Guidehouse INSIGHTS

White Paper

Stepping Stones on the Road to 24/7 Carbon-Free Energy

The Importance of 24/7 CFE in Unlocking Decarbonization Benefits and Strategies for Getting There

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Introduction

Around-the-clock carbon-free energy (24/7 CFE) is increasingly viewed as a vital way to slash an industry's carbon footprint. This process of energy procurement, which is focused on granularity and accuracy, offers a framework for targeting difficult-to-abate carbon emissions but poses tremendous difficulties for energy consumers, so widespread adoption likely remains far in the future.

In 2020, Google became the first company to commit to procuring 24/7 CFE, with the goal of fully powering its operations by 2030. Other large corporations with data center assets followed. Microsoft also aims to procure 24/7 CFE by 2030, while information management services company Iron Mountain aims to do the same by 2040. Other stakeholders that have committed to achieving 100% 24/7 CFE in the coming decades include local governments and regional utility firms.

Although the concept of 24/7 CFE is simple, it is challenging to implement. Previous Scope 2 decarbonization commitments typically involved matching annual electricity consumption with an equivalent amount of annual renewable electricity supply. While this approach has helped support growth in renewable energy deployments, detractors argue that the actual emissions intensity of electricity consumed onsite is still determined by the real-time availability of generation sources on the local grid.

To achieve 100% 24/7 CFE, an energy consumer must ensure that it can procure carbon-free electricity from assets located in the same grid area and in line with its real-time electricity consumption. The shift to 24/7 CFE has therefore driven growth in the market for granular energy attribute certificates (EACs), which provide proof of carbon-free electricity supply on an hourly basis. This shift is also helping drive demand for battery energy storage systems, long-duration energy storage, and clean firm power technologies such as geothermal or nuclear energy.

This Guidehouse Insights white paper provides a primer on the 24/7 CFE landscape. It outlines the key concepts involved, the rationale for 100% 24/7 CFE as a means of reducing emissions at the system level, and the options energy consumers can use to meet their 24/7 CFE targets. It concludes with recommendations for energy consumers seeking to achieve 24/7 CFE.

Defining the 24/7 CFE Landscape

24/7 CFE: A method of energy procurement in which every kilowatt-hour of electricity consumption is met with CFE produced on an hourly basis on the regional grid where the energy is consumed. This can be achieved through a combination of power purchase agreements (PPAs) and granular EACs.

X% 24/7 CFE: Energy consumers can set targets such as 50% or 70% 24/7 CFE as a means of working toward full 24/7 CFE. A 50% 24/7 CFE target involves procuring 50% of energy from carbon-free sources in the regional grid where the energy is consumed, on a 24/7 basis.

Traditional EAC: For the purposes of this paper, traditional EACs are defined as EACs with no time or location component, in contrast with renewable energy certificates (RECs) in North America and guarantees of origin (GOs) in Europe.

Granular EAC: EACs can be tracked at a more granular level either on an hourly basis (time-based EACs) or a location basis. For the purposes of this paper, granular EACs refer to EACs that track CFE generation on an hourly basis and on the regional grid from which the energy buyer consumes energy.

The EAC Market Is Moving from Annual to Hourly Attribution

Emissions reduction targets set by governments and corporations have kick-started renewable energy procurement across industries. To date, through the RE100 initiative, more than 400 companies globally have committed to matching 100% of their electricity use with energy from renewable sources annually by 2050. This energy can be acquired through PPAs, green energy programs, or green tariffs. PPAs are the most frequently used procurement option—in the US, for example, they account for around 80% of corporations' contracted clean power offtake.[1] Energy is sold with EACs, which in theory enable corporations to demonstrate the renewable attributes of the energy they purchase.

EACs also allow renewable energy producers to charge a premium for the green element of their electricity and subsequently trade it in a market. However, as the deployment of renewables accelerates and costs continue to decline, certain geographies will have an oversupply of EACs relative to voluntary market demand. In these areas, additional renewable energy development could lead to curtailment and revenue cannibalization. Thus, **as the cost of clean energy declines and markets become saturated, traditional EACs' role as a driver of clean energy deployment will likely shrink**.

Traditional EACs often lack the temporal transparency needed to provide detailed information on important clean energy characteristics, such as the month, season, or hour in which electricity is produced. This lack of transparency threatens the market's longevity. Because most EACs only allow customers to track their certificates on a monthly or annual basis, purchasers often have no visibility into when the associated clean power is being produced. Further, the prices for EACs are not tied to the value of that clean power in the electricity system. As a result, when clean power is not available, consumers claiming 100% renewable energy procurement are, in practice, often consuming electricity that is generated by fossil fuel combustion.

