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Worldwide energy consumption of hyperscale data centers: a Survey

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Abstract

At present, in the whole world from developed countries to third-world, digitization has taken place in society and economy with great intensity and also being adapted by a common person as his/her normal daily routine. Due to this huge amount of data is being processed and stored in data centers. Based on earlier studies, it has been observed that, Due to the overload of data & traffic, data centers are consuming more energy than any other setup. Energy consumption of hyperscale & mid level data centers increasing continuously from the very beginning of their setup. As the demand of energy is growing, so the need of production and expense on energy is also growing in energy demand in future (at-least one decade). In this paper one of the topics specially related to the improvement of energy efficiency through IT software has been taken. And a method has to be established whereby all the data centers with different geographical locations can have fewer loads on power sources and they can take advantage of low cost energy and hence will be able to operate even less.

Keywords: Big Data, Hyperscale Data Centers, Energy Consumption, Energy Efficiency, Hadoop, Map-reduce.

1. Introduction

As we have seen during the worst phase of Covid-19 period in 2020, demand for data in different fields like video streaming, Social Media, Artificial Intelligence, Business processes and education has increased many fold and is continuously growing. Big Data has come-out as big support to fully fill this growing demand of data worldwide. Due to this increased storage and processing demand, capacity of Data Centers has grown many folds, so the energy consumption also.

According to an analysis by IT Company Cisco, from 2016 to the present 2020, work load was measured at 2.3 times more computer intensive. And the worldwide capacity of data centers has become more than doubled. Due to which data

storage capacity is also increasing as a factor in data messages. Due to which, about 4 to 2.6 ZB are occurring in the period. Is this excessive demand in computer processing and storage capacity, the reason for the increase in energy consumption?

As Andrae/Edler suggest, for example, predict a 15-fold increase in the energy consumption of data centers worldwide between 2010 and 2030 [1-5], Shehabi et al., found that the energy consumption of data centers in the USA has stabilized in recent years due to increasing energy efficiency[6-10]. Yet according to earlier studies of wide range energy consumption of data centers in the USA has stabilized. In the coming 10 years, with the help of a comprehensive structural model of the authors and data centers, energy comebacks at data

centers are discussing a development. Using this scenario, the present subscription addresses the following examinations:

- How energy is being used in data centers and their individual components developed between 2010 and 2020?
- What are the research results of the energy consumption of data centers on development works compared to the world-wide energy consumption?
- In what ratio different components of data center setup consume energy?
- What are the current statistics that affect the energy consumption of data centers?
- How can the energy consumption of data centers will develop up to the year 2030? What forecasts are likely?
- What are the particular challenges for energy-efficient operation of data centers in the future?
- What could be the possible immediate solutions to reduce energy consumption by data centers?

The analysis presented in this paper and the results derived from them are designed as project work. In which we discuss energy consumption of professional data centers and proposed methods to optimize energy consumption through various means of research.

systems also have an important contribution in the infection of data centers, which is designed keeping in mind various sections like air conditioning and power supply and UPS etc. Also, we have taken into account the world-wide energy consumption comparison from 2010 to 2019 depicting the scenario of energy consumption of hyperscale data centers. After this we have depicted the forecast by various sources about energy consumption of hyperscale data centers world-wide by the end of 2030.

Taking into consideration these forecasts, suggesting solutions at software level to reduce energy consumption. Hadoop processing is also discussed in conjunction with the Big Data process to design efficient algorithms to reduce processing steps and time by using Map-reduce optimization.

2. Methodology

This paper deals with the energy requirement of data centers. In this, the conclusions of many

international studies have been taken, comparing various authors with their own calculations. This calculation gives the form of a comprehensive structural model in the data center environment. Through this model, various data centers are depicted by different units such as server-installed rooms, building area or related whole area server shelves. In which communication physical servers have been installed. Standalone servers are also calculated based on their energy requirements. Data center is developed by a specialized (data center) IT equipment (server storage network) along with storage capabilities. In this model server storage structure, its different operating states, keeping in mind the energy requirement of different server types.

A part from this, many other energy related various sources in particular have been used to perform estimations:

- Various consultations with market research organizations on data server storage and market development for various components of the network.
- Market Research for Server (Storage) and Networks in Europe Market development of data of various institutes and ITOs.
- To provide scientific manufacturer information on energy consumption and development for the highest efficiency technology of various data centers for server storage and network products.
- Development of consumption related to electricity in various studies, important methodology by Vader Step on behalf of Federal and Economics, Ministry of Energy.
- Various models have been detailed by various international publications in the papers (1 – 22).

