

Seminar Report

Sustainability For Data Centers

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Abstract

The enormous growth of digital data and increasing demand for computational power has resulted in a significant rise in the number and scale of data centers globally and growing importance of sustainability in data centers. The amount of energy consumed by data centers also underscores the need for eco-friendly sources of energy to sustain data centers seeing the threat which non-renewable energy sources energy sources poses to our environment resulting from carbon footprint emitted from the use of these non-renewable energy sources. This document delves into the challenges faced in sustaining data centers, associated challenges in embarking on green energy sources for powering data centers, and highlights the significant benefits of relying on eco-friendly energy sources as a means of sustaining data centers, not only to mitigate environmental impact, but also for long-term viability, a critical aspect that cannot be overemphasized.

Furthermore, existing solutions to challenges associated with powering data centers as well as innovative technologies which enhance efficiency of data centers is discussed.

1 Introduction

Data centers play a significant role in digital infrastructure, serving as a facility that houses IT infrastructure for building and delivering applications and services, storing, processing and managing data associated with those applications and services. As stated in the book written by Corey Gough et al., titled ‘Why data efficiency matters’, “data centers are the nucleus of digital economy” and “the information factories that shape our modern experience”[1]. Sustaining a data center is a crucial aspect of the IT industry, and with an increased need for a greater number of data centers comes increased efforts to make them sustainable. Energy consumption of data centers draws global attention to data centers because of the huge amount of electricity they consume. The enormous energy consumption of data centers has been a growing concern and an increased need for data centers arises because of an increase in demand for digital services, cloud computing, exponential rise in data-intensive applications, continual dematerialization of goods, and growth of the economy e.t.c. Internet of things is a major contributing factor to the exponential increase in need for more data centers[2]. Sustainability of Data centers, refers to when the energy powering data centers is made to run uninterrupted. Power outage in data centers is disastrous and should be avoided completely. As a result of the huge capital required to get the data centers running again, and the significant consequences on the services they supply. The necessity of sustaining Data centers is crucial for Business Continuity purposes, Data integrity and availability, preventive loss due to downtime. The need, therefore, for the sustainability of Data centers cannot be overstated.

Asides being an energy-intensive infrastructure, they are highly capital intensive. Power outage in data centers can occur in data centers because of insufficient backup power, cooling failures, cyber security threats, Human errors, among other factors. Commonly used existing solutions to ensure backup power in case of electrical outages include Uninterrupted Power Supply and Diesel Generators. Some more advanced improvements to these solutions to power outage in data centers include but not limited to; Onsite-Power generation, renewable energy sources which include Green Hydrogen, Solar Power, and the use of Data Center Heat.

The challenges as well as the benefits associated with these means of sustaining data centers, will all be addressed in more detail further in this report. Deploying these cutting-edge methods to power data centers guarantees the prevention of power failures in the facility.

2 Energy Consumption in Data Centers

The primary element influencing efficiency in data centers is “scale”, which is attributed to the substantial energy consumption by these facilities. Scaling up a data center involves augmenting the existing data center infrastructure by adding more CPU, memory, or I/O devices, or upgrading to a larger and more powerful server. The size and configuration of hardware in data centers vary, contingent on the workload they handle, and companies may employ different types, based on their business requirements. Data centers demand significant electrical energy for their operations, with considerable portion attributed to sustaining servers. According to C and C Technology Group[1], typically, they consume about 1000kWh per square meter, a magnitude approximately ten times greater than the energy consumption of an average American household. According to the US Department of Energy, “ the largest data centers with tens of thousands of devices require over 100MW of power, which is enough to power approximately 80,000 households” [8]. A data center can vary from a few set up of servers in a room, to extensive structures that span hundreds of thousands square meters, housing tens of thousands of servers and additional hardware.

