load to other lower-carbon hours, it may appear to be out of options.

One component of alleviating this problem takes the form of EACs, or environmental attribute certificates. An EAC is a calculated value that represents a carbon emissions reduction related to energy consumption. That EAC can be expressed in terms of mass of carbon reduced or the energy saved that led to that carbon reduction.

An EAC captures the set of attributes associated with energy generation that determines the value of that energy. Examples of these attributes include the time, location, and carbon intensity of the generated energy. The generating organization—by virtue of funding the emissions reduction project—would retain ownership of the value of that energy, which it could count against its own emissions.

Aspects of EACs may be valued differently across jurisdictions and can be transacted in a variety of ways. On the supply-side, one example of an EAC is renewable energy credits (RECs), which represent the environmental attributes of 1 MWh of electricity generated by a renewable energy resource.[8] These RECs allow organizations unable to directly procure more renewable energy to instead pay another generator for ownership of that clean generation's environmental attributes, which ideally builds the market for clean energy despite any local limitations. Similarly, zero emission credits (ZECs) are similar to RECs but admit nonrenewable, non-emitting electricity generation including nuclear power.

A more granular version of a traditional EAC is the time-based environment attribute certificate, or T-EAC. While RECs are typically only created on a monthly basis, T-EACs would be minted on an hourly (or shorter) basis. They would include similar information as traditional EACs, including data like the locational marginal price or marginal emission rate for the grid location where they were produced. T-EACs can help enable both 24/7 carbon-free electricity and climate-forward efficiency.

[8] In the European Union, a similar tool that provides transparency about the provenance of electricity is referred to as a "guarantee of origin," or GO.

EACs can be specified not just in the context of energy generated but also in terms of energy saved. Yet tools for the procurement of demand-side resources are far more nascent and have yet to grow to the scale needed for widespread adoption.

Despite growing awareness, large energy buyers like Google and Microsoft remain skeptical about the validity of demand-side resource EACs in carbon-free procurement frameworks. Part of this skepticism stems from experience with cheap, unbundled RECs (with weak additionality requirements) that have allowed many companies to make claims of using 100% renewable energy while doing little to actually add renewable energy to the grid or reduce emissions. Those doubtful about demand-side EACs are looking for assurances that they can be used without running into issues with double counting, especially in a purely voluntary framework.

Silos

Siloed organizational structures can hinder decarbonization efforts. Organizations may have dedicated facilities teams that design and construct the buildings and handle demand-side measures (e.g., energy efficiency, peak shaving); energy procurement teams that buy the power; and sometimes even a third team of sustainability professionals trying to make everything green. The rationale for separate teams is that construction, energy procurement, and other tasks are often large and complex enough that specialized teams are required.

However, decarbonization necessitates an integrated consideration of both supply- and demand-side options. Energy solutions are not monolithic: Some solutions can be pursued at low cost, while others require greater investment. The optimal combination of resources should be a function of the organization’s budget and decarbonization goals. An energy portfolio not based on considering all the options in relation to each other will cost more than an integrated one.

Standards and goals

Many organizations, including utilities, cities, and corporations have set clean energy or decarbonization goals. Many of these goals, however, are focused on supply-side solutions like procuring enough renewable energy to meet loads or buying and retiring renewable energy credits (RECs).

These goals urgently need to incorporate demand-side solutions, such as stating how much load or emissions reduction the organization plans to achieve through efficiency and load flexibility. An explicit demand-side target can significantly impact the trajectory of an organization’s activities, ensuring DSM is effectively leveraged for decarbonization.

For example, a facility with a large gas boiler has options: improve or replace the gas boiler, install an electric boiler, or install a large heat pump. Installing the heat pump is the best option for reducing emissions, but the heat pump’s payback period might be longer than replacing the existing boiler with a high-efficiency boiler. When corporations are faced with longer payback periods, the decision they ultimately make often comes down to how motivated they are to decarbonize. Here, explicit decarbonization goals can make the difference. A corporation at risk of missing its decarbonization targets will be more willing to work through the complexities and time frame associated with a heat pump than a corporation with no such goals.

Effective goal setting requires adequate standards against which to measure demand-side progress. These standards exist in the utility sector, where the use of deemed and measured savings approaches for evaluation, measurement, and verification are well established and are presently being used to assess how well utilities are meeting efficiency requirements laid out as part of energy efficiency resource standards (EERS).

24/7 carbon-free electricity challenges

Data

Energy data: Advancing from an annual framework to a granular deep decarbonization framework requires additional data and can add significant complexity and operational challenges for companies. First, organizations need to understand their hourly load for an entire year. Corporations may require this data from just a single facility or a collection of buildings. City governments would likely require load data for all their city's buildings, which can easily number in the thousands. Those data are not typically publicly available. One option is to rely on submetering data, but many facilities lack that kind of infrastructure. Cities can begin with buildings under public control, but even then, utilities are generally not accustomed to meeting this kind of data request and may be ill-equipped to satisfy it. Without these data, it becomes challenging to optimize clean energy measures effectively.

While Advanced Metering Infrastructure (AMI) can make it easier for utilities to provide consumption data to customers on an hourly basis, it should be possible even without AMI. Utilities that do not have an AMI network often have legacy MV-90 metering, which also records consumption on a 15-minute basis for large commercial customers.

Yet access to high-quality, granular data remains a significant barrier for many companies, especially smaller ones, as well as for cities without large internal teams. Even sophisticated organizations can face challenges in managing and interpreting large datasets to align supply and demand on an hourly basis.

Greenhouse gas data: Deep decarbonization frameworks require mapping energy consumption to GHG emissions. Cities and corporations cannot easily optimize their operations for decarbonization without a reliable signal indicating when the grid's carbon intensity is high. While the locational marginal price of electricity or the presence of peak system demand are good indicators, reliable measures and forecasts of the grid's marginal emission rates should theoretically be the standard for determining the emissions reduction contribution of demand-side measures. Access to those data enables organizations to optimize their operations around that variable. They help inform a building about when to, for example, run loads or charge behind-the-meter storage. Without those data, organizations are likely to optimize using the variables they do have access to—notably price.

An additional challenge is the uncertainty associated with hourly marginal emission rates. While they are almost certainly preferable to average emission rates when estimating the GHG reduction associated with a demand-side measure, they are impossible to calculate precisely. Not only are there different types of marginal emission rates,[9] but their calculated values are also subject to bias associated with the models used to derive them. However, research suggests that averaging hourly marginal emission rates over months, seasons, or even an entire year can mitigate that uncertainly and may be preferable for accurately assessing the emissions reductions of DSM (Elenes et al. 2022).

Savings load shapes: Utilities do not always quantify the benefits of their energy efficiency investments in ways that support climate-forward efficiency. Energy savings realized by energy efficiency measures

[9] Marginal emission rates are always calculated as a change in emissions over a change in energy. The denominator can be represented by total demand or by demand for thermal generators. They can also be calculated as the emission rate of the costliest plant dispatched (assuming economic dispatch) or based on incremental emissions resulting from a small (e.g., 1 kWh) change in demand.

are often quantified in technical reference manuals (TRMs).[10] TRMs typically report these savings on an annual or seasonal basis, but rarely on an hourly basis. TRMs also do not report emissions reductions, which rely on time-dependent factors like the real-time carbon content of delivered electricity.

