

## Chapter 21

# Green Cloud Computing: Data Center Case Study

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### ABSTRACT

*Green Cloud computing is envisioned to achieve not only efficient processing and utilization of computing but also to minimize energy consumption. This is essential for ensuring that the future growth of Cloud computing is sustainable. Otherwise, Cloud computing with increasingly pervasive client devices interacting with data centers will cause an enormous escalation of energy usage. To address this problem, data center resources need to be managed in an energy-efficient manner to drive Green Cloud computing. The management of power consumption in data centers has led to a number of substantial improvements in energy efficiency. Techniques such as ON/OFF mode on server of data centers improve the energy efficiency of Cloud computing. In this chapter, the authors present how to calculate power consumption in Cloud computing and how power consumption in a data center can be reduced when its storage is used in a way that decreases the time needed to access it.*

### INTRODUCTION

Recently, many researchers and practitioners became interested in the world of cloud computing because the growth of high speed networks and many IT companies, such as Microsoft and IBM,

have started work on the development of cloud computing and make it more environmentally safe and affordable for all types of users.

Developers started thinking about how making cloud computing environment-friendly, with a note that green computing concentrates on energy efficiency, reducing resource consumption and disposing of electronic waste in a responsible manner.

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The overriding goal is how to reduce electricity consumption which in turn reduces pollution. Saving money is a secondary benefit which is also important. Many companies such as Amazon and IBM may be willing to reduce consumption based on green. By reducing the amount of power consumption in the data center, there is a direct benefit of lower electricity consumption and preserving the same performance.

The principle of green computing is the management of energy consumption with good performance and awareness in use. The most part in that Cloud computing that consumes energy is the data center according to EPA studies, and servers are more data center part where power consumption is. In this chapter, all these elements are studied and analyzed.

## ENERGY EFFICIENCY

Public concern about environmental sustainability and corporate stewardship has grown steadily in recent years. In particular, the impact of greenhouse gas (GHG) emissions on climate change and the role of fossil fuel electricity generation as the largest source of GHG emissions in the U.S. have attracted substantial attention. Emissions associated with electricity consumption are often a significant barrier to improving the environmental profile of many organizations because the average amount of CO<sub>2</sub> emitted per unit of electricity consumed is very high.

IT and telecom firms, many known for their progressive, game-changing strategies, have led the charge in reducing energy use and associated emissions. Several of these companies have focused their efforts on data centers, which contribute significantly to the companies' total environmental footprints. Data centers are facilities that house equipment to store, manage, and distribute digital information. They already make up about 1.5% of national electricity use in the U.S. and account for an annual GHG impact of at

least 76 million metric tons of CO<sub>2</sub>. The energy and GHG impacts of data centers are expected to more than double by 2020.

An increasing number of commercial, government, and non-profit organizations are cutting their energy use and associated carbon footprints by improving the energy efficiency of their data centers. Organizations that reduce their carbon emissions by improving efficiency, rather than by purchasing RECs or carbon offsets, are often perceived as taking more direct responsibility for their environmental impact. Google and Yahoo!, two leaders in green IT, have both shifted to this efficiency-focused approach, prompting many other organizations to also invest in energy efficiency solutions for their data center operations.

Data center electricity consumption represents about 1.5% of total U.S. electricity load, and this share is growing quickly. The U.S. Environmental Protection Agency (EPA) estimates that U.S. data center energy consumption doubled between 2000 and 2006, and it projects that consumption has since doubled again. Emissions will rise in step with consumption, and one estimate projects that global data center emissions will quadruple from 2007 levels by 2020. Energy-intensive data centers can be a substantial barrier to achieving green operations at many companies. Implementing data center efficiency solutions can protect and sometimes enhance an organization's image. However, improving data center efficiency is now more commonly perceived as a "must-do" rather than as an admirable goal. Greenpeace recently voiced this view in its criticism of Facebook's new ultra-efficient data center in Oregon. The environmental organization wrote a letter to Facebook saying, "Efficiency is certainly important, but is only the beginning of taking responsibility for your rapidly growing energy and environmental footprint."

On average, data centers experience energy costs per square foot that are 10 to 30 times those of office buildings. Data center efficiency solutions yield immediate, permanent reductions in energy

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