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Green Cloud Computing and Its Role in Reducing Carbon Footprint

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Abstract

Green cloud computing has been used in many sectors like the manufacturing sector, service sector and in the information technology sector. There has been tremendous technological development in the cloud management technology and in the due process some of the companies had made a significant impact and those are like Google, Azure and Amazon. This discussion has given the importance of the green cloud computing in reduction of the carbon footprints. The first section of this discussion has talked about the background about the research topic which is here reduction of the carbon footprints with the green cloud computing. The next part that had been discussed here is about the material and method section where the research design qualitative has been used. The research type that has been used is secondary and the data has been collected on the basis of secondary data collection method. After the material part the results section have been discussed and with respect to the topic where the important graph has been used and it had been interpreted with the topic. Finally, the discussion has been concluded with the brief discussion part which had provided all the necessary findings.

Keywords

Green cloud, carbon footprint, technology.

INTRODUCTION

Cloud computing in the modern technological era can be explained as the availability of the computer system resources like the storage of data and other power for computing and it should be on demand supply. In today's computing there are three four types of *cloud* computing and they are like the private clouds, public clouds, hybrid clouds and multi clouds [1]. According to the data storage capacity they are used by different entities as the data that are stored by the government is enormous and they definitely need a *cloud* which can store billions of information with proper security. Today, the computer has become the crucial part of the working sector whether it is the commercial or it is the service sector. Computers are used in each and every workplace exclusively also in the manufacturing industry for ensuring the quality [2]. Managing all these business operations the *cloud technology* can help to manage the useful data storage and can be accessed in future. Moreover, the *cloud technology* provides the agility and flexibility in the working process as well as it delivers the digital transformation which is vital for the business operation. Some of the popular *cloud* computing service providing countries is Host winds, Clouds, Hostinger, Amazon web services are the example of popular *cloud* services providing companies.

Green ***cloud*** computing is a term which basically refers to the benefits to the environment that will be provided by the IT services over the internet to the society. It can be implied in the process of the business cooperation and they are like purchasing the environmentally committed companies, should participate in the recycling of the electronics, using the virtual reality and augmented reality ***technology*** and limiting the use of the paper and use only recycled papers [3]. This is the whole concept of the green ***cloud technology*** and it is going to be key ***technology*** that will help many industries in future to become sustainable. Today there are many applications which help with paperless transitions like PayPal, Google Pay and other ***technology*** [4]. Today many of the IT companies have become paperless and all the work is done in the online workspace. The ***technology*** that has been providing these services is like the Google drive, Google sheet and all the products that are provided by Microsoft. If the working space will push its business process more and more paperless and the increase in online connectivity can help to reduce the use of the paper. In this way the deforestation can be minimized and therefore the ***carbon*** footprints can somehow be less. As the minimization has been minimal but at the same time it is important to take collective steps in all the domains so that the ***carbon*** footprints can somehow be reduced. The use of green ***cloud technology*** like virtual ***technology*** can also help a company to reduce the ***carbon*** footprints as each and everything changes that are made in the virtual world have no correspondence with the real world.

MATERIALS AND METHODS

The research design of the given research topic is qualitative research design and it has been chosen taking in consideration of the significance of the research topic. The given research topic is based on green computing and its role in reduction of the ***carbon*** footprints that have been created through various processes. A qualitative research design can be defined as the type of research design which focuses on obtaining the data from the conversational communication and open end sources. It does include some of the quantitative

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data and which will be used further which will be interpreted with the research topic not calculated.

Research type is the term that is often used to explain the significance of different methodologies that have been used for preparing a research study. There are various types of research type and according to the research topic the research type is chosen and taking in consideration of this research topic the research topic that has been used here is secondary research type [5]. The given research topic has included to show the significance of the green ***cloud technology*** in reducing the ***carbon*** footprints. It will need to study the concepts of ***cloud*** computing as well as green ***cloud*** computing. The best possible way to explain this will be the secondary research type hence it has been taken here in this research topic analysis.

For any of the research the data is the most important ingredient as without this any of the arguments cannot be made and it cannot be proved. Therefore, in this research the data has been collected on the basis of the secondary data analysis which includes the theoretical data collected from the research of others, journals, and books. After the data collection part the next part is the data analysis and in this research studies the data that has been collected is analyzed with the help of thematic data analysis method. Thematic data analysis is the type of data analysis method which is often used in the qualitative data analysis research type [6]. In this the data are basically analyzed with the help of preparing the themes based on the research topic.

