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## Implementation guidelines for green data centres

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### Abstract

Increased reliance on technology and online transactions has increased the heat generated in data centres, due to greater access, storage, aggregation and analysis of such data. This paper discusses the downsides of traditional data centres and highlights the importance of applying green IT practices. It explores the benefits and proposes guidelines on shifting to green data centres. The recommendations to go green are to: a) reduce energy by applying green IT practices, b) eliminate redundancies in server systems and cooling modules, c) turn on power management tools on servers and terminals when applicable, d) utilise newer technologies of power consumption and e) minimise internal barriers to establish a good energy management policy. The benefits expected from the proposed approach are minimised pollution levels and lower the cost of activities, among others. The findings of the study will also contribute to face the challenge of global warming and help in better management and control of power consumption.

Keywords: Traditional data centres, green data centres, green computing, emission.

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## 1. Introduction

In the IT infrastructure, data centres are an essential element for the business functioning of large-scale enterprises. Any business that generates or uses data in large volumes has the need to build data centres. There is no way to ignore the importance of the data centre, as it is critical in business processing. In this context, any interruptions in the data centre can bring the business operation down in the absence of a backup plan [1].

A data centre is a facility that gathers all the components of the hardware and software equipment for the IT operation, wherein it stores, manages and processes the data. In addition, it is a house of networked vital systems that are always used for daily operations [1].

Online services and facilities that are provided to customers result in generation of huge amounts of data for processing and storage. Individuals working at these centres also contribute to this large data, since a lot of digital activities are conducted by a third party. However, the responsibility lies more with the companies for dealing with the impacts of the information inflation in data centres. According to a recent study, a single data centre consumes more power than a medium-sized town [2]. In 2015, the amount of data generated was double than what it was in 2012; it reached 2.8 ZB. With the massive amount of data and its continual growth at a high rate, concerns are being raised about the energy consumption and the impacts on the environment and enterprises.

The high power used by data centres becomes a challenge due to the cost as well as the environmentally hazardous effects. The power used does not only mean the energy for operating the data centre but also the energy used for the cooling process. Thus, the more the power used to run a data centre, the more the power required to cool it down. Besides the high cost, emissions of greenhouse gases and the overall footprint will increase [3]. There is no doubt that data centres are playing a myriad of functions nowadays, and eliminating all the problems created by them is impossible. In this regard, data centres can be eco-friendly by ensuring that they use green sources of energy such as wind and solar energy.

Green computing involves the use of computers in a way that does not pollute the environment. Resources used through green computing methods involve the use of eco-friendly sources of energy; the disposal of computer wastes also does not harm the environment. Green data centres use computers that consume less energy and hence cause less pollution to the environment. An eco-friendly environment can also be achieved by ensuring that the materials used in the data centre are recycled whenever possible [4]. Data centres should also deal with suppliers who adhere to the environmental standards. This ensures that the whole chain of green data centres does not pollute the environment [5]. In addition, it will contribute to the fight against global warming, which is a great challenge in the modern world.

This research aims to discover the new ways and practices to be followed to go green in data centres. It highlights the challenges in using traditional data centres and the importance of applying green IT practices (Section 2). Moreover, it shows the impacts of big data centres on the organisation and the environment. Section 3 illustrates the advantages of implementing green data centres and its challenges. Furthermore, it demonstrates the best practices and approaches to shifting to green data centres. In Section 4, we propose guidelines and instructions on how to start shifting into a green data centre. The benefits of implementing the guidelines in enterprises are shown in Section 5. Finally, the summary and conclusions are given in Section 6.

## 2. Challenges of Traditional Data Centres

Current developments in information technology and the significant progress in inventions lead to generation of data by huge amounts for processing and storage. Thus in turn makes data centres to be one of the highest energy consumers in the world. Current energy indicators show that businesses are

involved in the bulk of energy consumption and carbon footprint [6]. This brings us to the importance of going green in data centres and the benefits to the business as a whole and to the environment. Although crucial, shifting to green data centres may not be easy, and seems to be a daunting and complicated task. Laws and regulations should be set for businesses to be more responsible with energy usage [3].

Polastre [7] estimated that there are around 4.75 million servers that are not actively used for daily operations. However, managing and running these servers cost approximately \$20.7 billion, and consume \$3.7 billion in energy cost. Furthermore, \$21.4 billion is wasted on maintenance, energy and cooling the unused servers, which is a huge loss.

### **3. Benefits of Green Data Centre**

Implementing green initiatives in data centres will lead to reduction in carbon emission, effective and efficient operation and will eventually help to reduce the overall cost. This can allow the money to be spent for further growth and development of the company. Every organisation has the goal of achieving a lower cost so that it can remain profitable. Data centres also aim to lower the costs of operation.