Automation

To leverage climate-forward efficiency for deep decarbonization, buildings must be equipped with more sophisticated technology than is needed in more basic decarbonization frameworks. For example, under an annual matching framework, a corporation can claim to run on 100% renewable energy by establishing that their annual load matches their annual procurement of renewable energy (or RECs). This calculation takes place on an annual basis and does not require any significant reaction from buildings to implement.

Matching load with renewable energy on something like an hourly basis is more complex. While some buildings, like data centers and industrial facilities, have control room desks that are quite sophisticated, greater controls and automation of loads will be necessary for other building types. Unlike conventional demand response, which may only be called upon a few times a year, demand-side adjustments for deep decarbonization may require changes in building operations a couple times a month or as much as every day. Buildings that are not equipped to respond with this frequency will find achieving deep decarbonization more difficult.

Policies and programs

The ability of individual organizations to deeply decarbonize depends upon policies and programs external to their operations. A policy environment that supports goals related to 24/7 carbon-free electricity and climate-forward efficiency will lead to market changes that organizations committed to deep decarbonization can take advantage of. For example, when the U.S. Treasury Department needed to set rules for how the 45V tax credit for the production of clean hydrogen would be applied, they decided upon an hourly accounting framework that aligns with the principles of 24/7 carbon-free electricity. In doing so, they established a need in the market for granular (i.e., hourly) GHG emission factors, which, once available, could be leveraged by other entities interested in deep decarbonization.

New York State, which is aiming for 70% renewable energy by 2030, believes that getting to 100% renewable energy by 2050 will lead to carbon-free electricity. However, we know that goals set on an annual accounting framework leave emissions on the table by failing to account for high-carbon periods within the year. If New York were to, for example, add 24/7 carbon-free electricity as an amendment to its Climate Leadership and Community Protection Act (Climate Act), it would make the pathway to carbon-free electricity at the state level easier by leading to changes for utilities, regulators, and the procurement process.

Efficiency and demand-side flexibility programs, including those run by utilities, are unlikely to be as adept at providing necessary data for deep decarbonization if no policy motivation compels them to do so. Likewise, demand-side solutions that reduce carbon in specific hours are unlikely to emerge if annual accounting frameworks remain the norm. Without those solutions, deep decarbonization will be harder for organizations to achieve. Additionally, without standards for climate-forward efficiency or 24/7

[10] These are also referred to as “deemed savings” and represent the savings energy efficiency measures are expected to generate. This approach differs from “measured savings,” which are calculated based on measured energy consumption.

carbon-free electricity, claims of having achieved either goal will be difficult to verify or to compare against other organizations' accomplishments.

Solutions

In this section, we discuss several possible solutions for getting organizations already interested in decarbonization to leverage demand-side resources toward that end. Several of the solutions in this section fall under the purview of DSM and decarbonization market service providers, such as ESCOs and REC/EAC traders. Enhanced collaboration between these service providers and their clients may be necessary in the near term as both groups calibrate their offerings and expectations based on the needs and capabilities of the other.

In the "Who Is Decarbonizing and Why?" section, we explained that corporations are usually primarily motivated to reduce energy costs, with other benefits like decarbonization being subordinate. An effective strategy for maximizing decarbonization, therefore, is to align carbon-reducing actions with cost savings. The remainder of this section discusses approaches that should be considered as components of an integrated supply- and demand-side energy solution. Not every solution will be applicable to all organizations, but cities, corporations, and others should find some useful approaches in the recommendations that follow.

Make DSM for decarbonization more accessible

While the challenges explained in the section "Insufficient Support from Service Providers" focused on ESCOs, many similar elements apply to other demand-side service providers. There are several approaches to addressing these challenges.

First, service providers will only offer services that their clients request. Therefore, service providers and other advocates should **build awareness of climate-forward efficiency and 24/7 carbon-free electricity**. Even when policies or funding to save energy or reduce GHG emissions exist (e.g., Energy Efficiency Conservation Block Grants), awareness of 24/7 carbon-free electricity—and especially the demand-side of that framework— among municipal and corporate decision makers is often not high enough to stimulate market demand for solutions.

One pathway for motivating customer interest is **connecting climate-forward efficiency with customer value**. The current service provider model works by identifying excess costs buildings face today, then implementing energy-saving measures that become a funding stream to pay for those measures.

Climate-related disasters like hurricanes and power outages pose a growing financial risk to building owners and occupants, though one that may not be routinely quantified. Illuminating the potential financial losses associated with climate change makes it easier to justify renewable energy and demand-side measures that also deliver resilience benefits. These could include envelope improvements that provide additional hours of thermal safety in the event of a power outage or storage systems that enable both the shifting of generation into hard-to-abate hours and backup power during outages.

Another approach is highlighting solutions with strong inherent value propositions for organizations. The most effective approaches will address multiple client goals, which may include energy abundance and reliability, decarbonizing operations, helping produce a healthier environment, reputational enhancement, and being a leader in decarbonization. Solutions that fail to capture at least a couple of values important to clients are unlikely to be adopted.

Second, service providers should **adjust the complexity of their DSM/decarbonization offerings to enhance the attractiveness of solutions**. Pursuing supply- or demand-side solutions can be complicated, requiring expertise that goes beyond the capabilities of many organizations. For that reason, many organizations will contract out their energy service needs to other companies who specialize in providing those services.

For example, even though Google has used its own advanced modeling to identify the optimal mix of renewable and demand-side measures in different regions, when the company wanted to streamline energy procurement and reduce transaction times, it collaborated with partners, such as LevelTen Energy, to develop tools like LEAP (S. Goodman, pers. comm., October 11, 2023).[11] For companies whose energy teams lack the necessary experience, relying on service provider partners to formulate and execute the trickier steps of carbon-free electricity and climate-forward efficiency is an attractive option.

Third, service providers should **explore options to more efficiently conduct investment-grade audits that incorporate climate-forward efficiency and carbon-free electricity**. This includes streamlining processes to conduct granular demand-side audits of an organization's operations. It may also involve data acquisition needed to provide climate-forward efficiency assessments, such as historic or forecasted emission rates needed to map energy interventions to GHG impacts.

Leverage environmental attribute certificates

Organizations can purchase environmental attribute certificates generated through demand-side interventions to address hard-to-match, carbon-intensive hours—similar to how RECs are used to lower market-based emissions on the supply-side. The principle is relatively straightforward and aligns with either 24/7 carbon-free electricity or emissionality.

The idea is that organizations with higher marginal abatement costs can pay to finance energy efficiency upgrades in buildings with lower marginal abatement costs (perhaps within low-income communities, for an additional equity benefit) that otherwise would lack the upfront capital for such upgrades. The upgrades would lead to a demonstrable energy savings benefit, lowering the building's operational energy costs and providing financial savings to the building owner or occupant.