3. Energy consumption by different components of hyperscale data centers worldwide

Energy Consumption of Hyperscale Data Centers In various resource studies, we have found that despite lower improvements in the energy efficiency of data centers, the 32% increase in energy consumption between 2010 to 2019 is mainly due to IT Hardware infrastructure in data centers. The number of consumption and various performances has also increased. Which has

around 4.38 billion servers in 2019, about 18% higher than in 2010? The use of IT hardware for data storage and network technology greatly increased in number of data centers between 2010

and 2019, almost doubling the number of hardware. This increase is shown as the growth of data centers by number.

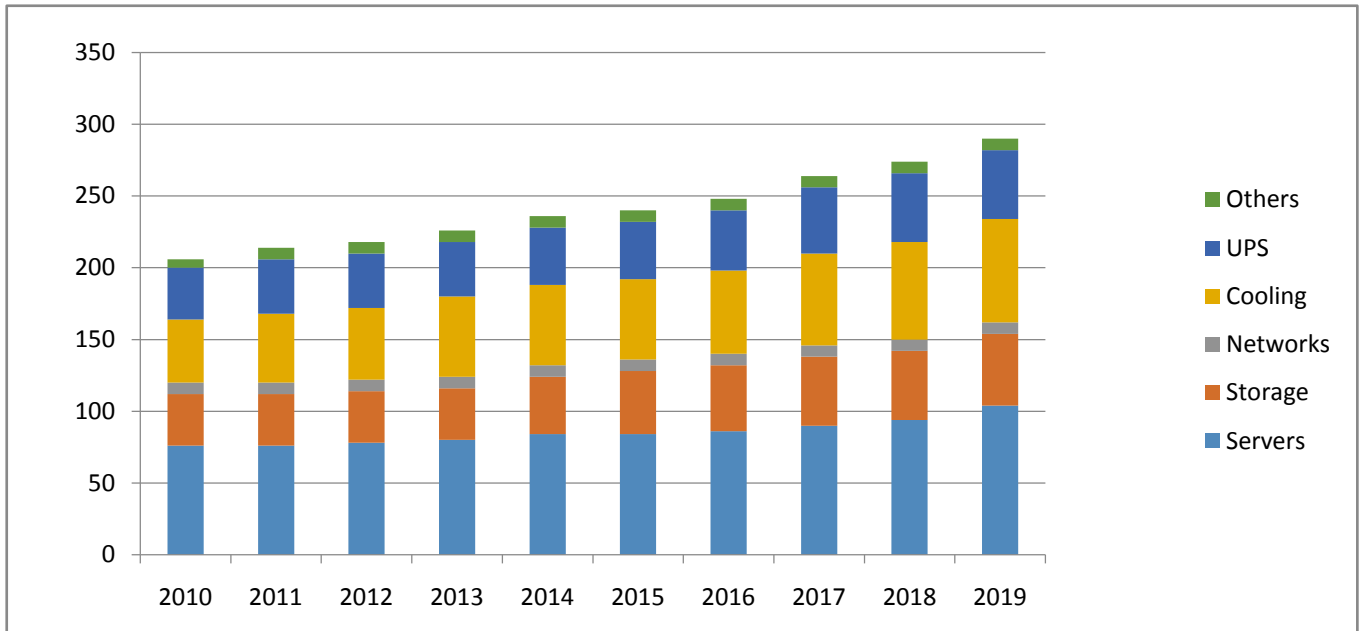


Fig.1. Energy consumption by different components of Hyperscale Data Centers in the years 2010 to 2019 (Source: Research gate)

The result of such growth is that the consumption of IT power in the data centers as power has increased from 5.8 billion KWh in 2010 to 8.3 billion KWh in 2019. In contrast, power consumption in the data center infrastructure has increased slightly from the devices installed in it.

The increase in energy consumption from 4.7 billion KWh in 2010 to 5.3 billion KWh in 2019. This increase has been found to be equal to the average increase in the structure and mass efficiency of the data center.