Various types of data centers include Colocation facilities, Enterprise data centers, and Hyperscale data centers. The latter, designed for hyperscale computing and essential for cloud and big data storage, typically encompass at least 929 square meters, and have more than 500 cabinets and 5000 servers operating on an ultra-high-speed network[9]. Numerous Hyperscale data centers are managed by leading cloud service providers such as Amazon Web Services (AWS), Google Cloud Platform, IBM Cloud, Microsoft Azure, among others. According to Enerdata IEA, Data centers use more electricity than entire countries.

Characteristic of large-scale data centers is their demand for tens of megawatts of electrical power, equivalent to the energy required to sustain a small city [2]. This substantial energy consumption is a key factor drawing attention to data centers.

See diagram below for further clarification[18].

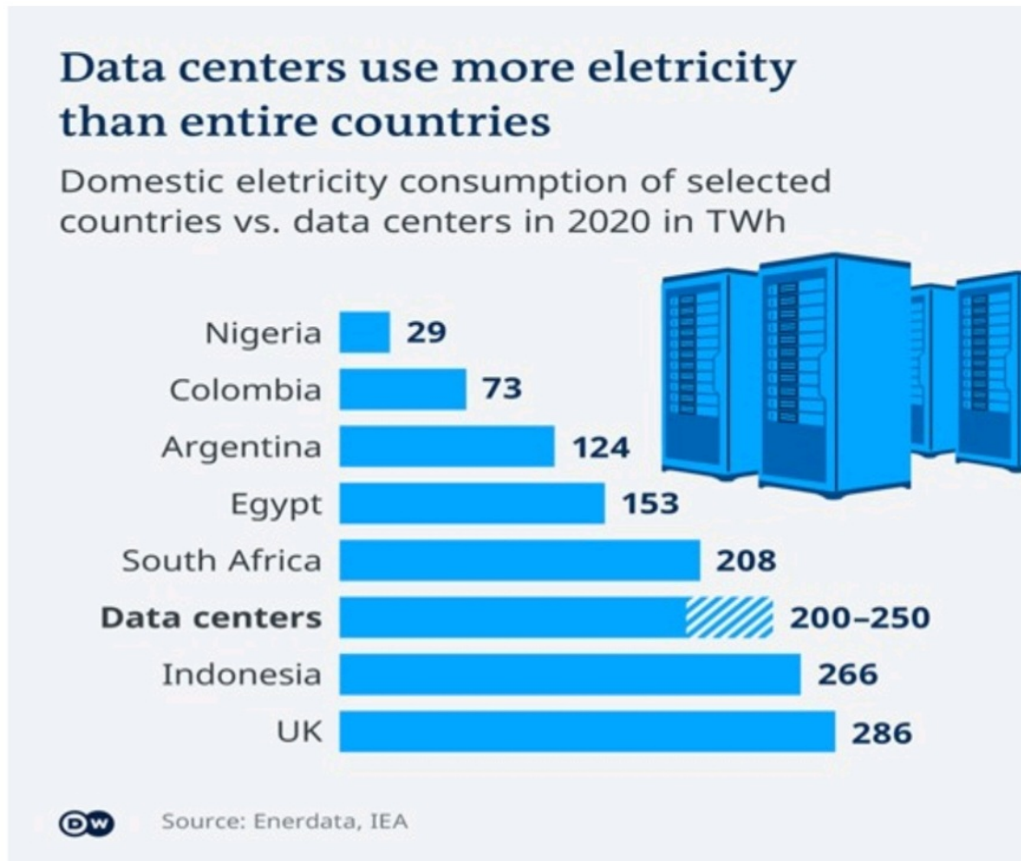


Figure 1: Domestic Electricity Consumption Of Selected Countries vs.Data Centers In TWh

3 Importance of Sustainability For Data Centers

The goal of a data center is to meet the computational needs of the organization. computational needs refer to physical and financial needs of the organization. Forecast by B Marcus Law, December 30, 2022 for 2023 says “Data centers are estimated to be responsible for up to 3% of global electricity consumption today and are projected to touch 4% by 2030” [10].