For these reasons, consumers are challenged in making accurate claims about the carbon reduction benefits of purchasing traditional EACs. In November 2023, the Greenhouse Gas (GHG) Protocol released a detailed summary of survey feedback that highlighted many of these concerns. Because the technical working group for Scope 2 updates announced in September 2024 includes many prominent 24/7 CFE advocates, updates to the GHG Protocol may push the industry toward more granular Scope 2 accounting to resolve these issues.

A 24/7 CFE approach backed by granular EACs is the key to resolving spatial and temporal concerns and has potential to unlock a variety of systemwide decarbonization benefits. These benefits include incentivizing higher impact clean energy technologies, providing differentiated price signals to generators and energy storage operators, optimizing locational deployment of clean energy resources, and helping support grid flexibility.

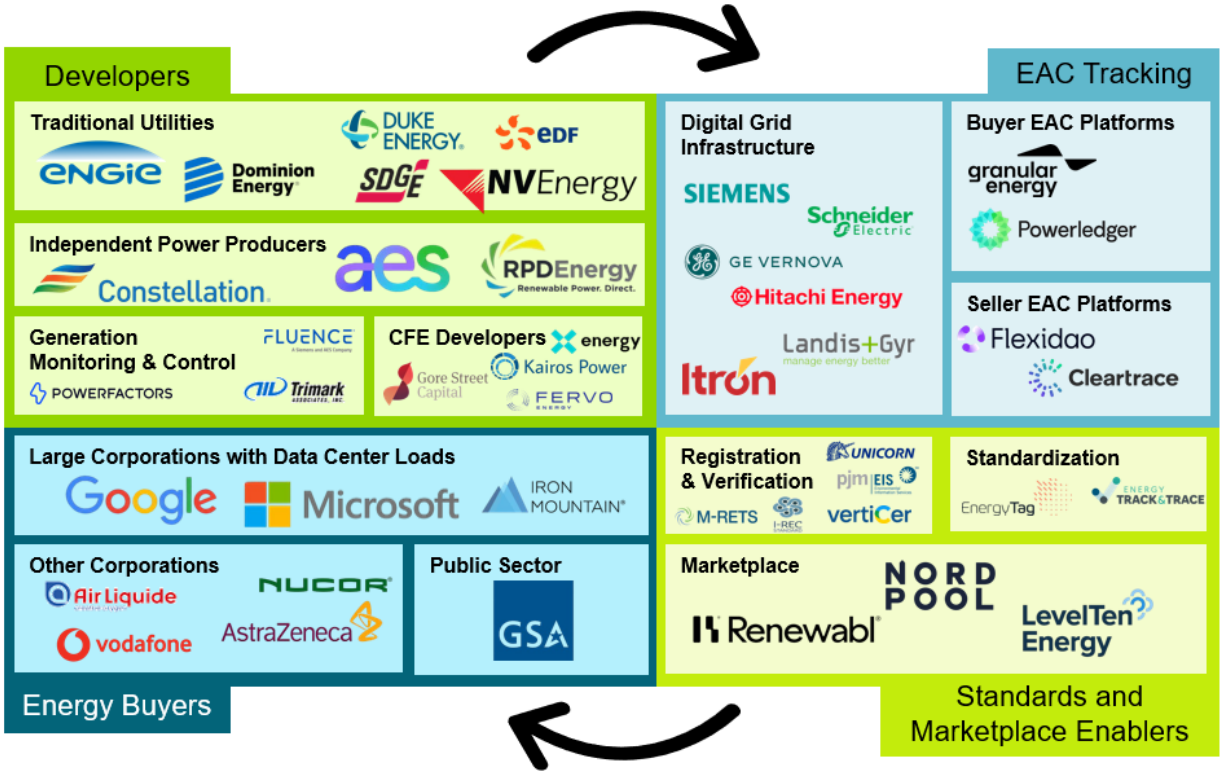
24/7 CFE Service Providers Are Driving Growth in Granular EAC Demand

Early adopters of 24/7 CFE commitments are mostly concentrated in the technology industry. These companies have begun partnering with energy suppliers to procure 24/7 CFE for specific geographies.

[1] American Clean Power, *Clean Energy Powers American Business*, 2022, **https://cleanpower.org/wp-content/uploads/2023/01/2022_CorporateBuyersReport.pdf**.