The upgrades would also lead to the *environmental benefit* of lower carbon emissions, which would be captured in the form of an EAC. The EAC would contain information about the time, location, and magnitude of the Watt-hour savings. The original organization—by funding the project—would retain ownership of this benefit, which it would be able to count against its own emissions. If the EAC was generated in the same geographic region as the organization's load, it could count toward 24/7 carbon-free electricity goals. Otherwise, it could provide benefits within the emissionality framework.

Currently, use of EACs on the demand-side remains limited in comparison to the RECs marketplace. Advanced tools and platforms, such as WattCarbon's WEATS EAC registry, are enabling companies to measure, verify, and trade environmental attributes of energy efficiency and demand response.[12] Companies are beginning to understand that demand-side resources (e.g., efficiency, load shifting, demand response) can fill critical supply gaps during periods when renewables are unavailable (e.g.,

[11] LEAP, which stands for "LevelTen Energy's Accelerated Process", combines the request for proposal and power purchase agreement contracting stages into a single step, enabling PPAs to be executed much faster.

[12] WEATS is the WattCarbon Energy Attribute Tracking System. This is where WattCarbon keeps track of every EAC generated from its measurement and verification projects.

nighttime). In this way, energy efficiency is "solar at night," highlighting its role in offsetting carbon emissions during hours when renewable energy is not being generated. Companies want to ensure that demand-side energy attributes are transparently tracked and verified, avoiding concerns about greenwashing. For this reason, Measurement and Verification Protocols (MVPs), such as those provided by WEATS, are important to ensure the credibility of environmental attributes being traded.

Companies may also be motivated to use EACs as financial tools to reduce financing costs for distributed energy resources (DERs) like heat pumps, batteries, and solar panels. By using EACs to finance high-risk portions of projects, companies can significantly reduce interest rates, cutting the overall cost of projects by 40–60% (M. Young, pers. comm., April 12, 2024). In this way, DER financing can be used as a way to unlock long-term operational cost savings and stable, predictable energy costs.

Establish standards to facilitate goal setting

Supportive policy can accelerate the deployment of demand-side measures aimed at deep decarbonization by providing a clear framework for investment, implementation, and recognition by private companies, utilities, lenders, and others. While pricing carbon could effectively quantify the value of decarbonization and incentivize action, its adoption—especially at the national level—remains unlikely. Therefore, we focus on alternative approaches that clarify the value proposition of deep decarbonization efforts.

Unlocking deep decarbonization can be achieved through the same mechanism that helped unlock voluntary corporate procurements of renewable energy in 2015—**an update to the Greenhouse Gas Protocol that accounts for time- and location-based consumption patterns**. As shown in figure 1, renewable energy procurements accelerated exponentially once corporations were provided a standard protocol for measuring progress toward 100% renewable energy. An update to the Greenhouse Gas Protocol that addresses 24/7 carbon-free energy and that provides a consistent framework for measuring emissions on an hourly matching basis will provide incentives for deep decarbonization actions that exist today for only a limited number of corporate and municipal actors. These standards will provide confidence that an organization claiming to have achieved deep decarbonization actually did so. In the absence of such standards, anyone can make a claim of deep decarbonization without a rigorous method to verify those claims.

An important element of a Greenhouse Gas Protocol update would be a standardized calculation method and the ability to access and integrate that information into a building control system. The standardization would raise confidence in decarbonization claims, while the data component would make 24/7 carbon-free energy practical for service providers to implement. The alternative would be a smaller set of bespoke accounting systems that are more difficult to verify and compare against each other.

Once standards are established, **the next step for organizations is setting strong decarbonization targets**. Because corporations are primarily motivated to reduce energy costs, having a decarbonization target they publicly commit to can provide the incentive needed to opt for the more efficient technology solutions at critical decision points. A decarbonization goal provides the impetus to accept an efficiency upgrade (e.g., heat pump system) that comes with some perceived downsides (e.g., longer payback period, more complex). Corporate decarbonization goals are a way to infuse value into actions that may not directly improve the bottom line.

Economy-wide decarbonization targets can also be helpful, but usually less so than organization-specific targets. Often, economy-wide targets (e.g., net-zero by 2050) do not have the necessary granularity to inform how much decarbonization will be needed in each upcoming year, nor from which specific sources. A lack of specificity will often not lead to the level of action needed from specific organizations.

As described in the "Reputational Enhancement through Environmental Leadership" section, nongovernmental organizations like CDP, RE100, and the Science Based Targets initiative have played a key role in motivating companies to adopt clean energy through their public accountability systems. While early efforts included shaming companies for "bad" behavior, contemporary efforts have focused more on providing recognition for positive clean energy actions.

We recommend a similar approach for demand-side measures that align with the principles of climate-forward efficiency. Certifications like LEED and ENERGY STAR recognize that efficient practices have been integrated into building construction and operation. Pearl Certification and Home Energy Score communicate the (otherwise invisible) efficiency performance of residential buildings. **No similar recognition exists for demand-side actions aligned with granular accounting of GHG emissions, but its creation could recognize organizations specifically for the demand-side actions taken to reduce emissions**, allowing them to drive change as industry leaders and earn reputational benefits for their efforts.[13]

Elements of this kind of recognition system could include

- Performance pathways for meeting decarbonization needs with an optimal combination of supply- and demand-side resources
- An evaluation framework that has visibility across fuel categories (to recognize beneficial electrification)
- Granular evaluation to identify which of an organization's hours are associated with the greatest carbon intensity of operations
- A system to account for environmental attribute certificates that can be applied against an organization's Scope 2 emissions

The other side of the positive recognition coin is that companies recognize the importance of *credible* claims and want to avoid negative attention related to their environmental actions. For example, some EACs and offset markets are viewed as prone to double-counting and gaming. There is awareness that current claims of being fully decarbonized often do not hold up under close examination. Companies deeply invested in their reputation are more cautious about such practices to avoid public backlash. In pursuing decarbonization, companies want their claims to be credible and defensible against scrutiny. The focus on 24/7 carbon-free electricity, emissionality, or optimizing procurement for maximum emissions reductions reflects a commitment to measurable impact.

Obtain necessary data

To target efficiency and load flexibility measures toward the periods of greatest carbon intensity, subannual knowledge of energy usage and emission factors is preferable. If the data are reliable, hourly resolution is best. However, hourly marginal emission rates are subject to high variance and model bias. This means that in practice, averaging marginal emission rates in each hour over the course of a month, season, or year may facilitate a better approximation of avoided emissions.

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[13] The Climate Group recently released technical guidance intended to promote corporations measuring and matching of consumption on an hourly basis. It lays the groundwork for a recognition system for hourly matching (24/7 Carbon-Free Coalition 2025).