See below, a diagram for illustration [19].

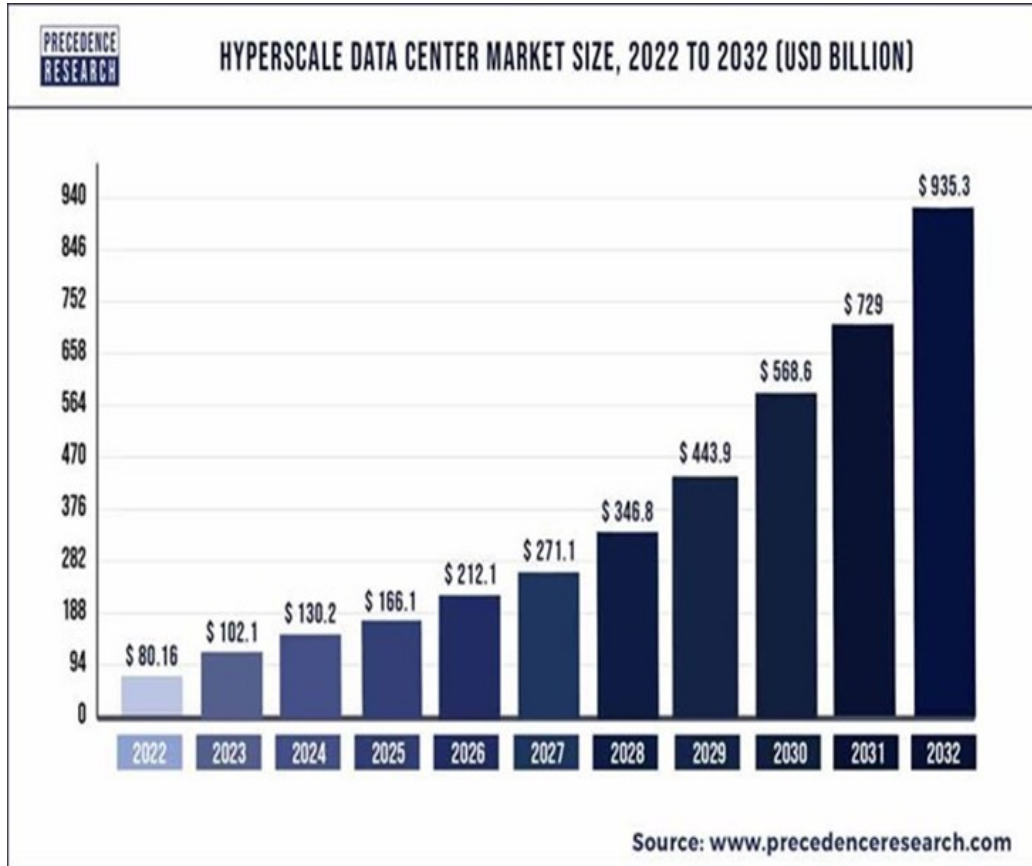


Figure 2: Hyperscale Data Center Market Size From 2022 To 2032.

Sustaining a data center is ensuring there is no power outage in the data center. It is crucial to meeting the organizational goals financially because power outage in a data center has great consequences which are inconvenient for the administrators, since it can cost huge expenses to get it running again. Recent survey from Uptime Institute Global Data Center Survey 2023, reports that 1 in 6 data centers that suffered a major outage incurred over 1 million. Unplanned data center outages are frequent events, occurring more often than they ideally should, considering the significant repercussions that power interruptions can impose on the administrators of such facilities. Preventive measures ought to be put in place to ensure uninterrupted power supply.

4 Causes of Power Outages in Data Centers

Some causes of data center failure include [11];

- Insufficient backup power.
- Cooling failures.
- Cyber security threats.
- Human error etc.