Table 1: Inclusion and exclusion criteria

Inclusion criterion	Exclusion criteria
• Collected data has been analyzed with the help of thematic data analysis. • Authenticated and recent journals article have been taken for the research. • Both the research type and the data collection method being the secondary.	• Quantitative data analysis has been excluded from this research study. • Old and out-dated articles have been excluded from this research. • Primary data and research type has been excluded from this research.

RESULTS

Different Green cloud computing technologies and its significance in reducing the carbon footprints

Before actually explaining the green ***technology*** the first and foremost important which needed to be explored is the reason behind using the green ***cloud*** computing for the reduction of the ***carbon*** footprints. The most significant point that is often considered here is that it provides the most efficient resource for provisioning and offers de-materialized the overworking setup. Meanwhile, the green ***cloud*** computing ***technology*** has three main goals which it has aimed to achieve and those are to increase the efficiency of energy of whatever the device is used, promote the recycling of the materials and reduce the harmful components that are used in IT operations [7]. It can be of two different types: they are like the green hardware and the green software. Most of IT operation includes both the hardware and software and in hardware components, especially the hardware components include the servers, network appliances, storage devices. Along with all these cooling units, power supply units and other such components are included in the green hardware technology.

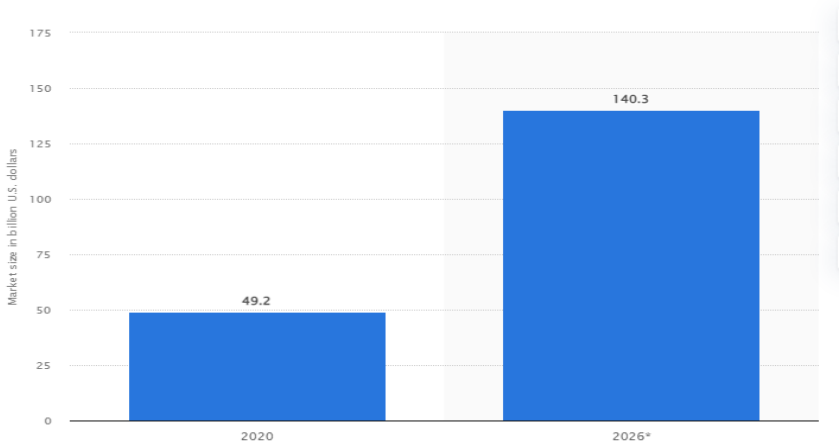

Figure 1: Global green data centre market estimation as compared to 2020 to the year 2026

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A graph has been provided in the above section and it is about the global green data centre and the estimation has been in the year 2026. Globally, the green data centre market is estimated to rise in future and hence to compete with the green ***cloud*** computing ***technology*** is useful. In the year the size of the overall market of the green data centre was 49.2 billion US dollars [8]. In the year 2026 according to statista the overall market size will be around 140.3 billion US dollars [8]. This can only be possible if the green ***cloud technology*** is used in the process of the business operation. Global ***carbon*** emission has been increasing day by day and the ***carbon*** footprints have also been increasing day by day. The global ***carbon*** emission has been explained in the figure based on various domains of the human livings.

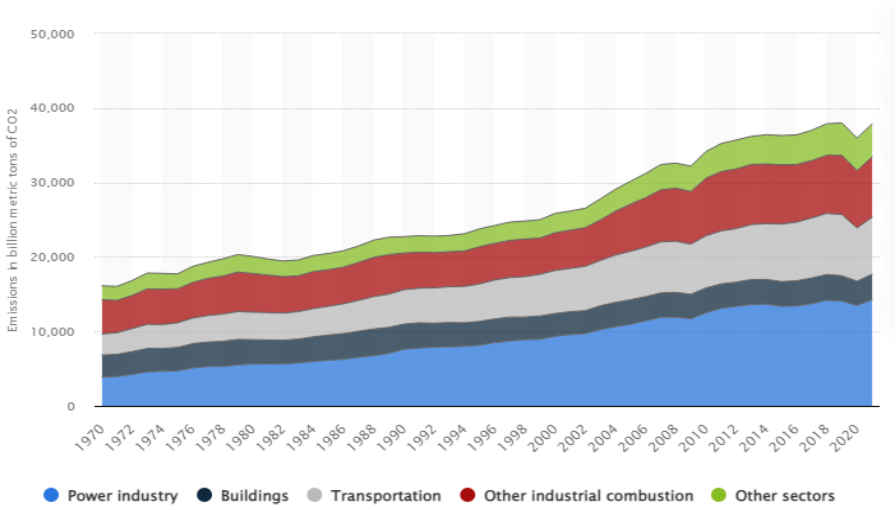

Figure 2: *Carbon* dioxide emission from the year 1970 to the year 2021 industrywise