Under this arrangement, the energy supplier is responsible for sourcing clean power backed by granular EACs from a portfolio of generation resources, up to a specified proportion of the consumer's electricity demand. A visual representation of the 24/7 CFE service model is provided in Figure 1.

Figure 1. 24/7 CFE Ecosystem



(Source: Guidehouse Insights)

Google has contracted ENGIE to supply 80% of its German data centers' electricity demand with 24/7 CFE, and the company recently signed an agreement with NV Energy to provide 350 MW of solar capacity and up to 280 MW of battery storage to its data centers in Nevada. Microsoft has deals for 24/7 CFE services with European utility Vattenfall and US energy supply company Constellation. Google and Microsoft have also signed agreements with AES to supply their Virginia data centers with CFE 90% of the time, and Iron Mountain has partnered with RPD Energy on a series of deals to obtain 24/7 CFE across nine US states.

The public sector is helping drive 24/7 CFE adoption as well. In 2021, President Biden signed an executive order requiring all federal agencies to purchase 50% of their energy from carbon-free sources in the regional grid where the energy is consumed on a 24/7 basis by 2030. Partial adoption could be an important stepping stone toward achieving 24/7 CFE, as research suggests that in many locations, meeting up to 90% of a consumer's electricity demand with 24/7 CFE could be accomplished at only a small cost premium.[2]

[2] Iegor Riepin and Tom Brown, "The Value of Space-Time Load-Shifting Flexibility for 24/7 Carbon-Free Electricity Procurement," Technische Universität Berlin, July 26, 2023, **https://zenodo.org/records/8185850**.

Applications outside of 24/7 CFE are also driving growth in granular EAC demand. For instance, regulations on electricity sourcing for green hydrogen production in the European Union require that from 2030 onward, renewable energy sourced via the grid be backed by a PPA with granular EACs. Projects that do not meet these criteria will be ineligible for subsidy support. Similar regulations currently being evaluated in the US would require the use of granular EACs for green hydrogen projects if they are to access tax credits set out under the Inflation Reduction Act.

Guidehouse Insights estimates that the global market for EACs will grow to around $69.8 billion by 2030,[3] while 24/7 CFE PPAs are expected to account for $10.8 billion in revenue by 2030.[4] The following section shows how shifting spending from annual EACs to hourly EACs could lead to targeted investment in technologies that have the greatest long-term impact on grid decarbonization.

24/7 CFE Commitments Will Promote Energy Storage, Clean Firm Power, and Load Shifting

In most locations, the current availability of clean power is not sufficient to enable consumers to meet their 24/7 CFE targets. As one project developer explained to Guidehouse Insights, "there are simply not enough clean energy projects, battery installations, etc., to generate [clean power] during the specific hours in which it will be needed." The shift to 24/7 CFE therefore provides incentives for the deployment of new technologies that are currently not cost-competitive on a per-unit-of-energy basis but can still provide clean power during the hours in which it is not currently available.

> *"There are simply not enough clean energy projects, battery installations, etc., to generate [clean power] during the specific hours in which it will be needed."*
>
> *–Project developer*

One example of this is long-duration energy storage technologies, generally defined as storage systems that can discharge for periods of 8 hours or more. Long-duration storage technologies typically suffer from lower technology readiness levels and lower round-trip efficiencies than lithium ion batteries. They have consequently struggled to compete in the ancillary services markets, which currently provide the bulk of energy storage sector revenue. However, **long-duration storage technologies are much more suitable for 24/7 clean power provisioning than lithium ion batteries**.

