Whitepaper

A Practical Approach to Implementing 24/7 Carbon-Free Energy for a Data Center

Abstract

EdgeConneX designs, builds, and operates data centers in markets around the globe serving cloud, content, network, and SaaS providers with a strong focus on achieving the goal of being carbon, water, and waste-neutral by 2030. Gridmatic is an AI-enabled power marketer with the mission to enable and accelerate the ascent of clean energy. The specific process discussed in this paper involves a pilot project by EdgeConneX and Gridmatic using a 24/7 Carbon-Free Energy (CFE) approach to increasing and tracking clean energy sourcing and utilization. This paper outlines how a pilot deployment may serve to provide data that can validate 24/7 CFE as a practical, effective solution for increasing the adoption of cleaner sources of energy. Subsequent papers will discuss the 24/7 CFE pilot deployment in more detail as it is implemented.

Introduction

Data centers are significant consumers of electrical power, housing cooling units, servers, networking and storage equipment, and other devices, all of which require 24x7 availability and operation. Much of this power has traditionally been generated using fossil fuels that contribute to significant carbon emission and shifting to more sustainable energy can be challenging. The purpose of this document is to guide data center owners and operators who are evaluating options and approaches for addressing their carbon footprint.

This paper highlights an important effort to implement a 24/7 Carbon Free Energy (CFE) pilot, collect and analyze data as the pilot proceeds, measure the results, and publish our findings in subsequent white papers. Our pilot has the added benefit of contributing to the United Nations 24/7 Carbon Free Energy Compact, and to the extent that our efforts may spur other businesses to consider their own 24/7 CFE deployments, our intention is to be transparent and accurate in our reporting.

Introduction to 24/7 CFE Datacenters

A key resource required by all data centers is electrical power, and as the reach and adoption of the Internet and digital business transformation have grown, data center electricity usage has grown significantly even as overall efficiency has improved. In recent studies, global data center energy was estimated at 205 TWh, or close to 1% of worldwide electricity consumption[i]. There are indications that improvements in Power Usage Efficiency (PUE) have slowed, which may accelerate energy consumption going forward. This is due in large part to older, less efficient data centers remaining in service, making further reductions toward a 1.0 industry-wide PUE challenging even with newer data centers coming online.

In addition to efficiency, much of the data center industry is incorporating sustainability in its operations and new construction, increasing its use of renewable and carbon-free energy. In the US alone, greenhouse gas (GHG) emissions attributed to data centers have been estimated to be 3.15×10^7 tons CO2-eq[ii], or approximately 0.5% of total US GHG emissions. To help address these emissions figures, data center providers rely on services such as Renewable Energy Credits (RECs), which offset their continued use of non-renewable, carbon-based energy by purchasing credits attributed to the generation of clean energy.

A new approach, 24/7 CFE, which entails tracking carbon-free energy usage in near real-time hourly or even more precise increments, can reduce the consumption of carbon-based energy and can be applied to both new and existing data centers. For older, less efficient facilities, it enables them to take better advantage of cleaner energy, reducing their carbon footprint without requiring new construction. So even though 24/7 CFE does not improve the efficiency of an older data center, it can mitigate the environmental impact for old and new data centers by reducing the local use of fossil fuels, helping to achieve ESG goals and increasing acceptance within local communities.

Introduction to 24/7 Carbon Free Energy

24/7 Carbon-free Energy (CFE) emerged as a response to the urgent need for elimination of carbon emissions and adoption of cleaner energy sources to address climate change. In 2021, the 24/7 Carbon-free Energy Compact, developed in partnership with the United Nations, was published and signed by a group of major energy buyers, governments, system operators, solutions providers, investors and other organizations. The definition of 24/7 CFE is simple: every kilowatt-hour of electricity consumption is fulfilled by carbon-free electricity generation and measured hourly or in even smaller time increments.

By committing to the 24/7 CFE Compact, signatories agree to the following five principles:

1. **Time-matched procurement:** 24/7 CFE focuses on time-sensitive matching of electricity consumption with carbon-free electricity generation.

2. **Local procurement**: 24/7 CFE means purchasing clean energy on the local/regional electricity grids where electricity consumption occurs.

3. **Technology-inclusive:** 24/7 CFE recognizes the need to create zero carbon electricity systems as fast as possible, and that all carbon free energy technologies can play a role in creating this future.

4. **Enable new Generation:** 24/7 CFE focuses on enabling new clean electricity generation, in order to support the rapid decarbonization of electricity systems.

5. **Maximize system impact:** 24/7 CFE focuses attention on maximizing emissions reductions and solving for the dirtiest hours of electricity consumption.

The U.N. end goal is to cut CO2 emissions by 50% from 2010 levels by 2030 and achieve net-zero emissions economies by 2050.

