

# A Review on Adoption of Green Cloud Computing

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**Abstract**—One of today's IT industry's fastest-growing subsectors is cloud computing. Through the use of their own gadgets and the internet, many people are able to use a variety of services. It offers a virtualized environment that is inexpensive, simple to use, and lower electricity usage. Considering energy use and the burden placed on computer servers, average job allocation and VM loads, this article examines the significance and utilization of green cloud computing and how it could provide alternatives to the IT sector.

**Keywords**—Green Computing; Cloud Computing; Load Balancing; SaaS; IaaS; PaaS; Carbon Footprints.

## I. INTRODUCTION

Today, a vast number of sectors and businesses are successfully utilizing cloud computing. As a result of the quickly rising demand, IT service providers are expanding their data centers, which are made up of big servers or hosts, which are essential components of a cloud environment. A growing carbon footprint results from the energy consumption that comes with using enormous amounts of computers. The amount of heat released during this operation is enormous. Due to this consumption, a significant amount of carbon dioxide is produced, which is highly harmful for humans.

Green cloud computing can solve this issue by arranging the resources in a way that is power-efficient. In order to enhance energy efficiency, the information technology staff must be spread out.

The study of how to use digital technologies and design them in a way that has a smaller negative environmental impact is known as green cloud computing. These methods can save operational costs in addition to saving energy. Green computing aims to utilize fewer harmful chemicals, consume as little energy as possible during a product's lifetime, and encourage the recycling of production waste and obsolete products. These objectives are similar to those of green chemistry.

Green cloud computing lowers energy consumption improves the power efficiency of data centers and decreases the use of hazardous equipment.[13]

Green cloud computing results are highly required because they not only conserve energy but also cut expenses and improve sustainable development.

This study must first understand the services like SaaS, IaaS, PaaS.

**Software as a Service:** This application is one that is already in use and can be accessed online using web browsers like Gmail, Google Chrome, Salesforce, Amazon, Facebook, and Mozilla Firefox. End users can access software and services on demand; there is no hardware setup or setup fee; it is a expect to be paid model.

**Platform as a Service:** It leads to results in the creation of IT systems using cloud platform. In PaaS, cloud allows developers and organizations to rent its platform to build applications and services over the internet. Salesforce, and Elastic Beanstalk from Amazon Web Services are some of the firms offering PaaS. [1]

**Infrastructure as a Service:** Leads to the development of your application. Only virtualized infrastructure can be rented and used to develop new applications in the cloud. IaaS is often a service where infrastructure, like networking hardware, devices, databases, and web servers, is delivered as an outsourced service to businesses. These are all crucial services in order to use green cloud computing services.

## II. MAIN STRATEGIES OF CLOUD COMPUTING

1) First, the architecture confers the highest quality of service and reduces operational costs, claim Beloglazov et al. The author considered manufacturers for optimizing energy conservation, including virtual network topologies that link virtual machines to the temperature status of computing nodes. Here, the data from cloud users is stored virtually rather than on actual servers, which aids in reducing the use of resources from physical infrastructure.

2) He appropriated from K. Mukerjee the behavior of ants and bees.

It helps by shutting down idle CPUs and moving jobs to avoid proper load balancing.

I) The bee colony strategy is used to reschedule jobs.

II) The Ant colony Technique is a way to use less energy.

## III. FACTORS ON GREEN COMPUTING

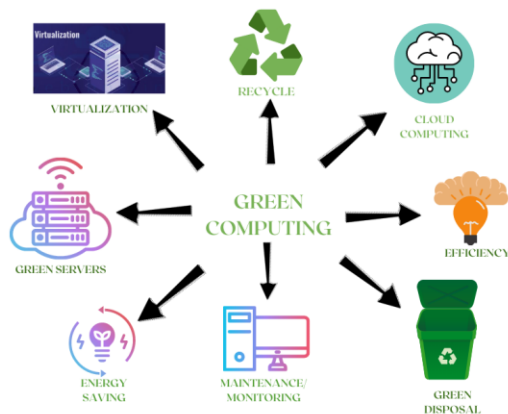
It is the study of information technology and computing that is ecologically friendly. Reducing overall power consumption can lead to green computing. Reconfiguring the network's infrastructure to use fewer servers, switches, and cables is how it is accomplished. Green computing aims

to reduce IT's carbon footprint. The main techniques to minimize carbon footprint are

- **Green Usage:** Reduce computer electricity consumption and use computers in an environmentally friendly manner.

#### Ways to achieve green computing & Energy efficiency

- **Upgrade data center:** In comparison to modern technologies, older ones consume more energy and generate more heat.
- **Power Management:** When inactive for a while, CPUs and other devices can be shut down and switched off.