As the graph that had been provided it can be said that the highest emitter of ***carbon*** being the power and energy sector after that the transportation and other industrial operation. In the year the annual ***carbon*** emission for the power industry was around 3879.6 billion metric tonnes but the figure has changed drastically in the last five decades and it had reached up to 14,258.8 billion metric tonnes in the year 2021 [9]. Power industry needs to work more and it can only be achieved through lowering dependence on fossil fuels as the primary source of energy and power generation. In other ***carbon*** forms the industries which are not based on fossil fuels like the IT sectors and the other technological sectors can become sustainable through policies which include the green ***cloud*** computing technology.

The green ***cloud*** computing technological tools that can be used to achieve sustainable goals are; virtualization, ***cloud*** optimization tools and ***carbon*** awareness among a larger population. *Virtualization* can be used in the data centre to reduce the electricity consumption in an enormous amount [10]. Up next is the ***cloud*** *optimization tools* which is often seen as the best to reduce the ***carbon*** emission from the process of the business. The best other sources being ***carbon*** aware and it includes taking the help from those service vendors who are well aware of the ***carbon*** and its reduction that is overall ***carbon*** awareness. These are the significance and importance of why the green ***cloud*** computing ***technology*** has been used in the current business atmosphere especially in the technological sector.

Recent developments of the green cloud computing and its future perspective regarding the reduction of the carbon footprints

Recent developments in the green ***cloud*** computing are making more and more developed ***technology*** of virtualization, reducing the usage of paper as much as possible, power management and green manufacturing. The importance of the paper reduction can be understood with the help of the globally paper consumption including the education sector, public as well as the private sector through various methods.

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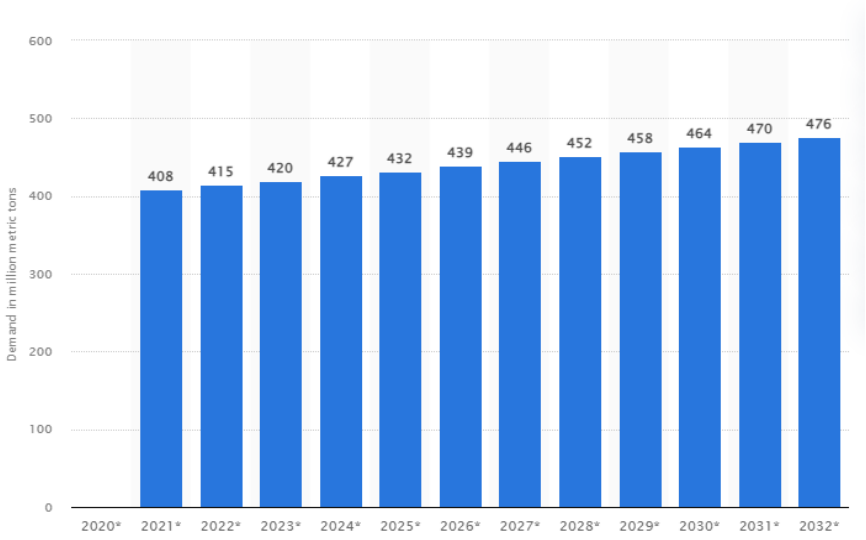

Figure 3: Global paper consumption from the year 2021 to the year 2032

In figure 3 the annual global consumption of paper and paperboard consumption by the companies as well as the other sectors which use. According to the year 2020 the total global consumption of the paper was 408 million metric tonnes at the same time the deforestation has also increased in the due years. In the year 2022 paper consumption was 415 million metric tonnes and this has been seen to rise further in future [11]. According to statista's projection in the year 2032 total paper consumption will be 476 million tonnes [11]. Hence, it has been clearly stated from the graph that in future the paper consumption would be increased. Therefore, here the ***cloud technology*** can be used to reduce those future possibilities with the ***technology*** of digitization and soft file rather than going with the hard copy of the document. Virtualization is yet another ***technology*** with the help of which the ***carbon*** footprints can be minimized as it reduces the use of excess hardware in the operation. In any computing ***cloud*** the role of hardware is important but at the same time these technologies have played an active role in ***cloud*** computing and made it green ***cloud*** computing. Virtual processes at the same time are cost as well as time efficient therefore the possession of virtualization is important.