Alternatives

Other large scale approaches to reducing carbon emissions are being explored and adopted by businesses and institutions around the world. These initiatives do not preclude adoption of 24/7 CFE; in most cases they are complementary. Two widely recognized alternatives to 24/7 CFE are an approach commonly called emissionality, and Renewable Energy Credits (RECs).

The guiding principle of emissionality is that businesses should invest in renewable energy in areas that are most reliant on carbon-intensive fuel sources. The argument is that the 24/7 CFE initiative has less immediate impact because it may encourage a subset of businesses and institutions to prioritize expensive decarbonization of grids that are already relatively clean.

The counterpoint is that 24/7 CFE and emissionality are not mutually exclusive, but organizations are more likely to have a substantial impact in areas where they do business and understand the drivers for decisions made by grid providers, municipalities, and local communities. 24/7 CFE aligns stakeholders and offers opportunities to manage costs, emissions, and other impacts to the environment.

24/7 CFE vs. Renewable Energy Credits (RECs)

RECs originated in 2001[iii] and are well established, with standards and markets for trading. A single credit is awarded to the generator for each megawatt hour of renewable energy produced (typically wind, solar, geothermal, or hydro). If an organization consumed 100 MWh of load for the year, to offset its carbon footprint it would buy 100 RECs corresponding to renewable energy produced by generators.

There are two important differences between RECs and 24/7 CFE: (a) 24/7 measures carbon-free energy rather than renewable energy, and (b) 24/7 requires time matching. An organization committing to the 24/7 pact doesn't match usage annually but on a time-based increment, and the energy must be carbon free and produced locally during that time period. The time matching requirement of 24/7 CFE targets is more difficult to meet than annual RECs because an organization may only claim generated energy is carbon free when consuming energy for that matched time slot.

Approaches for Datacenters to Achieve 24/7 CFE

There are three categories of approaches for achieving 24/7 CFE:

- **Offsite power procurement** where the data center obtains CFE from either their regular energy provider, or by contracting with CFE generators and specifying the amount of CFE required in their procurement contract.

- **Optimizing load profiles** via flexible loads such as cooling loads - this involves demand response and adjusting flexible data center functions to shift consumption to those hours where CFE is higher.

- **Onsite power generation** whereby the data center produces its own power, for example via rooftop solar.

The two onsite approaches - optimizing load profiles and onsite generation - typically can augment offsite generation to get to higher CFE targets but are not enough on their own. For instance, unless a data center understands its generation mix, it is challenging to optimize the load profile. As for solar power, data center roofs are often not large enough to support the number of solar panels required to supply energy needs, and large ground-mount solar arrays are not viable in dense urban environments.

"Solar power hasn't been widely used in data centers because it takes a very large installation of photovoltaic (PV) solar panels to produce even a fraction of the energy required by most data centers."[iv]

Adding an offsite approach by working with a third party 24/7 CFE provider is necessary. These providers specialize in assembling a portfolio of offsite power to meet time matching goals.

Case Study

EdgeConneX has placed a strong focus on reducing the carbon footprint of its data centers. The company has elected to pilot an EdgeConneX facility on 24x7 carbon-free energy with an eye to scaling this effort to other data centers within its global fleet.

EdgeConneX evaluated various onsite energy solutions such as solar and storage and determined that working with a vendor who could provide off-site CFE was the best option. The company researched vendors and found Gridmatic, an AI-enabled power marketer who applies years of success in financial trading in energy markets using AI-optimized bid curves to enable its partners to source renewable and carbon-free energy more easily and economically. Edgeconnex found that Gridmatic had the closest alignment to its goals, with a combination of technology and focus on carbon-free energy.

The decision was to take a phased approach to achieve long-term goals:

Phase I: Pilot | The baseline CFE content of the ERCOT grid in 2021 matched to the EdgeConneX load profile was 39%.[v] Gridmatic and EdgeConneX contracted for a time-matched CFE schedule target for one data center site in the ERCOT market. This pilot has "Low" CFE targets of 62% in 2023 and 63% in 2024. Gridmatic assembles a portfolio of offsite Gridmatic-contracted CFE generation and storage assets. Matching is done on an hourly basis.

Phase II: Optimized 24/7 CFE | Upon success of the pilot, the second phase could expand the 24/7 approach. Potential dimensions for expansion include the following:

- **Target:** The CFE content could be raised.
- **Dispatchability:** EdgeConnex could leverage the flexible portion of the data center load including IT and mechanical load as well as EV chargers.
- **Storage:** Storage assets could be deployed to further optimize matching of load and generation and reduce pricing.
- **Sites:** Additional sites and markets could be evaluated for expansion.