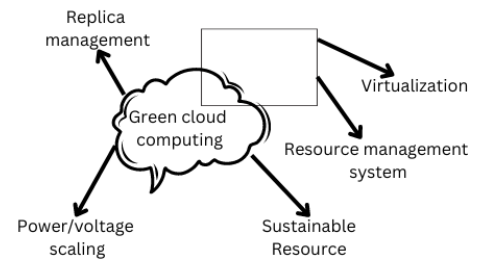
**Fig1:Green Computing**

A lot of resources are contained in the various parts that make up computers. Raw materials are required to do computations, and power is required to run computations. When computers reach the end of their useful lives, we must recycle them in order to dispose of them. Therefore, the design, production, use, and disposing of the product are the first steps in the green computing process. And computers in a way that they don't have an effect on the environment. Many IT firms and computer manufacturers have made significant efforts to move toward green computing. These include constructing computers out of more ecologically friendly materials, designing them to use less energy, and offering programs for recycling outdated systems.

#### IV. ANALYSIS ON GREEN CLOUD COMPUTING

In addition to saving energy, green cloud solutions can considerably lower operational costs for businesses. Green cloud computing includes some resource management systems, it is used to manage some resources such as virtualization, virtualization makes it easier to manage cloud computing resources, it is also used for resource scheduling. Green cloud computing use sustainable resources like

- **Heat Reuse:** When we use cloud computing services for a very long time, it will generate a lot of heat. With the help of GCC sustainability resources, we can easily use heat in a good way.
- **Sustainable Energy:** With the help of the GCC, we can reuse energy, which also includes free cooling.



**Fig2 :Case Study on Green Cloud**

The environment is greatly impacted by the global corporate expansion. Increased data centers are a sign of growth. Information and communication technology includes a data center as a subset. A rise in the number of workers who commute to work each day as well as an influx of the supplies and office equipment that are used every day. Green cloud computing offers solutions for lowering the carbon footprint of the entire planet, thereby addressing these pressing environmental problems.

#### V. APPROACHES TAKEN TO ACHIEVE GREEN CLOUD COMPUTING

##### ➤ **Virtualization:**

From a financial and energy-saving perspective, virtualization is the primary aspect in cloud computing that allows for sustainability.[5]

Installation of virtual infrastructure, which enables several operating systems and applications to coexist on fewer servers, aids in lowering total energy usage for IT companies. With help of virtualization, it becomes easier to manage resources of cloud computing.

##### ➤ **Cloud optimization tools:**

minimizes the number of servers, conserves electricity, and lowers carbon emissions. You may reduce your carbon footprint even further by adopting renewable energy.

##### ➤ **Carbon-aware CSPs:**

Carbon-conscious policy demands grid energy estimates and grid energy limitations. Users of digital services can better understand the carbon intensity of the electricity they use by using services that are designed with carbon awareness. It also influences energy demand, causing us to use digital services more frequently during periods of cleaner energy supply.

##### ➤ **Purchasing from environmentally committed companies:**

Businesses frequently fail to consider environmental issues. We must thus purchase the necessary goods from respectable companies that value the environment.

##### ➤ **Participating in Electronic Recycling Programs:**

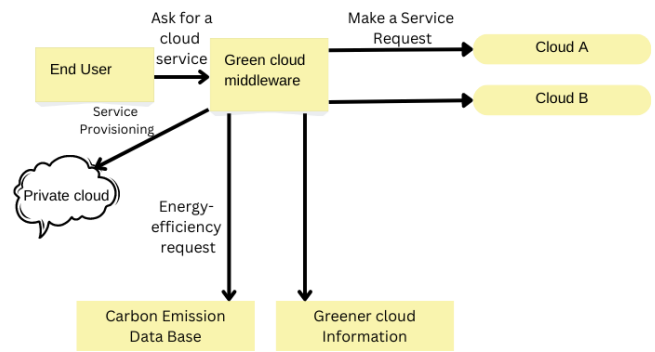
It is advisable to recycle electronic garbage and physical servers because doing so would lessen global warming.

### ➤ **Deploying Virtual Technologies:**

Utilized to divide up physical computing equipment into numerous virtual ones, each of which can be readily controlled and used to carry out computations.

### ➤ **Resource allocation:**

Additionally, data can be routed via algorithms to data centers with cheaper electricity. Sometimes larger data centers are situated in areas with inexpensive, readily accessible land and electricity. Green site selections may be influenced by factors such as the accessibility of renewable energy in the area, the climate's suitability for outdoor air conditioning, or the location of the renewable energy sources so that the heat they create can be put to other uses.



