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REVIEW ARTICLE

Data Centre: An Accelerator for Climate Change in the Decade Ahead

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ABSTRACT
Data centre are the primary information and communication technology hubs playing an essential role in the growth of economy and infrastructure worldwide. Data centre count has increased from 500,000 in 2012 to more than 8 million as of now. In the present investigation, the explosion of data centres, the energy consumed, and the expected Co2 emission have been examined. We accomplish this by applying a life cycle assessment model that aims to quantify the environmental impacts that arise from material inputs and outputs, such as energy use or air emissions. We examined that the amount of energy used by the data centre is doubling every four years, which means they have the fastest-growing carbon footprint of any area within the information technology field. By 2030, the data centre's expected energy consumption may increase to more than 8 percent globally and may emit up to 5.5% of the world's carbon emissions.
Keywords: *Carbon footprint, Climate change, Data centre, Energy consumption, Power usage effectiveness.*

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INTRODUCTION

Data centre is a space where organizations store their business related critical applications and data. They are composed of components such as routers, switches, firewalls, storage systems, servers, and application-delivery controllers. These components are important to store and manage critical systems vital to the continuous operations of an organization. Data centres are important to economy and infrastructure growth because they provide productivity applications, customer relationship management, storing and analyzing big data, artificial intelligence, and machine learning applications. They also help in virtual desktops, communications and collaboration services, email, file sharing, Enterprise resource planning and sharing and creation of databases. Currently, four main types of data centres are prevailing: first is enterprise data centres that are built owned and operated by companies and are optimized for their end users, Second is managed service data centres that are managed by third party for the company, third is collocation data centre which hosts the infrastructure: building, cooling, bandwidth, security, etc., while the company provides and manages the components, including servers, storage, and firewalls and lastly fourth one is cloud data centre where data and applications are hosted by a cloud services provider such as Amazon Web Services (AWS), Microsoft (Azure), or IBM Cloud [1]. Their size varies from single rack in a server to big server farms of size as 7.2 Million Square Feet. Data centre consume approximately 2 percent of the electricity used globally, and it is expected to reach 8 percent by 2030. Moreover, only about 6 percent of all data ever created is in active use today, according to research from Hewlett Packard Enterprise. That means 94 percent is sitting in a vast "landfill" with a massive carbon footprint [2].

Industry research company, International Data Corporation (IDC) puts the average age of a data centre at nine years old [3]. Gartner, another research company, says data centre older than seven years are

obsolete [4]. The growth in data (163 zettabytes by 2025) is one factor driving the need for data centre to modernize [5].
The global warming caused by humans may reach 1.5 ° C compared to the pre-industrial age by about the year 2040 [6].Therefore, one can assume that global warming will reach a higher level in the next decades, and that the consequences will be correspondingly serious.
17 percent of the total carbon footprint caused by technology usage is due to data centre. The electricity/energy needed to run these data centre is approximately 30 billion watts. These servers waste 90 percent of the energy they use because they run on full capacity for twenty four hours [7]. Electronic waste is generated when data centre dispose off their obsolete hardware equipments like server, storage, and networking equipments. Approximately 20 to 50 million metric tons of E-Waste are disposed of globally every year depositing heavy metals and other hazardous waste into our landfills [8] and are expected to grow 8% each year. This huge energy consumption and e –waste generation is contributing green house gas emission.
In the present study we have estimated the growth of data centre, energy consumed by power usage effectiveness metrics, and correspondingly the green house gas emission during entire life cycle of data centre. We have not considered the contribution made by e –waste since it is very difficult to estimate the exact amount of carbon footprints due to a lack of data on the locations of the vast majority of global data centre and the emissions intensities (measured in grams CO_2 per kilowatt-hour) of their actual electricity sources.

MATERIAL AND METHODS

- Life Cycle Assessment of data centre was performed to study potential environmental loads and resources consumed. We characterized all the power inputs and outputs over a data centre's life cycle such as energy use or air emissions, and evaluated the results considering the life of the data centre as of six years.