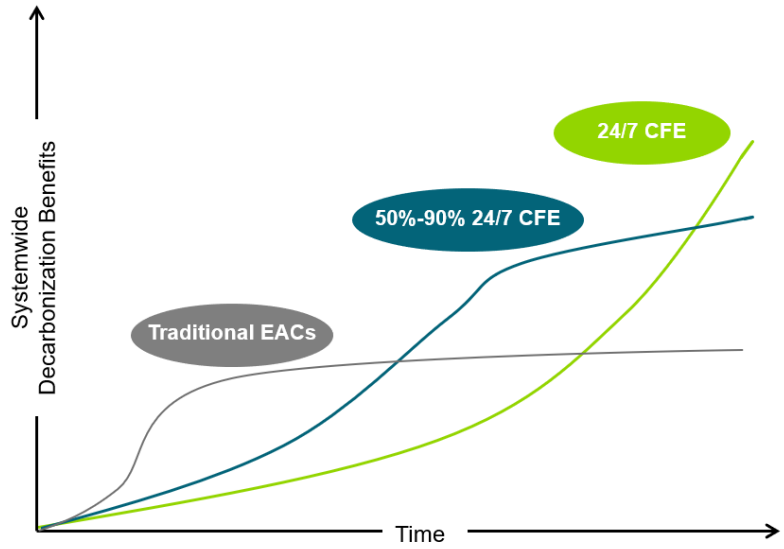
A second example is clean firm technologies such as geothermal power or nuclear power. Neither technology has experienced the rapid cost declines that have supported the deployment of wind and solar resources. However, both technologies can produce clean power continuously. Despite being more expensive than wind and solar on a per-kilowatt basis, they can act as part of a cost-optimal portfolio of generation and storage options used to deliver 24/7 CFE. Google has proven to be a strong supporter of geothermal technologies, partnering with advanced geothermal startup Fervo Energy to supply clean power to its data center assets in Nevada. Nuclear power has gained significant momentum in recent months, as Microsoft, Google, and Amazon all signed agreements to supply data centers with nuclear energy in September and October of 2024. These agreements amount to over a gigawatt of nuclear energy to match power demand from data centers by 2035.

[3] Guidehouse Insights, *Environmental Certificates*, 2Q 2023, **https://guidehouseinsights.com/reports/environmental-certificates**.

[4] Guidehouse Insights, *24/7 Carbon-Free Electricity Market*, 1Q 2024, **https://guidehouseinsights.com/reports/247-carbon-free-electricity-market**.

Additionally, **24/7 CFE commitments provide incentives for energy consumers to reduce energy demand during periods when clean power is more difficult to procure**. One study found that data centers can reduce the cost of 24/7 CFE by up to 34% with co-optimized space-time load shifting of computing jobs.[5] Importantly, the authors note that the findings are generally applicable to a wide range of companies and organizations with flexible demand.

Figure 2. Systemwide Benefits of 24/7 CFE Compared with Traditional EACs



(Source: Guidehouse Insights)

Traditional EACs currently act as a quick win for energy consumers, but with the expansion of renewable energy sources, their systemwide decarbonization benefits will level off over time.

Granular EACs and 50%-90% 24/7 CFE targets create markets for nascent technologies that enable systemwide decarbonization without being prohibitively difficult for energy consumers.

100% 24/7 CFE targets will be impossible without the most advanced technologies, and will thus enable the greatest decarbonization benefits, despite requiring the greatest amount of time and resources.

Achieving 24/7 CFE Requires Advanced Data Analytics and Software Platforms

The first step energy consumers must take toward 24/7 CFE is understanding their current renewable and nonrenewable electricity consumption on an hourly basis. Sustainable energy management platforms can provide detailed insights into a consumer's energy portfolio. Companies like Powerledger, Flexidao, Granular Energy, and Cleartrace have offerings that automate data collection for energy provenance and traceability of each energy source. In recent years, blockchain technology has also proved to be an effective energy tracking tool by creating a time- and location-stamped digital record using granular meter data. These tools integrate data posted by smart meters in near real time, requiring the efficient consolidation of millions of small energy transactions in seconds.

Gaining transparency also requires customizable reporting based on the locations and timeframes selected. Such reporting contains descriptive analytics on total consumption broken down by energy source, carbon emissions avoided, and verification of renewable EACs allocated to consumption at a

[5] Riepin and Brown, "The Value of Space-Time Load-Shifting Flexibility for 24/7 Carbon-Free Electricity Procurement," **https://zenodo.org/records/8185850**.

granular level. The more informed energy consumers are about their real-time energy consumption, the more opportunities exist for EAC market participation. **Assisted by the growth in 24/7 CFE commitments, traditional unbundled EAC marketplaces are evolving to digital and accessible EAC marketplaces.**

One of the most important functions for a digital marketplace is efficiently aggregating and matching participants' needs with the available supply of granular EACs in a region. In the short term, this regional aggregation will send clear price signals that drive both renewable energy generation and consumption decisions. In the longer term, price signals created by an undersupply of clean energy at specific times (or locations) will direct the development of new clean energy assets that can supply emissions-free power during a grid's most carbon-intensive hours.

Digital energy trading platforms can also facilitate the transition to 24/7 CFE by enabling large commercial and industrial consumers to collaborate through their renewable energy providers by forming local energy trading groups. An energy supplier can establish trading rules that allow customers to balance excess contracted renewable generation on an hourly basis with other contracted customers in the market who may be in deficit for that hour. Such trading practices can help offtakers as well as renewable energy producers to de-risk commitment to contracted volumes in long-term conventional PPAs. Several companies are developing trading platforms supporting more granular EACs, such as Renewabl or the Granular Certificate (GC) Trading Alliance, which will launch a new platform for trading and managing granular certificates in 2024. These groups and platforms can help build the foundation for localized energy trading groups.