Accessing more granular data is a surmountable hurdle, as many demand response service providers are already accustomed to providing load reductions that have a granular, intraday component, as DR events usually only last for a few hours at a time. Additionally, those looking to reduce their peak demand may focus on thermal space conditioning, which tends to be the most common driver of peak demand. Models for heating demand are often hourly, since that is a characteristic timescale over which heat pump performance (which is weather dependent) is likely to vary.

The key for integrating climate-forward efficiency and carbon-free electricity is leveraging these existing energy data capabilities for decarbonization purposes. One way to get needed data is through digital application programming interface (API) connections that allow software applications to communicate with each other. These connections can help third-party service providers serving cities and corporations better understand how their clients are operating and what impact their energy-related activities have had. If that is not feasible, service providers could install submetering devices to obtain this information.

Municipal data collection

When Ithaca, New York, attempted to quantify its emissions, it began by developing a framework that separated emissions from transportation and from buildings, with decarbonization of each requiring its own strategy. Cornell University then built a model for the city to estimate the energy consumption per building based on building archetypes and energy profiles for those archetypes. This model enabled Ithaca to estimate the load per building for the city's approximately 6,000 buildings and energy efficiency based on factors like the building's age, the energy code it was built to, and type of heating system.

This modeling approach was necessary because at the beginning of this process Ithaca found it "practically impossible" to secure any useful amount of data from the city's utility (Luis Aguirre-Torres, pers. comm.). Only after the city spent political capital at the White House, the New York Governor's Office, and the NY Public Service Commission—and came to the table with a preconstructed estimate of building load—did the utility finally start providing data to Ithaca. Using those data, Ithaca developed a strategy to address energy efficiency.

The City of Boulder, Colorado, obtained its data through a different path. The city spent nearly a decade exploring the creation of a municipal electric utility to accelerate decarbonization after losing faith in Xcel Energy's pace of decarbonization. The city became an active participant at the Colorado Public Utilities Commission, frequently intervening in rate cases, resource planning, and demand-side management programs to align utility strategies with municipal decarbonization goals. While the city did not ultimately form its own municipal utility, its active participation allowed them to successfully advocate for Xcel Energy to publish day-ahead emission factors, hourly forecasted emission factors, and hourly renewable energy generation, which will help enable smarter energy management decisions.[13]

Hourly meter data should be available from utilities, especially for large commercial customers, although utilities are not always practiced in providing those data. In California, utilities are already set up to share AMI data readily. In other jurisdictions, utilities may not have the software infrastructure to

[14] See Appendix B – Tools and Datasets in ACEEE's *Accounting for Change* report for more potential sources of emissions data (Specian 2024).

support delivery of AMI data. In these cases, working with a third-party service provider with experience in areas including utility metadata, billing, and rate analytics can be helpful, as they will likely be able to help the utility to deliver interval data to their clients. When large commercial and industrial customers issue "data requests," utilities typically have served them using manual processes, including downloading through internal databases as Excel files, or even cleaned-up PDF files. But regardless of the utility's infrastructure, they are usually willing to share those data for their commercial customers that typically make up a disproportionately large share of the utility's revenue (J. Zhang, pers. comm., July 25, 2024).

These granular data can help inform cities as to which demand-side measures will be most valuable for decarbonization. Considering those measures in the context of decarbonization underscores their emissions reduction benefits (rather than just their energy, cost, or peak shaving potentials) and potentially offsets the need for other energy solutions like renewable natural gas and hydrogen blending. Such an emissions-focused perspective is more likely to identify loads that positively correlate with high emissions, such as periods of very warm or cold weather.

It is especially important that these data be up to date. Demand-side management programs and time-of-use rates are often approved based on previous iterations of the generation system. Given the rapid growth of renewable energy—both utility-scale and voluntarily procured—regulatory mechanisms that update DSM programs and rate design so that they are aligned with current system emissions rather than historic conditions would be massively valuable.

Finally, climate-forward efficiency can be supported by updating technical reference manuals to provide load savings on an hourly basis. For measures like lighting and refrigeration, the savings realized by individual customers (with their own load schedules) can be integrated over a geographic region. For weather-dependent loads, savings shapes can be reported as a function of outside temperature, which can then be converted into hourly energy savings. Deemed savings estimates can be generated based on typical meteorological year weather and converted into measured estimates after the fact based on historical weather records.

Improving the resolution of TRMs would enable energy savings to be more readily converted into GHG reduction estimates. Users of the TRM could use either (1) estimates of grid carbon intensity to forecast emission reductions or (2) measures of historic grid carbon intensity to measure actual emissions reductions. Even if GHG reduction calculations can be reliably estimated with less granular data, hourly TRMs enable the user to lower the resolution of hourly energy savings data to a more optimal granularity.[15] In the absence of such a dataset, the hourly scale demand-side measures that characterize climate-forward efficiency and lead to deep decarbonization will not be recognizable, as those signals will be averaged over and lost in annually-oriented TRMs. These granular energy savings can also be used to identify peak demand shaving opportunities, and the avoided demand charges or utility system costs that come along with them.

Improve building automation

Because climate-forward efficiency and 24/7 carbon-free electricity benefit from rapid reactions to grid conditions, it helps for buildings to have robust automation systems to carry out energy-related tasks with minimal effort. When demand response events are called only a few times a year, manually

[15] Early research suggests that hourly granularity may not be required for precise conversions of energy savings to avoided GHG. For example, providing 24 hourly values each month (or 288 values per year) has been shown to be sufficient for describing HVAC electrification savings in a renewable energy–heavy grid region (Specian et al. 2022).

executing strategies like charging battery storage or time shifting load is tenable. But when similar strategies need to be executed anywhere from multiple times a year to daily, programming preferences and tolerance for demand-side adjustments into a building energy management system capable of carrying out related adjustments with minimal need for direct manual operation is far more practical. If a building automation system understands, for example, when production lines are not required to run or for how long refrigerated warehouses can curtail cooling, the facility can develop a more optimized solution that balances running all the time with other corporate goals such as decarbonization and cost savings.

One example where such automation could be particularly useful is in the hospitality sector. Hotels that are able to combine internal building data (e.g., room occupancy) with grid signals may be better able to control lighting and building temperatures in real time. Customers who consent to load shedding or shifting may see the air-conditioning or heating for their particular rooms shut off while they are not present if carbon intensity at that location is very high. Doing this at scale would require an automated script to make sure that all rooms are reacting in a predictable and productive way.

Break down silos

Decarbonization frameworks, including those that integrate climate-forward efficiency and carbon-free electricity, benefit from a joint consideration of both demand- and supply-side options. For this reason, it is important that the groups within an organization that deal with these issues (e.g., energy procurement team, facilities team) communicate and collaborate with each other.

The appropriate mix of energy solutions for decarbonization should ultimately be based on economics and the GHG reduction potentials of the available options. We need appropriate toolsets for modeling, forecasting, and understanding trade-offs —not just at the aggregated technology acquisition cost level, but in a nuanced, geographically and time-explicit way where correlations between options are likely to emerge.