The overall market size of ***cloud*** computing globally as of the year 2021 has seen a significant increase especially after the pandemic as during this period most of the workspace had understood the need of the IT services and clouds. According to statista in the year 2021, the overall revenue that has been generated by the ***cloud*** computing services was around 400 billion US dollars [12]. Moreover, worldwide IT services spend around 1.3 trillion US dollars and America is the largest country [12]. Most of the successful tech and IT giants are in the USA but slowly many other nations are also making tremendous investment in ***cloud*** computing ***technology*** are China and India. As the research and development regarding the ***technology*** of ***cloud*** computing has been going on in other nations as well and the demand for the green ***cloud*** in the future will also increase due to global ***carbon*** emission. In future for sustainability the most of the companies will be using the ***technology*** of the green ***cloud technology*** like the virtualization, reducing the paper and paperless translation and other process for promoting the green technology. In the future the green ***cloud*** commuting has focused on reducing reusing and recycling of the goods that are used in the business operation. In the future the society seems to be more curious about ***carbon*** footprints and therefore the ***technology*** will be explored and more development will be seen.

Global green cloud computing developments in various countries

Globally, there are more than 190 countries and there are further categories according to their technological developments. As it had been figured out that as for the majority of the global ***carbon*** emission the countries which are the most responsible are the western nations and still they are technologically advanced than the many of the emerging countries of Africa and Asia [13]. America is the world's largest country when it comes to the size of the economy and technological progress. Most of the green ***cloud*** computing technological companies is based in the USA itself like Microsoft, Google and IBM. Today Google has been providing its ***cloud*** and it has the capacity to store enormous amounts of data and its main competitors are Microsoft and Google.

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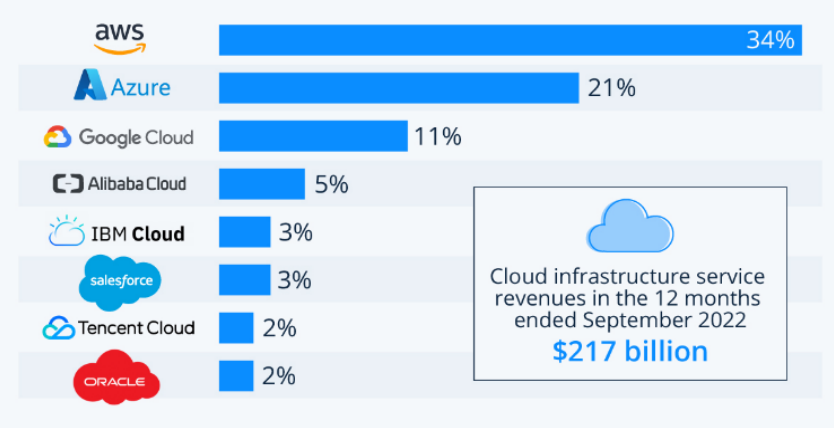

Figure 4: *Cloud* market Share Company wise

The figure four has been explaining the ***cloud*** market share of various companies across the globe which had been estimated to 217 billion US dollars as of the year 2022. The overall market share of the Amazon's around 34% and the company which is ranking in the second spot is Azure with 21% share [14]. After that comes the Google ***cloud*** with the market share of 11% [14]. Top four spots have been occupied by the US based companies and the fifth spot has been occupied by the Alibaba group. Amazon, Microsoft and Google are the three companies that have dominated the global ***cloud*** computing market despite the challenges that have appeared in the year 2022. The top eight companies that have been provided in the list have been controlling 80% of the market size [14]. During the time of pandemic and the recent geopolitical tension in Eastern Europe the growth has been projected to depreciate further but the company had somehow managed their growth and in the meantime it had grown by 24% [14]. This has been possible only because the process of ***cloud*** has aimed to provide more and more sustainable business processes. In terms of growth the Chinese company had performed more or less similar as it had performed in the previous year.

These companies have been operating globally and with their operation they have helped a lot in making the green ***cloud*** computing. These companies have however helped to boost the visualization process in those countries which have poor technological infrastructure and are still using the traditional methods in workspace. In the year 2021 the company had generated overall revenue of 19 billion US dollars which is 7% of the total revenue generated by Google [15]. At the same time the overall revenue that has been generated by the ***cloud*** of Microsoft Azure has generated overall revenue of 198 billion US dollars and its expenditure on its research and development is around 25 billion US dollars [16]. All these companies have played a key role in boosting green ***cloud*** computing and due to these reasons they are generating higher profits. Both Google as well as Microsoft have a clean and clear market image. Both the companies Microsoft and Google have made their process sustainable and due to these reasons green ***cloud*** computing products of these companies has become so much popular and it has been used in most of the workplaces. Hence with all these processes it can be said that green ***cloud*** computing can be very much useful in making the process more sustainable and reducing ***carbon*** emission.