The CFE targets were intended to be aggressive but realistic. The "Low" scenario is 150% of ERCOT's baseline CFE content, with a maximum value of 90% CFE. The "High" scenario is 125% of the "Low" scenario, with a maximum value of 100% CFE. The rationale for these targets is that they are a function of the baseline CFE percentage of the underlying grid. This is therefore likely to vary significantly whether the local grid is ERCOT, CAISO, or the Pacific NorthWest, for example.

In this partnership, Gridmatic will transfer to EdgeConneX Time-based Environmental Attribute Certificates ("T-EACs") to demonstrate that a MWh of carbon-free electricity delivered was produced in the specific hour of the day. Gridmatic will also estimate the time-based CFE provided by the grid. We recognize that accounting for Grid Mix CFE leads to double-counting issues, but believe estimation is the correct approach given the limited ability to trade T-EACs in electricity markets today. In the future, we anticipate that all carbon

free grid resources will be able to transact with T-EACs, and liquid markets for T-EACs will develop, at which point we will no longer estimate the Grid Mix CFE.

CFE as a Portion of Grid Mix

The following graphs illustrate carbon-free energy as a percentage of grid mix supplying this data center in ERCOT. The goal is to match as much of the load as shown in gray with carbon-free sources of energy on an hourly basis as possible.

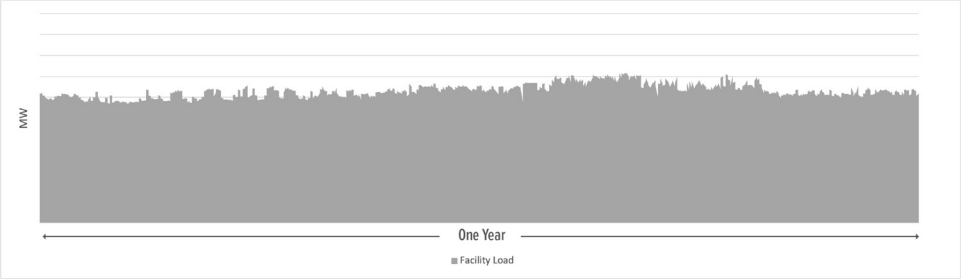

Figure 1: Total Data Center Load. This graph shows the load at the data center over the course of a year.

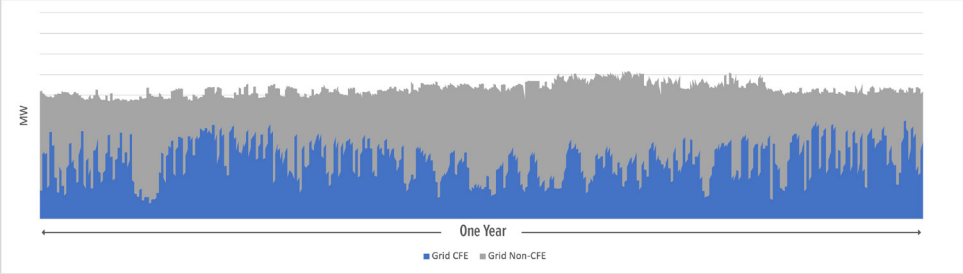

Figure 2: Utility-Supplied Carbon-Free Energy. This graph shows a typical grid mix where varying percentages of carbon-free and non-carbon free energy provided by the utility or retailer.

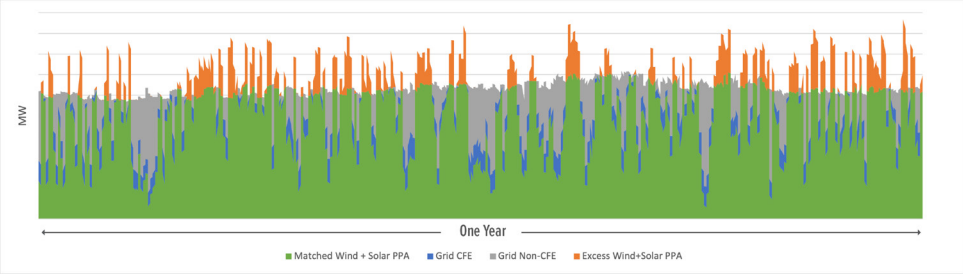

Figure 3: Carbon-Free Energy From Utility and Gridmatic. This graph illustrates where the data center has contracted with an offsite provider to maximize the amount of 24/7 CFE through a mix of matched Wind+Solar and grid CFE.

Ensuring Success

What are some of the success metrics to be considered for an initial 24/7 CFE project? It may vary for different industries and markets, **but here is a sample list aligned with a data center use case:**

- **Targets:** Set low and High targets, allowing a range of carbon-free contributions to a facility's power consumption. An example might identify a low target of 60% CFE measured in hourly intervals with a high-end target of 75% within a year and a longer-term target of 90% or 95%.
- **Costs:** Negotiate power costs up front with providers but note that costs will vary across markets depending on availability of carbon-free energy sources, so tracking and comparing costs will influence any evaluation of a project's success.
- **Reporting:** Define timely, auditable reporting to document share of renewable energy, time-matched data, the local grid energy used, anomalies, and power availability statistics.