Integrated consideration of supply and demand helps organizations ensure that their supply is right sized for their needs. If an organization procures renewable energy, then cuts demand, they may wind up paying for energy they do not need. This approach requires more coordination, but can be started by making sure that employees responsible for supply- and demand-side issues attend the same meetings, have access to the same information, and work jointly on solutions.

Embed climate-forward efficiency in policy and programs

The principles of climate-forward efficiency are more effectively embedded into deep decarbonization planning when complementary policies and programs support them. Governments should continue to support carbon-free electricity (and the data ecosystem it requires) through decarbonization goals and the programs they support. Options include setting or strengthening statewide climate targets, stipulating that ratepayer funds can be used to support electrification and other climate-forward efficiency measures, and clarifying regulatory responsibilities so that regulators are authorized and encouraged to consider decarbonization when making decisions.

These steps can help accelerate utility efficiency and demand flexibility programs that are aligned with climate-forward efficiency and carbon-free electricity. Such programs will not only make funding and technical assistance available to help individual organizations with their deep decarbonization journeys, but will also normalize the provision of granular energy and emissions data that are needed to properly inform deep decarbonization. Rewarding utilities through performance incentive mechanisms for climate-forward efficiency accomplishments can also help.

Another option to help accelerate electrification is fair policies that help bring down the cost of electricity. This could include dedicated electric heating rates that offer heat pump customers a lower per-kWh price for electricity in the winter months.[16] States can also consider spreading the costs of climate-related disruptions that increase the price of electricity (e.g., wildfires) across both the gas and electricity systems, since both systems have historically contributed to climate change.

Educate and raise awareness

There is less awareness of the concepts of climate-forward efficiency and 24/7 carbon-free electricity than there is of annual matching. Therefore, a key component of acceptance of these emerging frameworks is raising awareness around how they operate by, for example, socializing these ideas in venues frequented by decision makers.

For example, in 2022–2023 World Resources Institute ran a 10-part workshop series for what it called its 24/7 Local Governments Cohort. The workshops educated stakeholders from local governments on a variety of topics including assessing hourly loads, integrating storage into supply portfolios, emerging technologies for hourly matching, and verification and reporting practices. Efforts like this help nurture a productive information ecosystem and make carbon-free electricity more likely to be established as a goal for municipalities.

The City of Boulder credits a productive information ecosystem for helping move the needle in Colorado, noting that utility commissions and their staff read news, white papers, and reports on topics like 24/7 carbon-free electricity just like anybody else. When cities, companies, or other actors eventually propose related ideas to the Public Utilities Commission (PUC), regulators are more likely to acquiesce to requests if they are already informed on the related issues. The Colorado PUC has, for example, been very supportive of expanding programs for transportation electrification, beneficial electrification, and renewable energy programs, all of which support the city's goals.

Conclusion

Cities and corporations across the country have taken important steps to begin decarbonizing their operations. To date, however, demand-side management with an explicit focus on deep decarbonization has been an underutilized component of that solution. Whether organizations are content with meeting a 100% renewable energy standard or wish to pursue a more ambitious agenda like 24/7 carbon-free electricity or emissionality, DSM offers the potential to achieve decarbonization goals more affordably, efficiently, and flexibly. We encourage organizations to improve their awareness of the principles behind both 24/7 carbon-free electricity and climate-forward efficiency, and to push for their internal teams or energy service providers to offer solutions that align with these frameworks. Likewise, energy service providers should educate and advise client organizations on the merits of climate-forward efficiency, offering solutions that leverage the demand-side as a valued component of decarbonization. Simultaneously, standard setting organizations like the Greenhouse Gas Protocol should establish firm guidelines on both the supply- and the demand-sides to formally recognize organizations whose decarbonization actions align with these principles.

[16] Such rates are already in place in states like California, Massachusetts, North Carolina, and Ohio (Shea, Dammel, and Frank 2025).

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Appendix A. Climate-forward efficiency workshop report

The following is the agenda for a workshop purposed with exploring the potential of the CFE[2] concept at the Energy Efficiency as a Resource Conference in October 2023. Approximately 75 attendees participated in the four listed breakout sessions. Participants were asked to submit their answers to the questions indicated below on index cards. Summaries of those answers are provided below.

Climate-Forward Efficiency Workshop

October 16, 2023

Energy Efficiency as a Resource Conference

DoubleTree by Hilton, Philadelphia, PA

There has been growing momentum behind the concept of matching load with renewable energy on an hourly rather than annual basis. This emerging framework has been referred to as carbon-free electricity or 24/7 hourly accounting and offers the potential for deeper decarbonization than annual accounting alone. This supply-side approach bears a striking resemblance to the concept of climate-forward efficiency, which seeks to align utility demand-side management programs with decarbonization through a more granular consideration of the hourly benefits of energy efficiency. This workshop will explore what steps are needed to align these currently separate mechanisms into a unified framework that utilities can use to jointly decarbonize their operations from both a supply and demand perspective.

Desired Outcomes:

- Understand perspectives on granular energy accounting for purposes of decarbonization
- Explore benefits of an integrated supply- and demand-side "hourly" framework, as well as expected barriers to achieving it
- Identify which actors have a role in enabling an integrated framework and what motivations, incentives, opportunities, challenges, and questions surround each actor
- Create a preliminary set of "quick wins" and "long-term goals" to better integrate energy efficiency into supply-side deep decarbonization frameworks

Agenda

1:00 – 1:30	**Plenary Session**
	• **Welcome, Introduction, and Workshop Purpose and Objectives**
	  - *Mark Kresowik, Senior Director of Policy, ACEEE*
	• **Carbon-Free Electricity and Climate-Forward Efficiency, Summary and Potential for Integration**
	  - *Dr. Mike Specian, Utilities Research Manager, ACEEE*

1:30 – 2:00	**Breakout Session 1 – Warm Up** • **Share an initial reaction or perspective on the integrated framework** • **Share an example of an innovative step being taken by an organization to deeply decarbonize using either supply- or demand-side resources** • **What is a question that you'd like answered to better understand the integrated framework?** • **What compelled you to attend this workshop?**
2:00 – 2:45	**Breakout Session 2 – Perspectives on Granular Energy Accounting** • **Facilitated discussion**

	Level-setting on instances and methodologies for accounting for emissions benefits of granular supply-side or demand-side interventions *Exploration of potential benefits of integrated carbon-free electricity and climate-forward efficiency* *Identify which actors have a role in enabling an integrated framework* *Initial listing of perceived barriers to an integrated framework*
2:45 – 2:55	**Break**
2:55 – 3:10	**Breakout Session 2 – Report Out**
3:10 – 4:10	**Breakout Session 3** • **Facilitated discussion – Steps for Facilitating Change** *What roles do each of the following actors need to play to start incorporating demand-side considerations into hourly accounting frameworks? What could motivate each to pursue carbon-free electricity and climate-forward efficiency? What opportunities and challenges exist with each? What information or research questions does each need answered?* • *Private companies* • *Legislators* • *Utility Regulators* • *Environmental Regulators* • *Utilities* • *Governments* • *Efficiency Implementors* • *DSM aggregators* • *Research Community* • *Community-Based Organizations* • *…*
4:10 – 4:20	**Break**
4:20 – 4:55	**Breakout Session 4 – Next Steps** • **Facilitated discussion – Next Steps** *Draw from previous breakout sessions to suggest a set of next steps that stakeholders should take to advance an integrated decarbonization framework. Vote to select priority actions. Identify which actions are near-, medium-, and long-term.*
4:55 – 5:00pm	**Final Remarks and Adjourn**

For the responses below, all information that was submitted on a single index card appears under a single top-level black bullet.