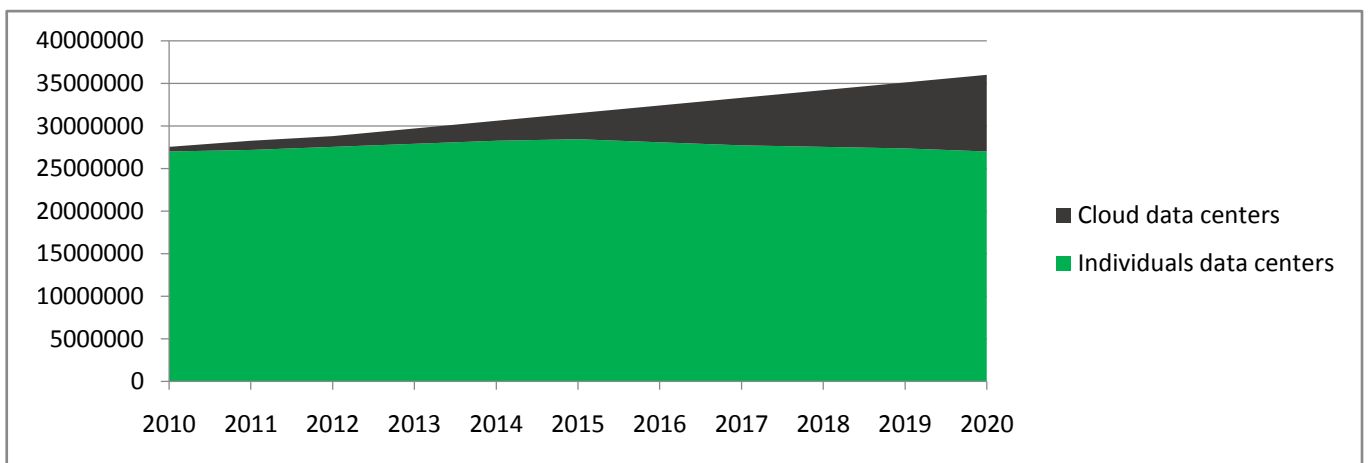


Fig. 2. World-wide data centers to develop IT area of cloud data centers and Individual data centers in the years 2010 to 2019 along with forecast to 2020 (Source: Research gate)

4. Energy consumption facts of hyperscale data centers worldwide

The energy composition of data centers and many scientific studies in Europe and throughout the world assess the energy consumption of data centers. In the following topics, various results of the selected studies have been summarized. And has drawn relatively high levels in the discussion about energy consumption that has been compared. This is due to the fact that Andrae/Eidler anticipated an increase in energy consumption. In this environment, according to their calculations, the energy consumption of data centers around the world is about 15 to one factor larger. Since 2010, around 3000 billion KWh 2030.

An update of calculations and forecasts was published in early 2019, which looks quite different from 2015. By the year 2030 the energy of data centers worldwide has increased by 1,929 billion KWh. For the year 2018, it is estimated that there has been 211 billion KWh as against 539 billion KWh from 2015. Some publications also believe that the energy requirements of data centers have increased significantly. Worldwide energy demand for data centers is considered high and an annual growth rate of 10% is projected by the year 2020. This growth rate has been

determined by the market research company. 659 billion KWh of energy expenditure as a result of data centers worldwide in the year 2018.

According to W. van Heddeghem et al, about 240 KWh derived from the calculation of the worldwide energy consumption of Arab data centers. No less than 270 billion KWh are required in 2012 [21]. Bitterlin posits that worldwide data centers require 416 billion KWh of energy. According to Borderstep Institute estimates, between 2010 and 2015 the energy consumption of server data centers worldwide has grown by about 30% to 287 billion KWh. This growth is once again large in the last two years.

According to a current project, between 2015 and 2019, energy consumption of data centers worldwide has increased almost. Which is shown in 20% to 350 billion KWh Figure 3. Increased digitalization and new applications such as bitcoin big data have sometimes been used as reasons for this accelerated increase in energy consumption with very high energy demand. There is little accurate information on energy consumption, it can be said that between the start of the year 2017 and the end of 2019 the worldwide energy consumption of this application has increased by more than 30 billion KWh[4].