**Fig3:Green Cloud Architecture**

Additionally, an overloaded server wastes energy. The issue is resolved by using several strategies, including load balancing, VM migration, job scheduling, etc...

## VI. ANALYSIS OF THE CARBON FOOTPRINT AND SOLUTIONS

The entire amount of greenhouse gases released by an entity—a company, a person, a car, or anything else—is known as their carbon footprint. A significant quantity of carbon emission is produced as a output of rapid increase in demand brought on by the widespread use of cloud computing across numerous industries and enterprises. Cloud computing computers produce a lot of CO<sub>2</sub> in their operation. The annual energy usage of the computers used in cloud computing is 500 kilowatts, and the associated carbon dioxide emissions total 290 kg. We can significantly advance green cloud computing and cut carbon emissions by 40% by deploying the tranquil PC.

By keeping your temperature system on a moderate setting while you are in the room, you can reduce the total amount of greenhouse gases (CO<sub>2</sub> and methane) produced by our actions.[14] There is an increase in carbon in a location where there are more information technology firms. Every organization can guarantee that their business leaves the smallest possible carbon footprint by using green cloud computing.

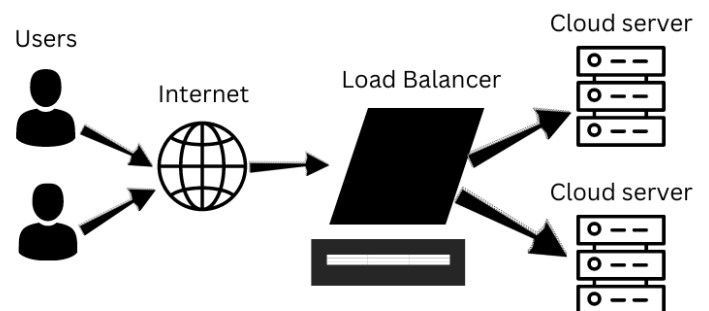
## VII. ENERGY EFFICIENCY IN CLOUD COMPUTING

A data center is probably the most obvious component of cloud computing, which consists of a group of servers used to store and execute applications and corporate data. Data centers, which contain servers, cables, air conditioners, networks, and other equipment, use more energy and emit a significant amount of carbon dioxide (CO<sub>2</sub>) into the atmosphere. One of the main challenges in cloud computing is the optimization of energy use. Thus, the idea of "green cloud computing" was created. Data caners use a significant quantity of energy as a result of organizations and enterprises employing more data centers and consuming more power. A significant amount of energy is wasted by data center's idle servers and resources.

## VIII. LOAD BALANCING IN CLOUD

Load balancing decreases energy usage and prevents overheating by distributing work among numerous servers. Load balancing is less expensive and easier to use. This makes it possible for organizations to create client apps much more quickly and to do it at a lower cost. Cloud load balancing can provide scalability for controlling website traffic. Effective load balancers can be used to manage high-end traffic; this is made possible by network infrastructure and servers.

A website can have multiple simultaneous users. As a result, a software finds it challenging to manage the load brought on by numerous requests occurring at once. Sometimes, this can lead to a system failure.



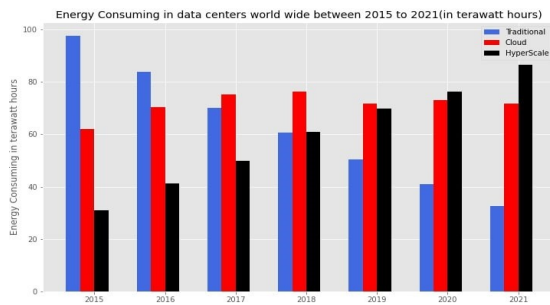
**Fig4:Load Balancing**

In cloud computing, there are two degrees of load balancing:

- Applications that are loaded into the virtual machine from the cloud are mapped at the virtual machine level.
- A connection between the virtual machine and host resources enables the host level processing of many arriving application request.