Breakout session 1

Participants are invited to answer to one of the warm-up questions listed below. We instructed them to indicate whether they are answering question 1, 2, 3, or 4. Everyone was provided about three minutes to jot down their answer on an index card.

- **Warm-up question**

1. Share any initial reaction or perspective on the potential of an integrated, granular framework that combines elements of carbon-free electricity and climate-forward efficiency

2. Share an example of an innovative supply-side or demand-side action being taken for the purposes of deep decarbonization.
3. Pose a question that you'd like to have answered to better understand the potential of an integrated framework.
4. What compelled you to attend this workshop?

1. Share any initial reaction or perspective on the potential of an integrated, granular framework that combines elements of carbon-free electricity and climate-forward efficiency.

There are challenges in accurately calculating power-related emissions, which affects how the value of energy efficiency is perceived. While the proposed framework shows promise for addressing climate change and supporting deep decarbonization technologies like electrification, there are concerns about how clearly it can be communicated. From a utility perspective, questions remain about grid reliability, infrastructure needs, and unintended consequences of rapid electrification (e.g., increased coal use). Additionally, standardizing hourly savings profiles—especially those influenced by weather—is essential for validating climate-forward efficiency.

2. Share an example of an innovative supply-side or demand-side action being taken for the purposes of deep decarbonization.

Innovative demand-side strategies are driving significant energy and emissions reductions. Behavioral interventions like those from Opower (Oracle) show strong short-term impact, with greater potential through expanded data access. Storage technologies and load management—on both supply and demand sides—enable flexible demand shaping. Integrated systems like networked lighting and HVAC controls can cut building energy use by up to 30%. Pilots such as Southern California Edison's clean energy optimization program incentivize GHG reductions using meter-based measurements and dynamic baselines. Demand flexibility markets are evolving into platform service architectures (PSAs), aligning price signals with avoided costs and carbon value, and supporting policy tools like carbon-optimized integrated resource plans and NMEC-based[17] codes.

3. Pose a question that you'd like to have answered to better understand the potential of an integrated framework.

There is strong interest in developing an integrated, equitable framework for climate-forward efficiency, but key questions remain. These include how utility-commission relationships might evolve, how to ensure equity at state and community levels, and where the framework would have the greatest emissions impact. Concerns were raised about data needs—particularly whether full hourly (8760) accounting is necessary or if simpler methods could suffice. Stakeholders are also asking how to harmonize policies across jurisdictions, standardize metrics for GHG attribution, and overcome communication and implementation barriers.

4. What compelled you to attend this workshop?

Participants are seeking deeper understanding of energy efficiency from both demand and supply perspectives. There is interest in building-level measurement, high-frequency savings estimates, and how these inform carbon reduction. Key concerns include how end users will engage—whether existing infrastructure suffices or new investment/training is needed—and how to convince supply-side stakeholders of the validity of demand-side hourly measurement and verification (M&V). Utility professionals are actively designing future program cycles and want to integrate decarbonization

[17] Normalized Metered Energy Consumption

frameworks. Others are focused on improving coordination across technical teams and gaining broader perspective on supply-side decarbonization.

Breakout session 2

In this breakout, facilitators should attempt to collect perspectives on the three issues below over about 40 minutes.

- *Level-setting on instances and methodologies for accounting for emissions benefits of granular supply-side or demand-side interventions*
- *Exploration of potential benefits of integrated carbon-free electricity and climate-forward efficiency*
- *Initial listing of perceived barriers to an integrated framework*

Level-setting

- Level-setting and methodologies
    - **Demand-side accounting** often uses regional emission factors and kWh conversions via EPA models.
    - **Supply-side accounting** includes Scope 1 emissions from utilities, calculated as annual gas consumption × emission factor.
    - **Annual average emissions** and **net-to-gross analysis** from Technical Reference Manuals are common baselines.
    - **Marginal emissions** are frequently used, sometimes with time-varying values to reflect lifecycle impacts.
- Quantification approaches
    - **Natural gas savings** are estimated using annual emission factors.
    - **Clean grid interventions** may be credited with zero CO_2e emissions.
    - **Production cost modeling** and **annual generation reports** are used for future projections.
    - **EACs/RECs** are typically not tracked hourly.
    - **Regional examples**:
        - Vermont uses annual RPS proportions.
        - DC uses average emissions.
        - New England's AESC uses marginal emissions with counterfactuals assuming no new efficiency.
        - A Synapse-led study with government and utility stakeholders quantifies avoided infrastructure and GHGs from energy efficiency in New England. These findings are integrated into cost-effectiveness testing for EE programs.
- Open-source and technical tools
    - **OpenEEMeter**: Standard M&V for energy consumption changes.
    - **WattCarbon**: Quantifies hourly CO_2 intensity.
    - **FLEX Value**: Aligns hourly energy changes with avoided costs, GHGs, and grid values.
    - **Challenges**: Opaque gross demand forecasts and the need to neutralize clean energy purchases.

Benefits

- Environmental and climate benefits
    - Avoid greenwashing by ensuring genuine emissions reductions.
    - Preserve land by reducing the need for new renewable infrastructure.

  - Accelerate decarbonization with better insights and transparency.
  - Shift fossil fuel plants offline, especially in environmental justice communities.
- Data and measurement advantages
  - Enable real-time tracking of energy use and emissions.
  - Support accurate GHG accounting and comparisons between supply and demand.
  - Promote trust through physics-based, transparent measurement.
- System and planning improvements
  - Align with EERS and GHG goals across jurisdictions.
  - Enhance IRP planning with integrated DSM forecasting.
  - Improve system operations and resource balancing.
- Economic and operational efficiency
  - Optimize energy efficiency investments and prioritize low-cost decarbonization paths.
  - Support tariff design, consumption-based billing, and fund allocation for DSM measures.
  - Enable "apples-to-apples" comparisons of supply and demand costs and benefits.
- Integration and strategic alignment
  - Link efficiency and renewables to better match demand.
  - Encourage efficiency-first approaches before renewable procurement.
  - Foster deeper savings and more informed decision making.
- Social and workforce impact
  - Attract young professionals motivated by climate action.
  - Highlight the importance of DSM planning in broader energy strategies.