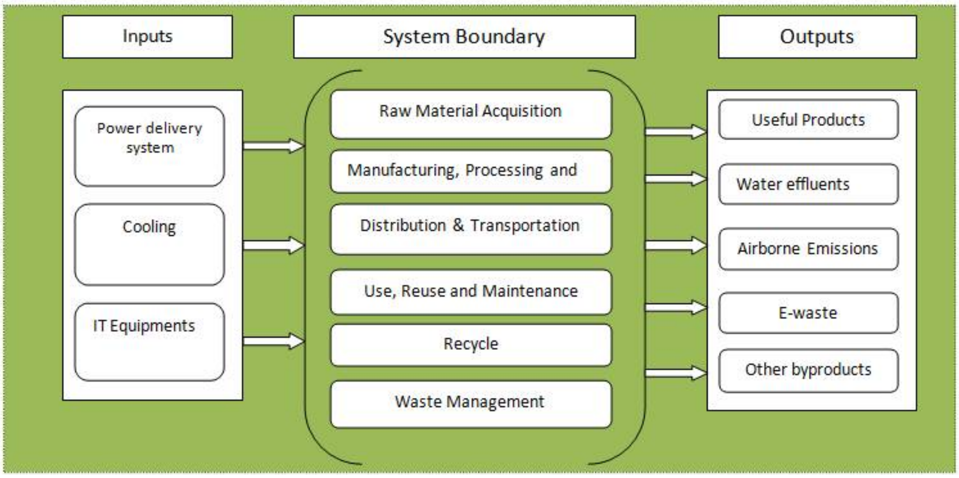

Figure 1 Life cycle assessment model of data centre

- Data centre metrics for power consumption comparison applied is power usage effectiveness (PUE) also known as energy efficiency metric of data centre; it is calculated as the ratio of total power entering the data centre divided by the power used by IT equipment.

$$PUE = \frac{Total\ facility\ power}{IT\ equipment\ power}$$

A data centre has power usage effectiveness rating of 1.2 or less. PUE rating of 1.0 would mean 100 percent of the facility's energy consumption went to powering the IT equipment. Anything above 1.0 represents additional energy spent in cooling, operations, and other non-IT energy consumption.

- We conducted a survey based on a secondary data from various sources, case studies of IT companies, NGO's, research projects, news papers and internet to capture the growth of data centre from last ten years and the increase in green house gas emission.

RESULTS AND DISCUSSION

Factors playing important role in determining a data centre's carbon footprint are location, IT load, and electrical efficiency. IT load reflects the power consumed by the electrical equipment in a data centre, and electrical efficiency varies with the running equipment on 24 hours basis. Therefore while quantifying the

environmental impacts that arise from IT load inputs and outputs, such as energy use or air emissions, over a data centre's entire life cycle based on two scenarios, we evaluated that if the data centre location is in India and in the first case the electricity used is generated from fossil fuels and the IT load is 100 kW then PUE is 2.50, in the second case if the electricity used is generated from wind or solar power or another alternate mechanism then IT load is 60 kW then PUE is 1.50.
The consequent total input power, annual electrical energy, annual Co2 footprint, and Equivalency in cars are given in table 2. If the IT load is increased to 10000 kW, then PUE is 2.50; in the second case, if the IT load is 50000 kW, then PUE is 1.50, and the consequent total input power, annual electrical energy, annual Co2 footprint, and Equivalency in cars is given in table 3. If we change from case 1 to case 2 over time using green fuel, then the subsequent reduction in possible Co2 emission per year will reduce to 260917 tons annually. There will be equivalent to 57521 fewer cars on the road [9].
We observed that if the electricity used by a data centre is generated from wind or solar power and seawater is used for cooling electrical equipment. It leads to lesser Co2 emission as compared to the use of electricity generated by fossil fuels. PUE value equal to 1.5 is efficient, and less than 1.5 is considered very efficient, as the PUE increases carbon footprint also increases. If we consider the data centre's life cycle as of six years, the Co2 impression rises to 16.66 percent.