**Table1. Authors Idea on Green Cloud Computing:**

S.NO	YEAR	TITLE	ASSIGNMENT OF ORIGIN	AUTHOR CONCLUSION
1.	2015	When internet raised to the things power: Are energy efficiency standards sufficient to curb carbon footprints?	The author describes the importance on Energy efficiency. He demonstrated that, despite significant improvements in energy efficiency and global energy consumption in the majority of countries has continue	Lesser carbon emission and better ICT goods and service should be aim. For next work, it is necessary to gather extensive Historical information on the ICT industry's contribution to the growth and quantity of energy efficiency.
2.	2016	Towards Green Cloud Computing: Impact of carbon footprint on environment.	The study concentrates mostly on how to evaluate the productivity of carbon usage and how to accomplish energy consumption in the cloud architecture.	The author arrives at the conclusion that green broker has a variety of modules each designed to carry out a particular function. It genuinely chooses which cloud will operate most sustainably to fulfil a request.
3.	2017	Green cloud computing: A review on efficiency of data centres and virtualization of servers.	According to the author, the usage of cloud computing has expanded, which has reflected in an increase in the amount of data centers where data is stored, accessed, and analyzed.	The physical data centers must be optimized to increase their energy efficiency. The objective is to examine additional resources like networks and storage that significantly increase a cloud's power usage.
4.	2018	Load balancing in cloud computing.	The significance of load balancing was noted by the author.	The centralized server's performance is enhanced through load balancing. In order to boost system performance , To spread out the load across many processing nodes with a lower capacity, load balancing is used..
5.	2019	Green cloud computing- A greener approach to IT.	This study discusses how green cloud computing might offer alternatives to other industries in terms of energy use. The author is extremely focused on the significance of this.	The author believes that the datacenter energy network scheduling technique is the least effective in terms of load balancing because it disregards the VM status.
6.	2020	Green Computing in Cloud Computing.	The author discusses how carbon dioxide and other environmentally hazardous gases are released by cloud computing, which is harmful to nature.	The author draws a conclusion about how much energy a Google search uses, compares it to others, and states that the future is certain, one day, green computing in cloud computing will be implemented in every cloud field, benefiting both us and the environment.
7.	2021	A Succinct Review Of Intelligent Computational Techniques In Green Cloud Computing.	In this study, present intelligent cloud computing solutions are discussed and analyzed based on a variety of factors, including resource consumption, reaction time, overhead, etc.	Future cloud computing development should prioritize both better performance and environmental capabilities. The basics to applying green cloud computing are providing lowering energy consumption, and the cutting carbon emissions.



**Fig5: Energy Consuming in data centers worldwide between 2015 – 2021**

#### To upgrade data center:

Three steps are followed by IT teams to modernize the data center and increase its effectiveness.

##### 1) keeping an eye on the environment

Checking the equipment is the primary step towards improving data center efficiency. Additionally, in order to effectively manage provisioning, capacity, and reactivation, companies should be able to control the power towards each source. IT teams can put DCIM software and intelligent rack PDUs in place for a high level of monitoring. With the help of these tools, you may learn how to use less energy. Teams may keep an eye on how the data center is organized generally, how much power is being used, and how the burden is distributed among the IT equipment.

##### 2) Stay away from hotpots.

The attention will shift to data center humidity and temperatures as the next phase in data center improvement. The effective management of airflow should be a primary concern for IT teams in order to control data center temperatures, rather than just expanding cooling capacity. Teams should use containment techniques and filler panels to direct cool air so that it enters IT systems to prevent this. In addition to lowering the amount of cold supply air needed, this aids in maintaining control over input temperatures. To further track equipment performance and moisture levels, IT teams can look into integrated environmental monitoring.

##### 3) Identify the stranded power capacity.

Locating servers with unused power can help businesses increase the effectiveness of their data centers and reduce the waste of important compute. To find out if their servers have any spare capacity, IT teams can examine the CPU use of their servers. Once IT personnel identify the underutilized server capacity, they can integrate applications and servers and more evenly distribute the workload among the data center's hardware.

The benefits are:

- 1) It lowers the amount of paper as well as other materials used in the IT sector.
- 2) Bamboo is used in green manufacturing for computer parts and accessories. Furthermore, reused plastics are used in the construction of computers. So, it won't have as much of an effect on the ecosystem.
- 3) IT virtualization enables the use of several computer systems on a single physical hardware setup. As an outcome, energy and cooling operational expenses are decreased. Saving money is eventually a result of this.
- 4) By utilizing refurbishment, and recycling techniques, it reduces the need for equipment disposal.

The drawbacks are:

- 1) Higher start-up costs are required for the deployment of green computing.
- 2) Performance is sacrificed by green computing devices in order to extend battery life.
- 3) This adoption and success take years of work from consumers and companies.
- 4) Some of the strategies or procedures are still being tested.

#### Conclusion:

Although the cloud computing industry is growing quickly and is essential to the IT sector, we also need to consider the environmental problems that cloud computing may bring about. This is the idea for economizing and to save environment. GCC impacts to make a various change in the IDC energy usage. GCC's objective aids in lowering data center's power consumption. In this actual life GCC is very supreme in order to rapid decrease in e-waste disposal. The combination of green computing and cloud technology will endeavor to reduction of carbon pollution which also helps in making of an advantageous work environment. Energy must be conserved for use by future generations. The future generation of cloud computing technologies, in our opinion, will include green cloud computing as one of its core elements.

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