Barriers

- Technical and data barriers
  - Lack of advanced metering infrastructure (AMI), especially for gas customers.
  - Insufficient data availability, granularity, and standardization—especially for hourly/locational emissions, load reduction, and avoided cost.
  - Difficulty in modeling demand-side measures and their GHG reduction potential.
  - Challenges with measurement, verification, and data validation.
  - Complexity of real-time data and data management systems.
- Policy and regulatory barriers
  - Misalignment between energy savings vs. carbon reduction goals.
  - Policies that overlook GHG impacts or prioritize annual metrics over hourly carbon-free goals.
  - Tensions with existing renewable portfolio standards.
  - Lack of harmonized policies to support new business models.
  - Difficulty integrating frameworks into legislation or corporate systems.
- Economic and market barriers
  - Low energy prices disincentivizing investment in new technologies.
  - Cost and complexity of studies, QA/QC, and implementation.
  - Electrification adds load to the grid, complicating avoided cost calculations.
  - Fossil fuels often remain cheaper than electricity.
- Behavioral and education barriers
  - Customer confusion over energy rates, bills, and decarbonization pathways.
  - Learning curve for end users and suspicion that changes will raise costs.
  - Need for education on benefits, technical implementation, and policy importance.
  - Difficulty in changing human behavior and aligning diverse stakeholder interests.

- Systemic and structural barriers
  - Incumbent actors benefiting from current demand response (DR) programs.
  - Trade-offs between energy efficiency and demand flexibility.
  - Slow development of standards due to many stakeholders.
  - Competing goals across electrification, offsets, and renewable energy credits (RECs).
  - Fragmented data across jurisdictions and unclear treatment of imports/exports.

During the breakout, ask participants to write down the name of an actor who they believe might have a role in helping to develop or enable the CFE² framework.

- Utilities
- Energy efficiency program implementers
- Public utility commissions
- Governments
- Corporations
- Industry
- Advocacy organizations
- Evaluators
- Researchers

Breakout session 3

In this breakout, facilitators should attempt to collect perspectives on steps for facilitating change for 60 minutes. At the beginning of the session, the facilitator should post the list of actors who could play a role in enabling CFE². Inform the participants that the goal is to populate a table where each row is an actor, and each column is an issue related to their role in CFE². The issues to consider are:

- ***Motivation.*** *What would motivate this actor to pursue hourly accounting and/or climate-forward efficiency today?*
- ***They enable…*** *What can this actor do that would incentivize hourly energy accounting for others? (For example, what can utilities, regulators, or legislatures do to incentivize hourly emissions accounting? Could they offer fast-track interconnection requests for CFE² approaches? Could organizations create a protocol for accounting for the emissions reductions achieved through demand-side measures?)*
- ***Opportunities****. What opportunities exist for this actor to advance CFE² in the near-term or over the long-term? [e.g., GSA's MOU to achieve 50% of 100% carbon-free electricity on a 24/7 basis with Entergy Arkansas, CCAs partner with utilities on procurement and EE]*
- ***Challenges****. What unique challenges does this actor face in adopting CFE²?*
- ***Questions****. What information or research questions does this actor need answered to proceed with CFE²?*
- ***Unintended Consequences****. Are there actions this actor could take in support of CFE² that could have inadvertent negative impacts (e.g., grid reliability, equity)?*

Facilitators should encourage participants to "fill out the matrix" as completely as possible, but to prioritize what they perceive to be most important combinations of actors and issues. Give everyone about 6 minutes to jot down their initial ideas on index cards.

Private companies/customers

Motivations

- Environmental concern and climate awareness.
- Financial incentives: upfront cost savings, payback clarity, and high energy prices.
- Recognition or rewards for energy-efficient homes using renewables.

Enablers

- Market pull: customers can drive demand for hourly accounting.

- Utilities providing clear, actionable data to support decarbonization decisions.

Opportunities

- Load flexibility (e.g., EV charging, heating).
- Investing in resilient, climate-aligned technologies.
- Trigger points like equipment replacement.
- Marketing higher climate standards.

Challenges

- Financial barriers and affordability.
- Understanding and engagement.
- Competing priorities and information overload.
- Equity: ensuring benefits are distributed fairly.
- **Private companies** prefer simplicity and may resist policy-heavy frameworks.

Questions

- Why should I participate?
- How is the value of energy efficiency measured?
- Where do emissions offsets occur?

Unintended Consequences

- Risk of excluding low-income participants.
- Potential to reduce momentum for behind-the-meter solar.
- Need for clear, limited options to avoid confusion.

Legislators

Motivation

- Legislators are driven by goals to reduce greenhouse gas (GHG) emissions and advance clean energy.
- Standardized measurement across companies and industries is seen as a political and environmental motivator.

Enablement

- Legislators can provide policy direction that empowers regulators and agencies (e.g., environmental regulators, utility commissions, state energy offices) to adapt policies and reporting frameworks.
- They can align existing Energy Efficiency Resource Standards (EERS) and GHG goals with CFE^2 principles.
- Though mandating CFE^2 is seen as unlikely, legislative support can still catalyze action through incentives and guidance.

- Legislative and regulatory bodies can lower the effective price of carbon and align incentives across sectors.

Opportunities

- Legislators have the potential to influence a large segment of GHG emissions through policy.
- They can help optimize societal outcomes by supporting carbon pricing or other market-based mechanisms.

Challenges

- Changing long-standing or emerging regulatory frameworks is difficult.
- Legislative mandates could be hard to implement, enforce, and fund over time.
- There is a risk of increasing electricity rates or creating inequities.

Questions

- What frameworks or protocols are needed to measure emissions reductions from demand-side measures?
- How can policies be structured to avoid unintended consequences while still incentivizing utilities?

Unintended consequences

- Poorly designed policies could unintentionally favor certain technologies or resources, creating “winners and losers.”
- There is concern about “unknown unknowns” that could affect grid reliability or equity.

Utility regulators

Motivation

- Driven by policy objectives, GHG reduction goals, and regulatory mandates.
- Desire to advance clean energy and ensure fair access to energy security.
- Some see regulators as needing to force change through alignment with existing frameworks like EERS.

Enablement

- Regulators can authorize and expand energy efficiency programs, tap into new value streams, and set standards for carbon measurement.
- They can incentivize utilities via mechanisms like fast-track interconnection, carbon M&V protocols, or rate design adjustments.

Opportunities

- Use tools like carbon-optimized IRPs, Normalized Metered Energy Consumption (NMEC), and Total System Benefit metrics.

- Leverage partnerships (e.g., General Service Administration's (GSA) memorandum of understanding (MOU) with Entergy Arkansas) and community choice aggregation (CCA) collaborations.
- Every regulatory case can be tied to carbon goals, offering broad influence.

Challenges

- Navigating cost recovery and rate impacts for new programs.
- Political resistance and lack of economic frameworks for environmental outcomes.
- Difficulty in valuing carbon and integrating it into existing utility structures.
- Need for a common set of standards and transparent processes.

Questions

- What forces must be considered in regulatory decisions?
- Why is carbon not being valued more consistently?
- What research is needed to justify decarbonization within regulatory frameworks?