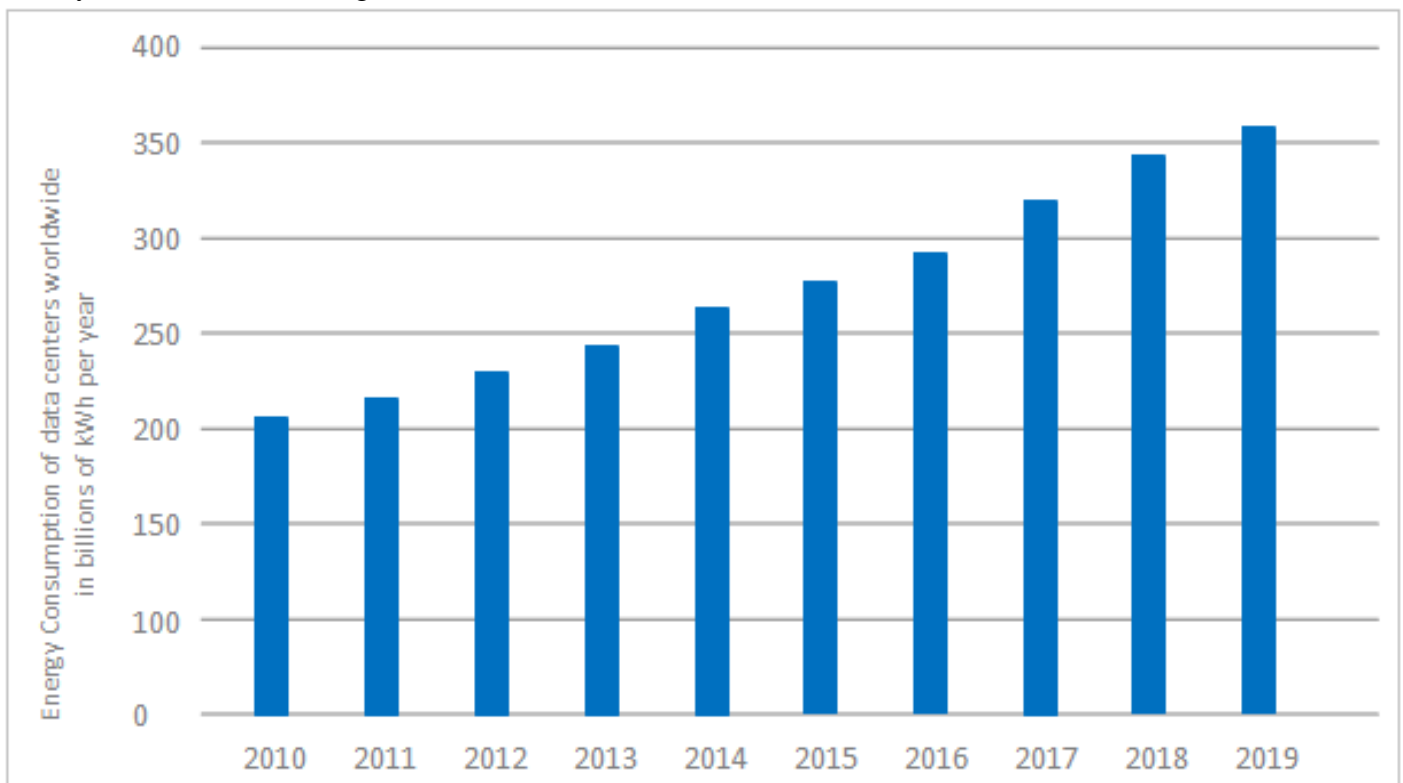


Fig. 3. Energy consumption of data centers worldwide in the years 2010 to 2019 (Source: Research gate)

In the USA, the energy consumption of data centers has hardly increased since 2010, according to a calculation by Shahabi et al., And an estimated approximate state of energy consumption of 70 billion KWh has been found in 2014. 67 billion KWh in the year 2010. Infrastructure is designed with a general improvement in the energy efficiency of IT systems in the form of small increases in the United States and lower PUE values. There has been a significant change in the power of particularly efficient hyperscale data centers of 1.2 [6], [10] in its computing power.

The basic structure of Shehabi et al.'s model is comparable to that of the Borderstep Institute. Therefore, it was possible to carry out a detailed comparison of the different model parameters. The differences in the developments can essentially be attributed to two factors.

The results of various studies on the energy consumption of data centers in Europe are relatively similar. The Eco design Preparatory Study on Enterprise Servers and Data Equipment determines energy consumption of 78 billion KWh for data centers in Europe by 2015 [11]. According to estimates by Borderstep, energy consumption of data centers in Western Europe also rose significantly between 2010 and 2019. Based on data on the development of workloads and server numbers in data centers of the IT company Cisco [15], [17], the authors assume that energy consumption has increased from 56 billion KWh in 2010 by a good 30% to 73 billion KWh in 2019.

