



INFORMATION AND COMMUNICATION TECHNOLOGIES: HIGH IMPACTS OF GREEN CLOUD COMPUTING

Ruth Barba-Vera

Escuela Superior Politécnica de Chimborazo (ESPOCH)
rbarba@epoch.edu.ec
<https://orcid.org/0000-0003-0272-171X>

Marco Vinicio Ramos Valencia

Escuela Superior Politécnica de Chimborazo (ESPOCH)
vi_ramos@epoch.edu.ec
<https://orcid.org/0000-0003-3033-2404>

Ligia Maricela Niama Rivera

Escuela Superior Politécnica de Chimborazo (ESPOCH)
ligia.niama@epoch.edu.ec
<https://orcid.org/0000-0002-1818-0041>

Maria Lorena Villacrés Pumagualli

Escuela Superior Politécnica de Chimborazo (ESPOCH)
marial.villacres@epoch.edu.ec
<https://orcid.org/0000-0002-5909-9629>

ABSTRACT

Cloud Computing is an enormously upgradable, ubiquitous and an application based infrastructure which is used to store the data on remote server, which can be accessed through Internet. This computing infrastructure is used for running High Performance Computing (HPC) and Web applications. Though there is a rising demand for Cloud communications, this demand has increased tremendously energy consumption of data centers. The increased data centers nowadays have become a grave issue as well. The profit margin of Cloud providers are reduced due to high operational cost which as a result of high power utilization. This high energy consumption leads to high carbon emission which is not eco-friendly to the environment. The enormous amount of CO₂ in environment has called for the need for Green Computing.

Nowadays, among many important fields in computer science, the Green Computing is one of the emergent computing technologies. The emergent computing technology is used to provide Green Information technology (Green TI/GC). This Green Computing is mostly used to defend energy conservation and save the

environment. Through this, the overall environmental impacts are being reduced through Green Computing technologies. Recycling, eliminating electronic waste, minimizing power consumption, improving cooling techniques, virtualization, and above all optimizing output requirements. The processors and the main memory in the servers are the major power consumption components.

This research is hoped to help researchers, administrators, producers and all other stakeholders to gain an insight in to both Green Computing and Cloud Computing. The study includes needs, merits, demerits, challenges and probable solutions to the challenges discussed. This paper discuss about the power usage effectiveness parameter which improves the usage of green computing. This paper highlights the impact of Green Computing on our environment.

Key words: Cloud computing, green computing, energy consumption of processors, electronic waste, PUE, Google data center.

1. INTRODUCTION

Now a days an elementary desire of a living being is a safe and non-polluted environment. But today, the circumstances are getting changed. Day by day our environment has been polluted due to high rate of compute. Computing is used for conniving and structuring the hardware and software system for a broad variety of purpose [2]. It is also used for scientific calculation, processing, structuring and managing various kind of information's using computers. Computing makes the computer system to behave intelligently and used for communication and react as an entertainment media. These computers are also used to finding and gathering information about the relevant information and so on. The usage of computing devices plays a fundamental task in destructiveness of atmosphere. Due to this process, the environment has filled with harmful impacts which can be reduced by implementing the concept called Green Computing. In the present, both Cloud and Green are treated as important relations in this IT world. The Advance Computing is treated as both Cloud Computing and Green Computing which are related to each other [2].

The hi-tech organization of Cloud Computing includes software, hardware, application, utilities, driver and so on. Basically, using cloud computing, one can get profit from a remote area at anytime and anywhere from the world. The follow of green technology or green initiatives for flourishing computing systems is known as Green Computing. In this study paper, we compare various technologies, and strategies which are worn for the execution of green computing and are used in an existing cloud computing. The major motive is the consciousness of a common abuser. The common abuser needs the awareness about the hazard of CO₂ emission over the environment. This awareness make the consumer to know about the impact of Green Computing towards our environment.

2. GREEN COMPUTING

The green surrounding, make use of computers and their resources eco-friendlier which plays a vital responsible for green computing. Green Computing can also be distinct as the computing device used for designing, engineering with less environmental impact. The computers which are manufactured without any side effect to the environment is concerned as Green Computers [1]. The eco-friendly hardware and software, recycling material, and control power and energy efficiency are some of the goals of Green Computing. The star management strategy and technologies will condense the energy consumption waste. Sinking the use of hazardous materials producing power efficient computing devices and reassuring the reusability of digital devices is known as Green Information Technology (Green IT). The purpose of using green computing is to attain profitable capability and progress the use of computing devices with less energy efficiency. The performance of Green IT includes the development of green environment with energy effective computers and better discarding with recycling procedures.

2.1 HISTORY OF GREEN COMPUTING

In 90's the US environment started the Energy Star program which is used to launch Green computing. The computers and other electronic devices are awarded with label called Energy Star. This energy star is used to maximize the efficiency of the product/devices and minimize the use of energy. Basically, the labeling programs are planned to support and identify the energy efficiency, climate manage equipments and other technologies [3]. The embracing of "sleep mode" along with consumer's electronics will be increased by these techniques. This plan was shortly extending to embrace criteria on energy consumption and use of hazardous material in manufacture.