- **Select Facilities:** Choose a facility capable of monitoring and measuring power loads related to tracking sourcing, including IT load, cooling units, and awareness of breaker ratings, generator capacity, UPS capacity, mechanical plant capacity, and more.
- **Utility History: :** Determine if your utility can provide historical data for up to a year, allowing the facility owner to refine model predictions.

Process / Next Steps

Steps to start the 24/7 CFE journey are illustrated below. Note the iterative approach which enables a company to begin with a pilot and increase its carbon-free goals over time:

Impact of 24/7 CFE on Utilities

It is important for utilities to track the rise of 24/7 CFE. Load Serving Entities will likely begin to see interest from their customers for 24/7 CFE, and generation utilities may be interested in assembling portfolios of renewable energy assets to meet demand. Interests may vary based on location and customer profiles, but ultimately, it's important to meet the demands of customers with corporate 24/7 CFE targets and who need their utility's help in doing so.

Assembling a 24/7 CFE portfolio is non-trivial and with current lead and development times, utilities need to begin the planning process.

Long duration storage

At lower penetrations of clean energy - 60% or lower - large energy consumers can source CFE and use grid mix to fill in during times when solar and wind are not producing. At these ranges, the value of storage is low. However, as the ratio of clean energy gets closer to 100% and when solar and wind have the potential for synchronous low production, storage is needed to store clean energy to match hours of consumption.

This points to an inflection point in the cost curve for 24/7 CFE where storage is not needed until the grid mix approaches 100% CFE, and then there's a steep increase in the need for storage or other resources to meet the needs, corresponding to a cost impact.

Conclusions

Everyone has a role and an obligation in the effort to reduce or even reverse global warming trends associated with carbon emissions and fossil fuels. No single solution will work in every region or apply to every business around the globe. But everyone can do something to help.

The data center industry holds significant influence owing to its scale, its reliance on TWh of energy, and its presence in virtually every country worldwide. The purpose of the joint EdgeConneX / Gridmatic pilot outlined in this paper is to document the environmental impact of a 24/7 Carbon-Free Energy approach to powering a large data center. By working in tandem with local utilities and grid providers, to increase the distribution and consumption of carbon-free energy from solar, wind, hydro, and other sources, the goal is to prove that there is demand for cleaner energy and that cleaner energy can be provided reliably at both normal and peak levels.

We hope this white paper has provided some insights based on a real-world application of 24/7 CFE. We plan to gather lessons learned and insights as this pilot progresses, and report updated results in further papers planned for Q3 2023. In the interim, we encourage you to engage with us with any questions or to discuss your thoughts on this topic.

For more information, contact the authors of this paper at
edgeconnex.com/company/sustainability or 247CFE@gridmatic.com

About EdgeConnex

Founded in 2009, EdgeConneX is focused on driving innovation and helping our customers define and deliver their own unique vision for the Edge, at any scale, in any market worldwide, for any requirement. Today, with headquarters in Northern Virginia, Singapore, and Amsterdam, we are building tomorrow's data center infrastructure.

Delivering innovative, proximate, and purpose-built data center solutions ranging from 40kW to 40MW or more, we work closely with our customers to provide the scalable capacity, power, and connectivity they need. In turn, our customers' content, connectivity, cloud services or any data requirement can be securely delivered with enhanced performance and lower latency to any device, anywhere.

About Gridmatic

Gridmatic is an AI-enabled power marketer with the mission to enable and accelerate the ascent of clean energy. We apply machine learning to deliver predictability and manage risk for renewable energy supply and demand. We work with renewable energy generators and consumers, and owners and operators of storage assets to optimize returns. We offer tolling, offtake, and supply contracts for scheduling and bidding, resource trading, and firming and shaping and are a licensed Retail Electric Provider in the State of Texas. Gridmatic is a privately held company headquartered in Silicon Valley.

Endnotes

i *Science - https://datacenters.lbl.gov/sites/default/files/Masanet_et_al_Science_2020.full_.pdf*

ii *https://iopscience.iop.org/- "The enviromental footprint of data centers in the United States" article/10.1088/1748-9326/abfba1#*

iii *https://en.wikipedia.org/wiki/Renewable_Energy_Certificate_(United_States)*

iv *Datacenter Knowledge - https://www.datacenterknowledge.com/solar-powered-data-centers*

v *Download: https://www.ercot.com/files/docs/2021/11/08/IntGenbyFuel2021.xlsx*