DISCUSSION

These days the situation of climate change and ***carbon*** emission has been increasing day by day and each country wants to reduce their ***carbon*** footprints. There are many processes in which the ***carbon*** footprints can be reduced and like reducing dependence on the non-renewable source of power generation method and many more. Here, in this discussion the ***carbon*** footprints will be reduced by the green ***cloud*** computing. It is generally termed as the type of ***cloud*** computing which basically focuses on reducing the ***carbon*** emission by including the process like reducing the paper in the process, recycling of goods and visualization of the process. All of these are the important part of reducing the ***carbon*** footprints instead of the fact that much of the ***carbon*** emissions are generated through the process of power generation.

In the results section themes have been prepared on the research topic which is based on ***cloud*** computing, especially the green ***cloud*** computing and its significance in reduction of ***carbon*** footprints. ***Carbon*** emissions was never an issue during the time of 1970 as at that time the overall global ***carbon*** emission was 3879.6 billion metric tonnes in the power and energy sector but in the year 2021, it had become 14,259 billion metric tonnes of ***carbon*** only for the energy and power generation sector [9]. Contribution of other sources has been less as compared to the energy and power and therefore now it has become to minimize the ***carbon*** footprints. Green ***cloud*** computing has certain goals and these are to reduce the use of paper in the workplaces and recycle those things that cannot be reduced like using plastic. Single use plastic has use in many of the workplaces and it should be reduced. In the sales industry they have to prepare the bills and have to make the transaction through the offline mode. Using the green ***cloud*** computing the payment can be carried out easily through digitally. Digital payments have been carried all over the world and it has also played a key role in reducing the use of paper globally. Coming to the billing part the company had been encouraged to use certain

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types of software for preparing the billing or preparing the financial statements and those are like the Microsoft excel and Google sheet.

In the corporate sector today especially the corporations which are based on information ***technology*** have been performing each and every task in online mode. In these three companies namely Google, Microsoft and Amazon have outperformed in the market and they have been dominating the market. As per the figure that has been mentioned, the top eight companies have been controlling more than 80% of the market share [14]. In the second theme it had been discussed in terms of countries which are the companies which are huge emitters of ***carbon*** and how they are technological in the ***cloud*** computing ***technology***. It had been found that USA is the country that had performed best infrastructure in terms of ***technology*** of green ***cloud*** computing and ironically it is the country which ranks top in terms emitting the ***carbon*** dioxide. It can be understood with the help of the forth figure that has been given as major ***cloud*** companies are from the USA and Alibaba ***cloud***s the lone major ***cloud*** company of China.

CONCLUSION

Cloud computing has become popular in the workplace as it possesses certain benefits and those benefits are; it is fast and it is secure. It can hold a large amount of data at a time and it can increase the connectivity among the people who are either working in a workplace or working from a distant location. Green ***cloud*** computing is totally new and it has been introduced due to increasing ***carbon*** footprints globally. This discussion has focused basically on the significance of the green ***cloud technology*** in minimizing the ***carbon*** threats. In the introductory section the importance of the green ***cloud***ing modern day has been given. Today most of the workplace has been using the computer and it has become the backbone of the modern workplace. Programming, preparing the financial statements and planning a project for the future or present are some of the uses of clouds. For each of the processes the importance of computers has been increased and as its use has been increased the data has been increasing. Storing those data the ***technology*** of clouds was introduced and for sustainable practice along with reducing the ***carbon*** footprints it had been green clouds were introduced. Some of the popular ***cloud*** computing companies are Google cloud, Azure ***cloud***land Amazon's AWS has been used exclusively in the market. All the data has been collected from the website and only authentic data from recent data has been used.

One of the main goals of the green ***cloud*** computing is to reduce the paper consumption form the workplaces as according to figure 3 the overall consumption of the paper in the year 2023 is expected to 420 million metric tonnes which is higher as compared to the year 2020. The growth has been phenomenal in the coming year and it has been expected that if the figure goes in this way in the year 2032 the paper consumption will be 476 million metric tonnes. Therefore, by reducing the consumption using the green ***cloud*** computing ***technology*** can be helpful in reduction of the ***carbon*** footprints. Although the ***cloud*** companies of developed has been helping the emerging countries of Asia and Africa to reduce the ***carbon*** footprints. Finally, talking about the future perspective of green ***cloud*** computing, it will rise further in the future and the main reason is increasing ***carbon*** awareness among the people.

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