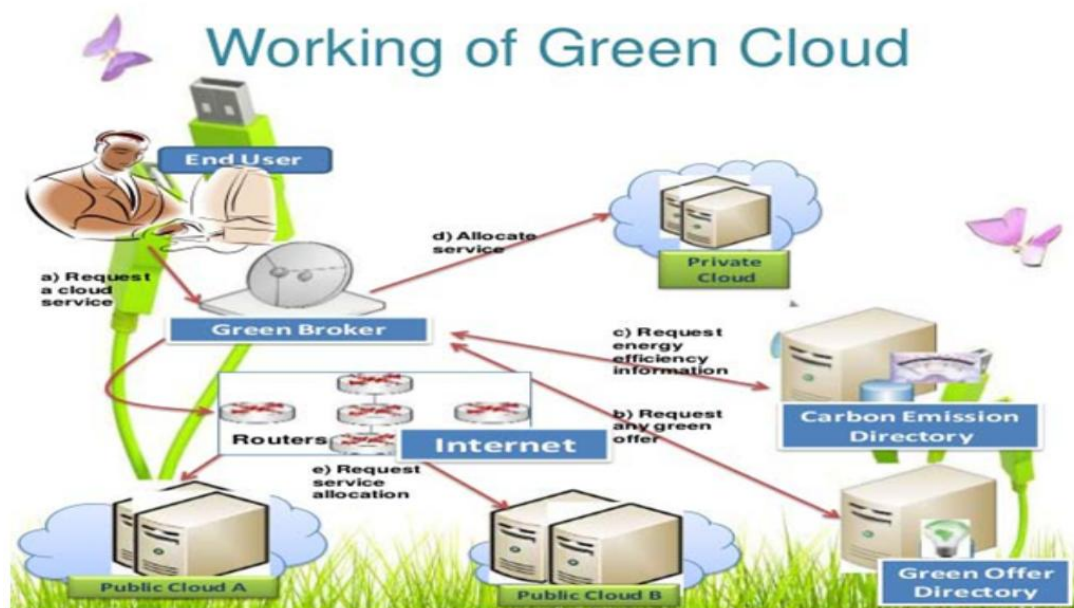


Figure 1: Working of Green Cloud Computing [2]

2.2 WHY GREEN COMPUTING?

Now a day, computer plays a vital role in all human life, which makes their work extremely easier and hoards their time and effort. But, use of these computers, increases the production of huge amount of heat and also increase the power consumption. Due to huge quantity of power utilization and heat generation, which increases to release of green house gas like carbon dioxide(CO₂) which is extremely dangerous impact for the environment and natural resources. The computers with old technology and in many data center consume large amount of energy and also don't have any cooling system[6]. This makes the environment to get highly polluted. To reduce this impact the concept of green computing initiates into existence. The following are some of the reasons for using green computing[11]:

- ☐ Hoard Our Environment: The current OS implement the ACPI (Advance Configuration and Power Interface) system which helps to save power and instruct the device to control itself after certain period of time.
- ☐ Virtualization Technology: Multiple virtual machines can sprint on single substantial server by using virtualization technology.
- ☐ Energy Star Labeled Product: The energy labeled product are manufactured for green computing features like fewer power feeding and ecofriendly product[5].
- ☐ Using LCD: The LCD monitors consume less power consumptions than CRT which leads to less carbon dioxide.
- ☐ Turn off your Computer: Turning off your PC is very necessary when not in use, because it will consume large power an emit carbon dioxide.

2.3 MERITS AND DEMERITS OF GREEN COMPUTING

MERITS OF GREEN COMPUTING

1. The Computer Technique with low emission of carbon dioxide and with less energy consumption is main advantage of Green Computing.
2. The Green computing techniques are used to save money which was spent for extra usage of power and resources.
3. Green computing also persuades recycling.
4. Green computing use to limit the hazard from laptop which leads to cause cancer, nerve damage etc.,
5. Green computing uses the preserves resources the product which can dispose and recycle easily.

DEMERITS OF GREEN COMPUTING

- 1) Green computing pretty expensive.
- 2) Fast technology change.