Insufficient backup power: Power outages can occur when backup systems like generators and UPS (Uninterrupted Power Supply) systems, such as batteries, fail. Generators may cease running after a few hours, and there is a potential risk of them failing to start. Additionally, when the UPS system reaches the end of its runtime, it can lead to complete power outage in data center.

Cooling failures: Data centers can experience failures due to overheating. When the equipment reaches excessively high temperatures, it automatically shuts down to prevent damage, resulting in downtime. Overheating is often exacerbated by inadequate circulation of cold air through the cabinets and the loss of cooling system redundancy.

Cyber security threats: A prevalent form of cyber-attack is the use of malicious software, commonly referred to as malware, which can wreck havoc in data centers. For example, the reported cyber-attack on the Power grid of Ukraine in 2015, attributed to Russia, resulted in power outage affecting more than 200,000 people for a duration of 1-6 hours[4]. Similarly, cyber-attacks on data centers have the potential to disrupt power systems. Hackers may employ phishing techniques, a procedure that could be utilized to induce power outage in data centers.

Human error: Human error as reported by Uptime Institute in a 2021 survey [6], is frequently cited as a factor contributing to power outages in data centers. The survey revealed that 48% of the outage in power were attributed to the actions of data center staff, specifically instances of failure to follow procedures. The two primary causes highlighted in the survey were failure to adhere to procedures and having incorrect processes and procedures. Furthermore, when some personnel are not properly trained to operate data centers, huge mistakes in running operations can occur, leading to disruptions power in data centers.

5 Remedies/Proper Management of Data Centers

See below, a diagram that illustrates percentage allocation of where data center power goes [20].

Where Data Center Power Goes

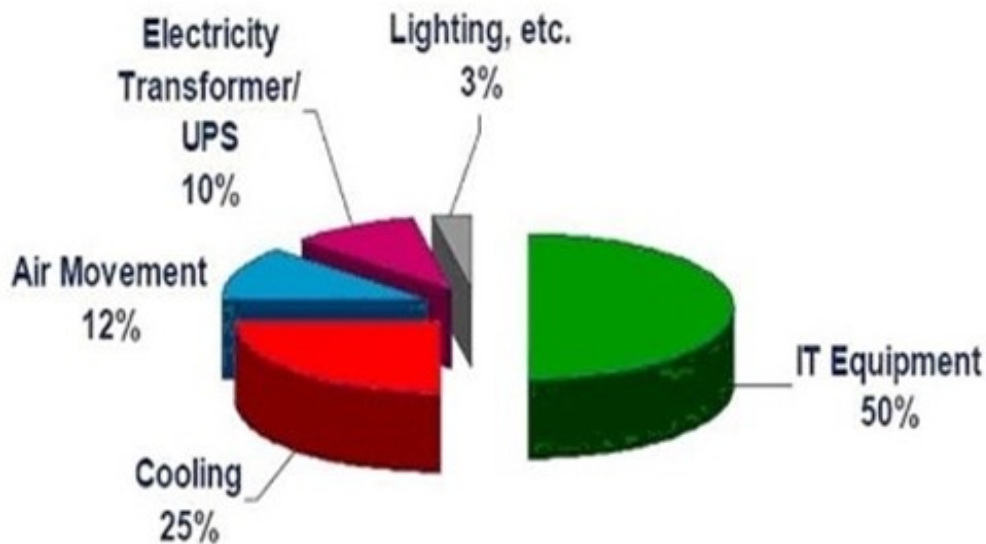


Figure 3: Percentage Estimate Of Where Data Center Power Goes.

Servers: Rack servers are one of the two dominant energy-draining component in data centers [3] and are one of the most important structures of a data center. They constitute a significant power draw[12].

Cooling Systems: High density racking can increase the need for cooling, resulting in the use of more power. Hence, the need to balance efficient use of space while considering the impact that the infrastructure can have on things like cooling and power consumption. Cooling systems are also a major energy draining facility in a data center [5].