Unintended consequences

- Risk of picking winners and losers among technologies.
- Potential to undermine reliability or grid value if carbon is overprioritized.
- Possibility of higher rates and equity concerns.
- Need to avoid perverse outcomes when incentivizing utilities.

Environmental regulators

- Regulatory cooperation between PUCs and environmental regulation
- Motivation to achieve GHG and avoid climate impacts
- Risks of paralysis and infighting

Utilities/grid operator

Motivation

- Utilities are primarily motivated by **regulatory requirements or financial incentives**; they tend to act only when compelled or rewarded.
- Grid operators are motivated by the potential to **bring more resources into the market** and **enhance grid reliability**.
- Low-income program administrators are driven by the need to **ensure equitable access** for their constituents.
- Standardized carbon measurement and reporting frameworks could motivate utilities to act.
- Federal, state, and regulatory mandates for **demand-side management (DSM)** programs are key motivators.

They enable …

- Utilities can **provide critical data** and **communicate with customers**, but need incentives to do so.
- Grid operators can enable **market-based solutions** and support **virtual power plants (VPPs)**.
- Utilities could incentivize hourly emissions accounting through mechanisms like **fast-track interconnection for CFE^2 approaches** or **protocols for emissions reductions from demand-side measures**.

Opportunities

- Utilities in several states are engaged in **three-year planning processes**, presenting a chance to rethink **data access and sharing**.
- The **evolution of electric vehicles (EVs)** offers new pathways for CFE^2.
- Grid operators can leverage **marginal emissions data** and support **VPPs**.
- Low-income program administrators could benefit from **changes in program rules**.
- Examples like the **GSA–Entergy Arkansas MOU** and **CCA–utility partnerships** illustrate near-term collaboration potential.
- **Grid operators** could more easily incorporate demand-side solutions into resource planning.

Challenges

- Utilities face structural silos across departments (e.g., marketing, DSM, engineering), and issues with **databases, tracking systems, and cost recovery**.
- Rate-setting complexities: how to incorporate the **additional costs** of implementing CFE^2 into customer rates.
- Balancing **short-term costs** with **long-term flexibility** is difficult for grid operators.
- Administrators worry about **economic impacts on low-income customers the household level**.
- Utilities may struggle to offset carbon emissions while still relying on **traditional power plants for load balancing**.

Questions

- How can utilities and regulators **build CFE^2 costs into existing programs**?
- What protocols are needed to **account for emissions reductions** from demand-side measures?
- How can low-income program administrators **address household-level economic challenges**?

Unintended consequences

- Risk of **"emissions cream-skimming"**—prioritizing easy wins over long-term solutions.
- Potential **grid reliability and equity issues** if CFE^2 is not carefully implemented.
- Technological changes may lead to **landlord–tenant conflicts** or other unforeseen impacts.

Efficiency implementors/service providers

Motivation

- **Implementers** are driven by the need to understand how CFE policies affect their programs.
- **Private companies/software providers** are motivated by market opportunities and profit—"let's make some money."
- **Aggregators/ESCOs** are motivated by the potential to monetize load flexibility and efficiency.

They enable …

- **Private companies** can drive customer engagement and optimize performance-based payments.
- **Software tools** can integrate planning, interval data, and DSM potential to identify cost-effective decarbonization paths.
- **DSM aggregators** can generate hourly profiles (8760s) for regional projects, enabling them to be valued as non-emitting resources.

Opportunities

- **Open market models** allow private firms to access funding and shift utility/regulator focus to outcomes.
- **Public-private partnerships** (e.g., GSA's MOU with Entergy Arkansas) offer models for scaling CFE[2].

Challenges

- **Implementers** face hurdles in participation, customer skepticism, and communicating complex program benefits.
- **Equity concerns** arise for implementers—ensuring access for disadvantaged communities and managing affordability.
- **Aggregators** must navigate regional variability and emission factor inconsistencies.

Questions

- Who are the successful actors or coalitions already doing this? (e.g., Flex Coalition)
- What protocols exist—or are needed—for emissions accounting from demand-side measures?

Unintended consequences

- **Market success** could lead to customer confusion from multiple competing offers.
- **Equity risks** if programs unintentionally exclude or burden vulnerable populations.
- **Grid reliability** could be affected if demand-side resources are not well-integrated or verified.

<u>**Others**</u>

Motivation

- Researchers can help understand how hourly accounting affects grid management, especially for operators.

- NGOs can save money, make a difference, and align energy efficiency (EE) programs with client realities.
- Promote environmental justice and racial equity through education and workforce development.

They Enable

- NGOs highlight concrete results that demonstrate impact.
- NGOs support for inclusive legislation and utility policies.
- Visual, interactive tools to communicate impacts and outcomes.
- Systemic change by translating benefits to diverse constituents.

Opportunities

- NGOs adapt programs to fast-changing conditions.
- NGOs engage younger audiences through updated media.
- Workforce development in regions like DC and Maryland.
- Use of visual narratives to simplify complex ideas.

Challenges

- Navigating red tape and legislative hurdles.
- Ensuring IT solutions are developed to support implementation.
- Diverse motivations and slow operationalization across stakeholders.
- Need for technical support and knowledge sharing.

Questions

- What do customers know? How can education be improved?
- How do we quantify the economic impacts and costs of 24/7 carbon-free energy and demand from companies.
- How can EE programs be measured effectively?
- How can equity be defined beyond financial metrics?

Unintended Consequences

- Risk of excluding underserved groups if laws are not inclusive.
- Potential increases in energy costs and burdens.

Breakout session 4

In this breakout, facilitators should attempt to collect perspectives on next steps for facilitating change. Ask participants to consider the matrix of actors and actions that they worked on in the previous section, and think about some actions that should be pursued in order to realize the full potential of CFE^2. Give everyone 5 minutes to write some of their ideas down on note cards.

Strategic partnerships and policy engagement

- Collaborate with organizations like EEI, DOE, DoD, and educational institutions.
- Engage utilities, regulators, and state energy offices to align programs with clean energy goals.
- Seek sponsorship and regulatory support.
- Encourage utility investment in carbon-free technologies and materials.

Measurement, methodology, and research

- Develop an industry-standard methodology and best practice guide (e.g., ACEEE led).
- Start measuring hourly DSM impacts and build cost valuation tools.
- Conduct studies on capacity market design and economic models for mutual benefits.
- Explore real-world pilots and case studies (e.g., campuses, states with new EE goals).

Education and awareness

- Promote understanding of the time value of energy and the limits of "100% renewable" claims.
- Keep the topic active at future conferences and in regulatory processes.
- Share success stories to create a domino effect.
- Maintain ongoing stakeholder education and engagement.

Infrastructure and Implementation

- Install advanced metering infrastructure (AMI) and enable real-time data sharing.
- Create roadmaps and "how-tos" for regulators and policymakers.
- Form an advisory group with decision-making power from key stakeholders.

Workforce

- Invest in workforce development and engage labor groups.

Innovation and visibility

- Push for splashy carbon efficiency credits from major tech players (e.g., Microsoft, Google).
- Encourage proposals for new analysis methods and pilot programs.