In summary, the various studies on the development of the energy consumption of data centers do not provide a uniform picture. While some studies, e.g. Andrae/Edler, assume a very strong increase, other studies assume low to moderate growth in the last ten years. However, the energy efficiency of the data center infrastructure and thus the PUE values have improved significantly in recent years, and the share of IT components in the energy consumption of the data centers has thus increased.

5. Discussion: worldwide energy consumption of data centers future forecast?

According to all the presented results, even at this time there are huge uncertainties in determining the energy consumption of data centers worldwide.

The forecasts for the year 2020 are even more difficult due to unclear development of technologies and the services provided by the data center will be used in future. In particular, the potential end of efficiency advances, and such future energy consumption, may increase significantly.

If seen, thus the end of the huge increase in the efficiency of the data center [3]. This is a major reason for the increase in energy consumption in their scenarios. It can be discussed that technological development has reached very close to the physical limitations of traditional CMOS silicon technology. Currently the structures include only a few atomic layers. Leading companies such as Intel and AMD hope, however, that alternative materials and 3D architectures are likely to contribute to further enhancements in performance and reliability, albeit with smaller structures. The termination is unlikely to result in changes in the energy efficiency of computing operations.

Another reason for the significant increase in energy consumption in this model is that the performance of data centers is determined by the IT traffic between the user and the data center. According to Cisco's forecast, it increases by 23% annually [7]. If the perception of the performance of a growing data center is chosen in this way, based on the number of workloads and counts as a measure, then the calculated increase in energy consumption in the model will be lower.

Currently averaging 18.6% [1] based on workload and number of calculations, according to Cisco, the annual rate is increasing. In order to illustrate the difference between different analyzes, different forecasts of energy consumption of data centers in the world through different data is visible. The selection of studies allows the presentation of developments up to the year 2030. According to the investigation of André / Adler [14], R. Hintemann [16] has given an "important case". The use of the Andre / Adler model would be very appropriate for this development. Accordingly, according to Borderstep's calculations, the trends in the development of worldwide energy consumption of data centers between 2010 and 2019 will remain the same until 2030.