Emergency Power: Emergency Power: Installing a backup power is a preventive measure to avoid power failure. This keeps the systems running.

Sustainability: Solar power can be feasible in some instances. Depending on the climate, allowing cool outdoor air into the environment can aid to reduce power draw from cooling systems.

Power Usage Efficiency(PUE): The monitoring of power consumption involves segmenting it into IT tasks such as server, power, and non-IT tasks, including lighting and cooling. If the power requirements remain consistent for IT essential functions, efforts should be made to identify opportunities for reducing power consumption in non-IT tasks. Effective management and proactive preventive measures, play a crucial role significantly reducing outages and optimizing the productivity of data centers.

The primary cause of data centers failures is often power loss, with generators and batteries being commonly employed as backup power sources. However, potential downsides to these methods include the failure on the part of operators to conduct ‘power failure tests’, and infrequent replacement of batteries. Neglecting essential preventive steps can lead to the unavailability of backup power when it is needed most.

6 Maximizing Efficiency/Uptime of Data Centers

Maximizing Efficiency/Uptime of Data Centers Power and Performance Utility costs are a major concern for most data centers. According to Packer-Power, in the document ‘Guide to Data Center Monitoring’, year 2023 it is stated that power constitutes 70 percent of the total operational cost (TOC) of a data center. Maximizing uptime and minimizing downtime caused by factors such as power failure is crucial. A well-known strategy to prevent failures resulting from power outages is to invest in an uninterruptible power supply (UPS).

7 Ways to Ensure Energy Efficiency in Data Centers

Some ways to ensure energy efficiency in data centers [13] include;

- Onsite-Power generation
- Green Hydrogen
- Solar Power
- Use of data center heat.

On-site Power generation:

On-site power generation in data centers refers to the production of electricity within the data center facility [14] This is accomplished through various means such as solar panels, wind turbines and diesel generators

Pros:

- Serves as an emergency backup during power outages.
- Increased energy efficiency and maximized uptime.
- Promotes technological advancement in renewable energy.
- Provides improved energy density, reduced transmission line losses, decreased conversion losses.
- Lowers operating cost.

Cons:

- Very costly.
- Resource availability poses barriers to success.
- local market supply and monopolies are challenges.

Solar Power: Solar power is a sustainable means to improve data center resiliency as a renewable source of backup power.

Pros:

- According to the U.S. National Renewable Energy Labs (NREL), connecting solar production to systems in data centers improves generator runtimes, maintains uptime with batteries and solar in the event of fuel exhaustion.
- Provide operational savings, improve reliability.
- Greener future (power-related CO_2 emissions can be reduced to zero).

Cons:

- Enormous investment required for setting up photovoltaic solar panels.
- Takes several years to recover investments due to the relatively lower actual power generated.

Green Hydrogen: Hydrogen as a green energy option, can be utilized for backup power [15]. Hydrogen energy systems have significant benefits, leading to extensive research on hydrogen-powered data centers [7]. Green hydrogen produced from renewable energy is a clean alternative to non-renewable energy sources for powering data centers [16]. Different colours of hydrogen below are used to depict the various processes involved in hydrogen production.

See below, a diagram illustrating colours of hydrogen [21].