Granular EAC tracking, management, and trading remains at an early stage. The registries responsible for issuing, transferring, and retiring EACs have not yet fully developed the tracking system capabilities for accessing hourly generation data. However, **Guidehouse Insights believes that most registry providers only require 1 to 2 years to establish these capabilities**. Some registry providers, including M-RETS (US), PJM EIS (US), Unicorn Systems (Europe), and the Evident Registry (international), have already begun the process of incorporating granular tracking functionality.

Conclusions and Recommendations

The push for 24/7 CFE is driving change in every part of the electricity value chain. Energy suppliers are seeing a rise in demand for 24/7 CFE services that require deeper insight into clean power generation's locational and temporal characteristics. Software and analytics providers are evolving their offerings to account for the rise in granular EACs, focusing on real-time reporting on customers' energy portfolios. In the longer term, project developers will likely see a market emerge for novel technologies capable of generating clean energy continuously or storing it over long periods.

The complexity of achieving 24/7 CFE remains daunting for many energy consumers. Without the appropriate strategy, partnerships, and tools in place, some companies may defer clean power commitments—or worse, fail to deliver on their targets.

However, the complexity of achieving 24/7 CFE remains daunting for many energy consumers. Without the appropriate strategy, partnerships, and tools in place, some companies may defer clean power commitments—or worse, fail to deliver on their targets.

Guidehouse Insights has outlined five steps an energy consumer can take to ensure that a 24/7 CFE commitment is achievable, affordable, and executed effectively.

1. **Assess the options available for real-time tracking and energy supply management.** Achieving the granularity needed for 24/7 matching requires an exponential expansion in data tracking and verification. Thankfully, many of the systems needed are already in place, but not aggregated nor standardized. Instead of recreating this data, 24/7 CFE stakeholders should engage with the current players in the space—such as providers of advanced metering infrastructure (AMI), generation asset performance management tools, and grid platforms like energy management systems (EMS), advanced distribution management systems (ADMS), and distributed energy resource management systems (DERMS)—to increase adoption of real-time tracking and standardize 24/7 CFE management.
2. **Develop a roadmap with intermediate targets for partial 24/7 CFE adoption.** Achieving 24/7 CFE can feel out of reach for many organizations relying on traditional EACs. Intermediate targets are more achievable, such as 50%-70% 24/7 CFE or procuring 50% of RECs on a more granular (time or location) level. These actions can act as stepping stones to spur development of the technologies and marketplaces necessary for a 24/7 CFE world.
3. **Partner with energy consumers and suppliers to identify potential synergies.** Collaboration with industry partners, utilities, and market solution providers will accelerate the transition to 24/7 CFE. Broad collaborations such as the newly formed 24/7 Carbon-Free Coalition can help spread expertise, fill knowledge gaps, and aggregate demand for advanced decarbonization technologies. Energy consumers can work with utilities to pursue innovative tariff structures to promote novel generation and storage technologies that enable 24/7 CFE. Marketplace partnerships such as the GC Trading Alliance can accelerate the tracking and management systems needed for a fully functioning granular EAC market. Currently, participation in these initiatives is limited to the strongest 24/7 CFE advocates, such as Google and Microsoft. These collaborations should seek to shape initiatives that encourage broader participation from corporations and local governments.
4. **Assess the potential for demand flexibility across sites and processes.** Achieving 24/7 CFE is likely to require a combination of supply-side and demand-side measures. The industries currently driving 24/7 CFE commitments have significant untapped potential for load shifting, as do participants in other sectors that consume electricity for heating, cooling, material processing, and mechanical power. 24/7 CFE adopters should review the technical and economic potential for demand flexibility across their sites, including detailed cost comparisons of demand reduction measures versus low carbon electricity procurement during the most challenging hours.
5. **Make targeted investments in novel generation and storage technologies.** Wind, solar, and battery energy storage are expected to be the key pillars of energy consumers' procurement decisions for 24/7 CFE. However, fundamental technological limitations mean that the additional cost of procuring clean power from conventional technologies rises exponentially at higher 24/7 CFE percentages. Alongside demand flexibility, long-duration energy storage technologies and clean firm power technologies can be important enablers of emissions reduction on an hourly basis. Energy consumers should work to create a market for new technology players to scale their solutions and drive down costs.

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