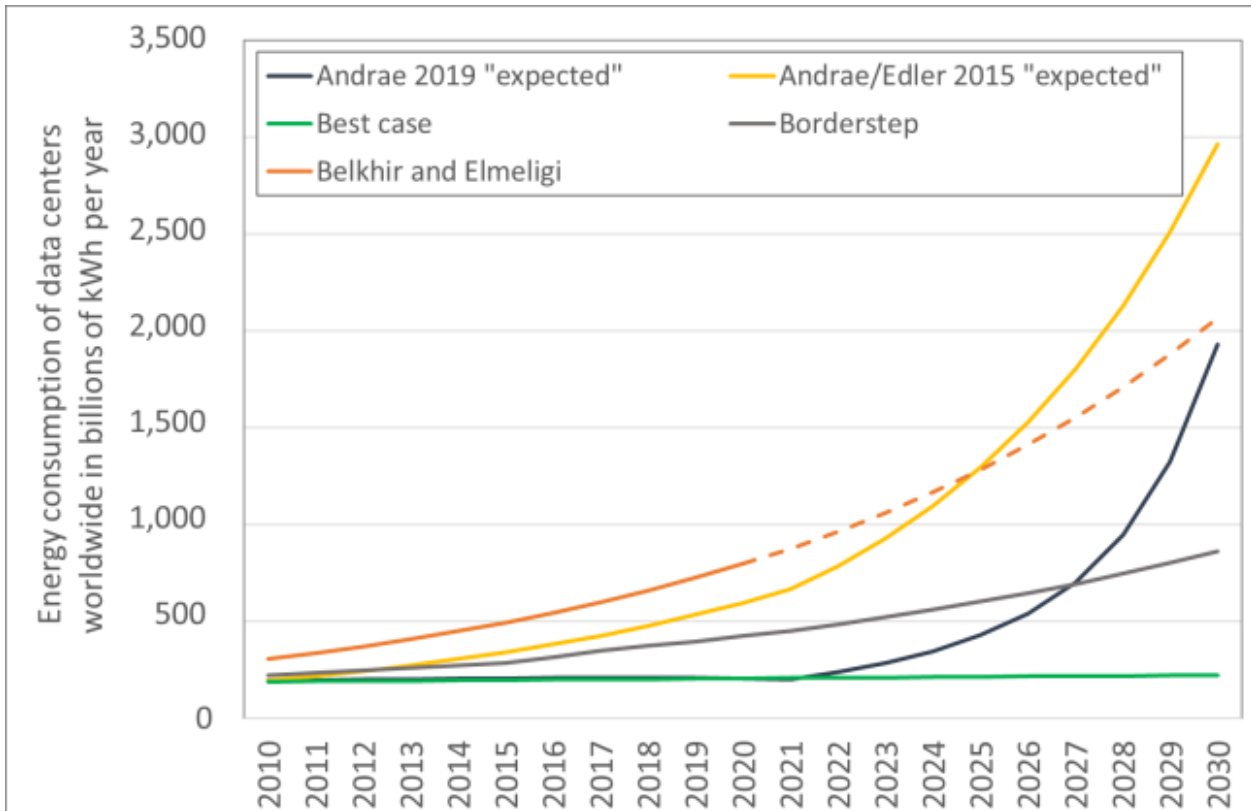


Fig.4. Energy consumption of servers and data centers worldwide – forecasts to 2030

All forecasts suggest that data centers will have a wide range of potential future developments in energy consumption. In the "advanced state" the energy consumption of data centers can be largely constant. Andre 2019 and Belkir / ElMeligi expect an energy consumption of approx. 2000 billion KWh 2030[18]. If the current events set by Borderstep remain the same, then it will not be wrong if the energy consumption of data centers is doubled by 2030 compared to today.

Whereas, analysis of development makes one thing clear that energy-efficient operation of data centers holds great importance in future. Already, the challenges are constantly changing. So this will be the reason for discussion in the following section.

6. Future provocation: how to develop energy-efficient it hardware and software

Based on previous studies, the PUE values of data centers are increasing continuously. The reason for this is that data centers' infrastructure is becoming smaller in energy consumption of data centers. Looking to the future, efforts to improve the energy efficiency of data centers will have to focus even more on IT components. Further

improvements in IT hardware, energy efficient software and efficient software deployment such as virtualization and container technology are providing opportunities for model optimization.

In this way, the use of artificial intelligence to improve efficiency in new technologies such as asnuro morphic processors or data centers also provides high efficiency. Almost all future potential improvements in the efficiency of IT components and infrastructure are taken into account if almost everywhere, the electricity used in data centers is converted into heat and then released into the environment - mostly ventilation. And additional energy has to be used for cooling. The predominantly Sweden example suggests that under centers it is possible to use waste heat from data centers. In view of the increasing energy consumption of all data centers, the topic of the use of waste heat will play a central role in the future [18]. There should be different solutions here. This will depend on both air-cooled and new innovative liquid-cooled IT systems. In India and across countries as well, there is a need to change the design conditions to promote the use of waste heat in data centers. So far, electricity prices in India have been so high that the operation of heat pumps that can increase the waste heat level of

data centers to a useful level is not the same.

Environmentally, the reason for another future challenge for data center operation is the large-scale power supply generated from various sources because it is limited to continuously available power supplies from hydropower or biomass. This indicates that fluctuating wind and solar energy usage in data centers is becoming increasingly useful. Therefore the promising technical approach of the author [1], [19] is very optimistic. In this view, it should be magnified.

But this whole process will take its place in coming time (may take 5 to 10 years). So what will be the immediate solution to this problem? There is one area which may give us immediate solution. Change in IT software. Every data center process trillions of statements, which is composed as algorithm. So if we make changes in algorithm to optimize processing of instruction, it may greatly affect overall energy consumption of computer, may generate less heat, need lesser cooling and cut in some hardware. This will be achieved by changing algorithm in Hadoop processes by Map-Reduce technology.

Conclusion

This paper considers the evolution of consumption regarding the energy of data centers, and the results of all studies are presented. While various studies have acknowledged greater or smaller increases in energy consumption of data centers in recent years, estimates of absolute amounts of energy consumption and increases in energy consumption have been found to vary considerably.

Forecasts for the future energy consumption growth of data centers are even different. This article summarizes and discusses potential scenarios for energy consumption of data centers around the world through 2030, with energy consumption remaining stable up to over 40%.

From previous studies, this seems likely to further increase the energy consumption of data centers, based on uncertainty and variance. For this reason, improving energy efficiency is very important. The focus has also been on improving the energy efficiency of IT components in the future, as cold and uninterrupted power supplies have already been obtained for this significant improvement. So that the energy efficiency of data centers cannot be directly affected, its

operation will become even more important in the future.

Looking to the future, it can be said that, the focus of sustainable data center operation is the only means of energy requirements that will shift to different categories. Based on the initial approach, to consider the development goals of the United Nations, today also exist.

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