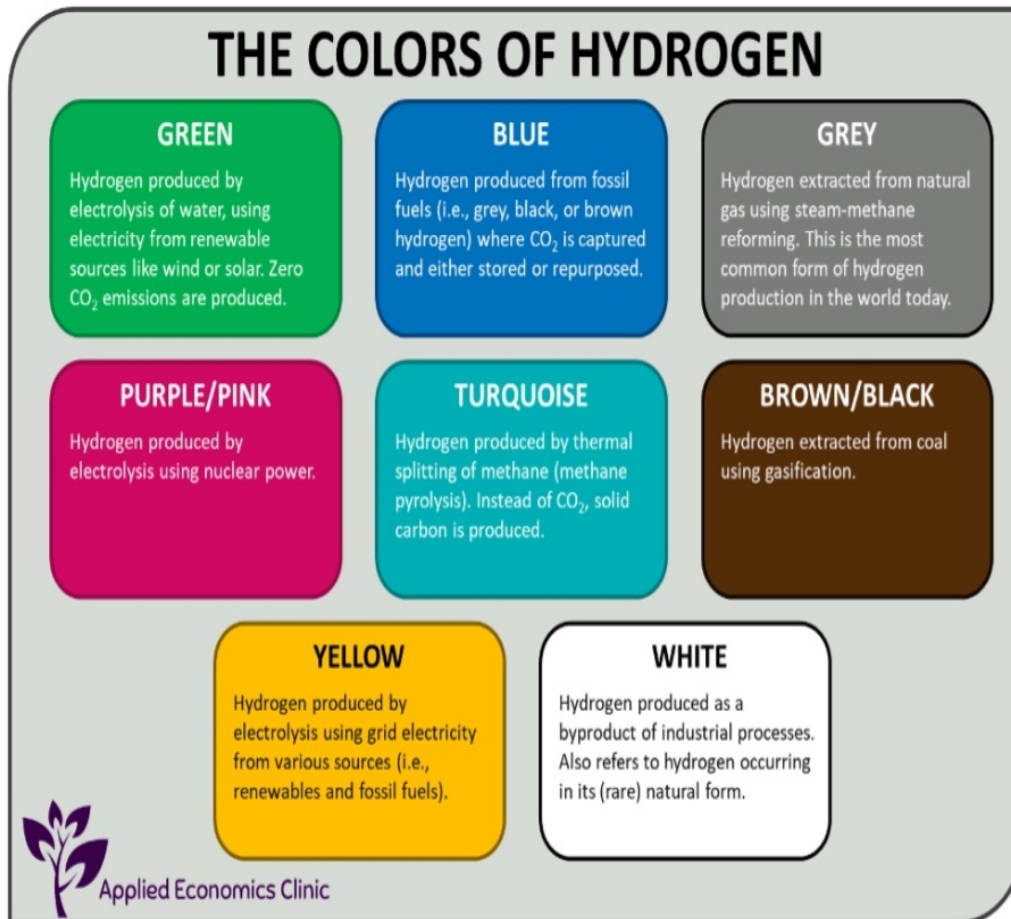


Figure 4: Colours Of Hydrogen Depicting Means Of Production

Pros:

- Advances sustainability for a greener future.
- Suits quick start-and-stop needs of standby applications.
- Most common element in the universe.
- It is also the lightest and simplest element, consisting of only one proton and one electron.

Cons:

- Production of hydrogen is a complex process involving the separation of hydrogen from its molecular counterparts.
- Only five percent of the globally produced hydrogen is green hydrogen, produced by renewable energy, typically wind or solar.
- Highly flammable.
- Considered very expensive.

Use of Data Center Heat:

Data centers generate significant heat requiring cooling systems to prevent servers from overheating. The heat produced can be used to generate power, through a process known as Combined Heat and Power(CHP). In this process, heat is used to warm up water, which is then employed to generate electricity. CHP is a highly efficient process, capturing and utilizing the heat that is a by-product of the electricity generation. This method of generating heat and power simultaneously, can reduce carbon emissions up to 30% compared to the traditional separate generation methods involving a boiler and power station [17].

In the paper “The Role of Distributed Generation and Combined Heat and Power in Data Centers” by U.S Environmental Protection Agency Combined Heat and Power Partnership, August 2007, CHP is an efficient, clean, and reliable approach to generating power and thermal energy from a single fuel source. Additionally, CHP can increase operational efficiency, reduce energy costs, and decrease emissions of greenhouse gases contributing to global climate change mitigation.