The green way of building data centres will improve the efficiency of energy, power usage, cooling, and lighting systems. It mainly increases the company's management and controlling abilities over power consumption. Consequently, a superior power capacity will lower the time of equipment failure due to power [8]. Data centres also aim at achieving a better way of managing the data they have. They need to ensure that data are never lost and can be accessed easily whenever needed. This ensures that the services delivered to customers are of better quality. Having green data centres makes them sustainable, considering that renewable sources of energy can never be exhausted. As regards environmental issues, it has the benefit of showing a strong commitment to corporate citizenship. Going green can also help to create a good reputation for an organisation. It will increase the company's brand name and image, as it shows its ways of contributing to reach a stable environment. Moreover, this could influence the individual's behaviour for recognising and understanding the importance of going green and utilising technology to achieve it. On the other hand, some of the green approaches in lighting, such as natural light when possible, could result in improving the performance in the workplace and increase the employee's morale [9].

#### *3.1. Challenges in Implementing Green Data Centres*

There are important facts regarding the difficulties and challenges that face organisations while implementing green data centres. Sustainable IT practices often struggle with important IT preferences. For instance, implementing a green data centre may require a huge investment, and increase the time spent on preparation. In addition, there is difficulty in maintaining a balance between revenue and energy. Organisations mostly take decisions on a project that brings immediate revenue and profits. For example, take the situation where an organisation cannot afford to implement solar panels for a data centre as well as open a new branch. In such situations, organisations are more likely to go for the second alternative. Moreover, although the IT department is responsible for purchasing hardware, the procurement department pays the bills, including the power bill. Therefore, IT managers often choose equipment that is cost-effective rather than energy efficient, although the higher cost provides greater savings in the long term.

### 3.2. Best Practices in Green Data Centres

Here are some of the best practices in implementing green data centres:

- First, using LED energy for lighting is a major factor that enhances green computing. This enhances saving of energy that is used in lighting, including saving the cost of pollution control when the source of energy used is not green [10].
- The second practice is using green sources of energy to power data centres. There are various sources of green energy and the choice depends on the location of data centres. It is possible for data centres to use solar energy in some or all their activities if they are in an area where solar energy generation is possible. An alternative is wind energy, which is generated by turbines [11].
- Green data centres use devices that have advanced technologies, hence they consume less power. In the past, data centres used devices that consumed more energy for cooling activities during normal functioning. This changed after the advent of devices that allowed cold air to facilitate cooling [12]. There are various other devices that consume less energy, and data centres should choose wisely when investing in them. Many of these devices are labelled in a way that shows that they are better when it comes to saving energy.
- Green data centres also consider the longevity factor while purchasing devices. Devices that are to be disposed within a short period end up being expensive in the long run, and pollute the environment greatly. Manufacturing a new computer is expensive, consumes a lot of energy and pollutes the environment. On the other hand, making a new RAM is cheaper, and this is why buying computers that can be upgraded are preferred by green data centres [10].
- Virtualisation is another best practice that is adapted by green data centres. This is where a system of computers uses the same hardware, such that the costs of energy used by the hardware are minimised compared to having several hardware in the system. Virtualisation ensures that several computers are connected using a single system that is powerful, making access to data easier [13].
- Machines with greater storage capacity must be procured in green data centres. This eliminates the need to have movable storage devices, which increase power consumption in green data centres. Computers having greater storage capacity can store a larger amount of data in offline mode; this eliminates online storage methods that require a lot of power [13].
- Recycling is another important practice in green data centres. The items that are used here can be reused, donated to charitable organisations or recycled to reduce environmental pollution. Disposing materials such as computers increases chemicals in landfills, which pollute the environment. Instead, such computers can be donated for use by others. Materials such as paper can also be recycled to avoid pollution. All these recycling activities save on the energy that would be required to manufacture new products and reduce the waste that goes to landfills, which would have polluted the environment [12].
- Green data centres allow for cloud computing, which saves on the costs of energy that are associated with storing data in a certain physical location. Customers can access information online without the need to travel. Apart from saving the energy that would have been used in managing devices at data centres, the costs that customers would have incurred in travelling to the data centres are reduced [10].
- The other best practice is telecommuting. With cloud computing, individuals can work from their homes, with the advantage of reducing emission that is associated with travelling to data centres.

### 4. Guidelines to Go Green

Data centres are one of the most energy-intensive building types, raising more concerns about energy consumption and its effects. In consequence, the key factor in this issue is energy usage, which can be reduced by applying green IT practices. The best start for this is by conducting a study for the

data centre energy efficiency. We propose comprehensive guidelines for shifting to a green data centre. The instructions will facilitate enterprises to view green data centres and their strategies as a whole. Subsequently, organisations will have a clear direction on how to start implementing green practices. A comprehensive educational series made by [datacenterknowledge.com](http://datacenterknowledge.com) describes the various factors that impact the efficiency of a data centre. In addition, IBM has identified strategic building blocks companies that can be used to take action to begin to achieve energy efficiency [14].

The guideline will include the following steps.