Table 1. Comparison with low IT load

	Case 1	Case 2
Total input power	250 kW	90 kW
Annual electrical energy	2190,000 kWh	788400 kWh
Annual Co_2 footprint	2,188 ton	788 ton
Equivalency in cars	482	174

Table 2. Comparison with high IT load

	Case 1	Case 2
Total input power	25000 kW	7500 kW
Annual electrical energy	2190,00000 kWh	65700000 kWh
Annual Co_2 footprint	2,18781 ton	65634 ton
Equivalency in cars	48232	14470

Alternatively, we observed that the data centre load is not static since the life of IT equipment used is varying and changes during the entire lifetime of the data centre. On average, one server can use 850 watts per hour; then, per day, it consumes 20400 watts, 20.4 kilowatts (kWh), and per year 7,446 kWh [10]. Considering the server's power consumption based on electricity generated from fossil fuel and no other source such as gasoline, diesel, and natural gas have been taken into account. So, the Co2 emission is Input value /year* 0.85 (emission factor) = output value (kg of Co2)/1000. It is approximately 6.329 tons of Co2 [11]. Considering the server's life as six years, it contributes 37.974 tons of Co2 during its entire lifetime.
The size of the data centre varies from 5000 sq ft to 7.2 million sq ft. Area wise the top ten data centres in the world are mentioned in table 3[12].

Table 3. Area wise top ten data centre in the world (Source- racksolutions.com)

S No.	Name & Country	Area
1	The Citadel – Tahoe Reno, Nevada	7.2 Million Square Feet
2	Range International Information Group – Langfang, China	6.3 Million Square Feet
3	Switch SuperNAP – Las Vegas, Nevada	3.5 Million Square Feet
4	DFT Data Centre – Ashburn, Virginia	1.6 Million Square Feet
5	Utah Data Centre – Bluffdale, Utah	1.5 Million Square Feet
6	Microsoft Data Centre – West Des Moines, Iowa	1.2 Million Square Feet
7	Lakeside Technology Centre – Chicago, Illinois	1.1 Million Square Feet
8	Tulip Data Centre – Bangalore, India	1 Million Square Feet
9	QTS Metro Data Centre – Atlanta, Georgia	990,000 Square Feet
10	Next Generation Data Europe – Wales, UK	750,000 Square Feet

There may be fewer to 80000 servers in each data centre. The tremendous expected growth in Annual global IP traffic is more than 3.3 zettabytes by 2021 in view of the ongoing COVID 19 pandemic. In 2016, international IP traffic was observed to be 1.2 ZB per year or 96 exabytes (one billion gigabytes) per month [13]. It is expected to increase nearly threefold over the next five years, and already have increased 127-fold from 2005 to 2021. The global data centre market size is expected to grow with a compound annual growth rate of 6.9% from 2019 to 2025 to 11% from 2017 to 2023[14, 15]. Global data centre electricity usage likely rose by only 6 percent between 2010 and 2018 [16], and we expect it to rise more by 2021. In an 'expected case' projection from Anders Andrae, ICT grows to only 8% of total electricity demand by 2030 [17]. Accurate carbon footprint calculation is not possible due to the non-availability of data by organizations of their data centres and emission intensities except a few like Amazon and Google.

CONCLUSION

Making data centre energy efficient should be an ongoing process for climate protection. In estimation, the data centres are likely to grow with a compound annual growth rate of 6.9 % to 11%. With this, the expected increase in global electricity consumption may increase by 8 % by the year 2030. This may increase the global carbon footprint by 5.5 % alone by data centre. The operational efficiency, hardware efficiency, infrastructure efficiency, and exploiting renewable energies sources should be looked upon to neutralize carbon emissions.

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