The document states “CHP systems typically achieve total system efficiencies of 60 to 80 percent, compared to only 49 percent for producing electricity and thermal energy separately”.

See figure below [17].

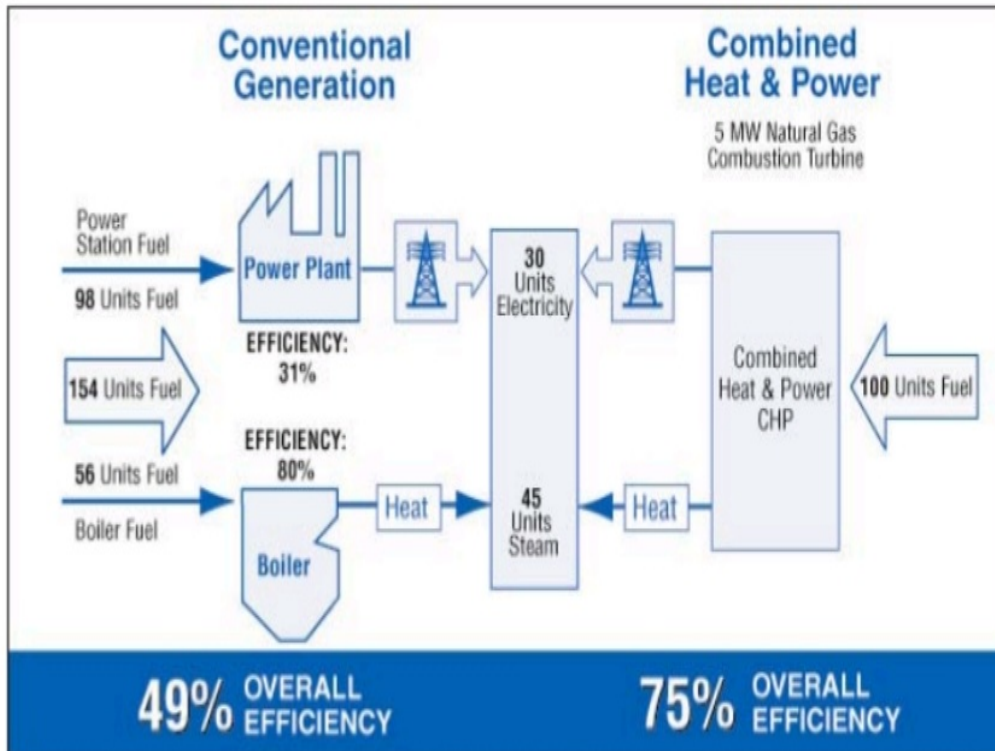


Figure 5: Combined Heat and Power Efficiency Advantage Compared To A Central Power Plant And An Onsite Boiler.

Pros:

- Reduced Energy consumption.
- Lower carbon footprint.
- Saves operational costs.

Cons:

- High initial cost for installing a CHP system.
- Maintenance costs associated with CHP systems.
- Limited scalability - finding a matching CHP system for different data centers may not be feasible due to their size.

8 Conclusion

The significance of having standby, uninterrupted backup power supply in data centers cannot be overstated. With proper planning and management, organizations can avoid financial losses resulting from power outages of data centers. Having reliable and efficient backup power system not only enhances energy efficiency but also reduces the Total Cost of Operation (TOC) for data centers.

Furthermore, prioritizing eco-friendly sustainability measures in data centers is crucial for a greener future. The goal of achieving climate-neutrality is to reach 100% renewable energy coverage in the coming years. Green data centers play a key role in maximizing energy efficiency, a critical factor for the growth and success of any company.

As the global call for eco-friendly practices in organizational operations continues, it is imperative that all relevant parties involved in managing data centers take active steps to ensure that daily operations align with the objectives and goals aimed at achieving 100% renewable energy sources for powering data centers, and given the substantial energy consumption required to keep data centers operational, especially as their number and scale increase globally, this commitment becomes even more vital.

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