- The first step is to evaluate the amount of power that is required and that which is consumed in the daily activities in data centres. Understanding the difference makes it possible for data centres to focus on reducing energy wastage in organisations. Identifying potential savings and opportunities are a way of making the green data centre plan more straightforward. The next step is to estimate the costs and benefits within a comprehensive study, depending on the established energy saving strategies that a company aspires to reach. There are many agencies and companies that assist in studying the potential costs and savings, facilitating evaluation and analysis of processes that help organisations to decide what is worthy for them.
- The second step is to reconsider redundancies in server systems and cooling modules. Using a specific measurement for the cooling system that is based on the performance level will result in the maximal outputs, when only a fraction is needed. In the past, data centres had no strategies for managing the air conditioning system, which was distributed randomly to prevent devices from damage due to overheating. Nowadays, there are many advanced ways that lead to a more efficient cooling process, such as using hot aisle isolation, economisers and liquid cooling [15]. Managing the airflow is one of the most effective factors that reduce the cost and energy consumption, which should be taken into consideration. Airflow management is mainly about delivering the cold air from AC units or fans in front of servers and removing the heat from the back of these devices as efficiently as possible. Airflow management strategies include placing the racks of servers in a way that ensures that cold and hot air do not mix together. This could also be done by using changeable speed fan drives in air conditioning units, and setting devices to direct cold air to appliances or areas in need. In addition, temperatures and humidity levels must be controlled to increase the energy usage efficiency. High temperatures or excessively dry conditions can damage equipment, with a possibility to lose the availability and accessibility of sensitive data. However, the modern devices used in data centres are now more capable of tolerating wider temperature and humidity conditions than those in the past. In consequence, by doing less cooling we can ensure saving of energy and thus save cost. Another way to reduce the cost of the cooling process is by utilizing what is called 'economisers'. These exploit the outside natural cold temperatures whenever possible to avoid employing the cool air machines as long as there are no weather fluctuations [16]. Managing data centres should present an effort to reduce the infrastructure energy required, such as lighting and cooling.
- The third step is to monitor and turn on power management tools on servers and terminals when applicable. This enables the power management system and power saver feature to reduce wastage of power. An advanced configuration and power interface is an open hardware standard that improves power management for hardware devices [5]. In addition, the saver servers could cost more than the regular ones, but they could save up to 80% when implemented and save a good deal in the long run. Another significant strategy is called scaling, or 'power proportionality'. Some servers are used lightly or even never used, wherein they often become inactive or idle. However, they are not designed in a way to scale back their electricity when not being utilised. The new technology has better power management of software and hardware, which provide the possibility of consuming less power when doing less processing [15].
- The fourth step is to utilise the new technologies and certifications that help in saving power. Virtualisation and modern processors are critical in this aspect. Taking the advantage of virtualisation will result in huge savings in energy, so that rather than having six servers

operating at about 10%, having one server running at about 50% will reduce the total number of servers [15]. Modern devices have developed physical parts such as the fan in servers with liquid cooling, which improves the efficiency of power consumption per unit of computing output. Data centres have other storage devices in addition to its servers; SSDs are efficient storage devices, which when deployed, will contribute highly to continue to drive efficiency. Moreover, the growing trend of cloud computing has resulted in running large data centres in a more efficient way in terms of maximizing the utilisation of the resources and infrastructure PUE, compared to traditional data centres [17].

- Finally, minimise internal barriers while establishing a good energy management policy. We propose to organize sessions to raise awareness among employees about saving power and its effects on the environment in which we live. Employees should feel responsible for contributing to the green environment plan, which will result in generating an effective clean environment for all. Therefore, the organisation will reach its goal in reducing energy usage, which means reducing cost.

## 5. Benefits of Implementing the Guidelines to Enterprises

There are many valuable benefits expected from the proposed approach. We argue that implementing the above guidelines will:

1. Minimise the pollution levels from data centres. The data centres should significantly reduce the pollution levels to ensure that environmental damage is also reduced.
2. Lower the costs of activities in the data centres. Every organisation has the goal of achieving lower costs to remain profitable. Data centres also aim at lowering the costs of operation.

Green data centres contribute to achieving a better way of managing the data they have. They need to ensure that data are never lost and can be accessed easily whenever needed. This ensures that the services delivered to customers are of better quality.

The initial costs of moving to green data centres may be high, but the long-run benefits include savings on costs. This includes lower energy costs as well as lower expenses on various devices in data centres [13]. The benefit to the society is that the environment remains cleaner as there are lower levels of emissions. This means that the costs that are associated with pollution are eliminated.

## 6. Summary of Contributions

Promoting energy efficiency is one of the fundamental goals of going green in data centres. This step will minimise the wastage of energy and money. Consumers will become aware of the importance of green practices and their effects on the planet; therefore, they will place a significant value on companies that do their share of providing a better living environment for society. The best practices at green data centres include buying equipment that consumes less energy, using green sources of energy, buying equipment that has a longer life span, telecommuting and virtualisation, as well as recycling of materials.

The findings of the proposed approach will reduce emissions to the environment and lower the costs of operation for data centres. Furthermore, it will contribute to facing the challenge of global warming. At the end, it will help in better managing and controlling abilities over power consumption.

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