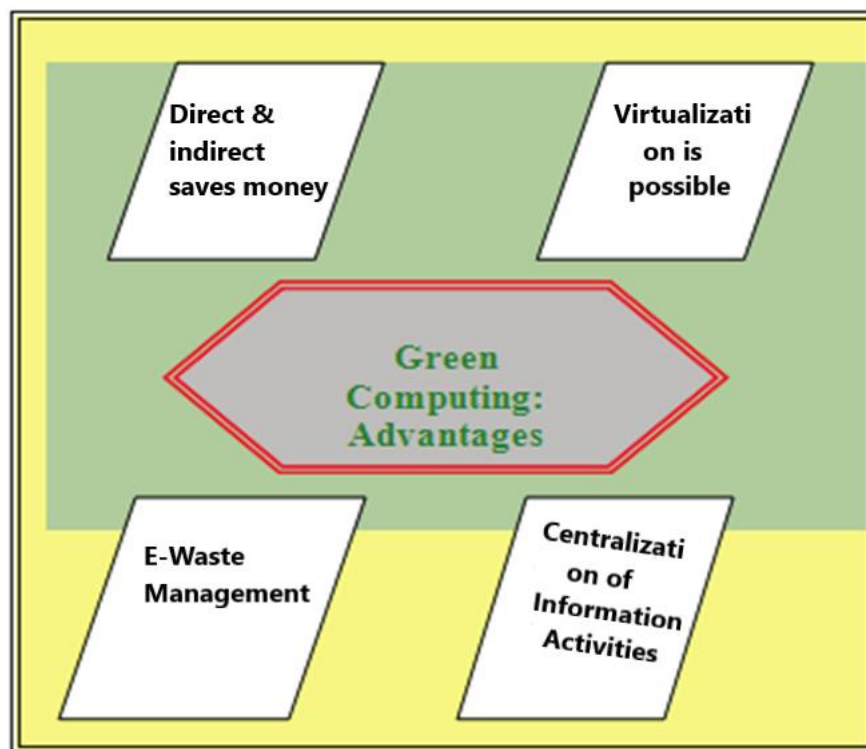


Fig. 2: Green Computing and its main advantage

2.4. GREEN CLOUD COMPUTING

Green Cloud refers to the budding environmental welfares, deliver the services over the Internet which will bid society. The word Green means friendly environment and the word Cloud means unfashionable symbol for the Internet and the delivery of overhaul form is known as Green Cloud Computing[7]. According to Pike Study, the implementation of Green Computing would direct towards a potential of 38% decline of data center energy expenditures by 2020 around worldwide.

New technologies and architectures have been designed by Storage Networking Industry Association(SNIA) to save energy. Development of these technologies, makes less data repetition, automated storage space virtualization, storage convergence decrease the quantity of substantial storage at a data center. These technologies help to reduce carbon footstep, lower operating expenditures (OPEX) and capital

expenditures (CAPEX)[12, 13]. These benefits of green cloud computing are Automatic updates, Remote Access, Scalability, Skill and ability, Enlarged storage space, Mobility.

2.5. GREEN COMPUTING: MAIN CHALLENGES AND ISSUES

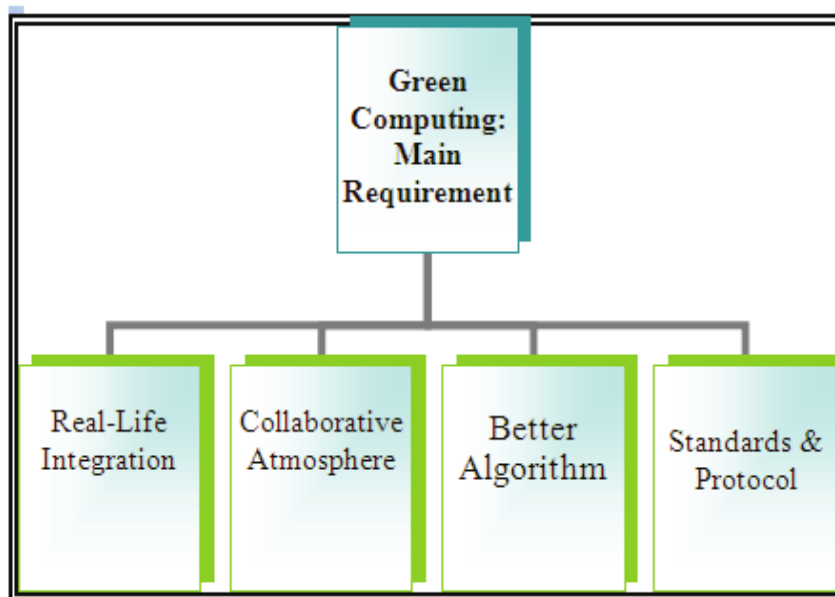


Fig.3: The fundamental requirement of Green Computing

Green Computing has several challenges and issues are:

- Many Manufacturer, Organization and Sponsor of computing ranges needs awareness of Green computing.
- Government of each country should produce identical policy for Green Computing.
- Due to less awareness of eco-friendly green initiative, many back up organizations still does not include in their program.
- Recycle materials are used in Green computing, but still many materials cannot recycled, this has to been consider.

Green Computing required trained manpower developer, which is still problematic among the computers science programmers.

- Resource allocation fund, Cloud architecture are still an important issues.
- Designing energy efficient algorithm is a big issue til date.
- Virtualization Techniques are not worked properly.
- Many IT companies are still not eco-friendly.
-

3. CLOUD COMPUTING

Cloud Computing is used to supply server, storage, databases, networking, software in the form of Virtualization. The Cloud Computing removes the principle of expenditure of buying software and hardware. The cloud computing is used to run on-site data centers and also track the servers. The welfares of cloud computing services include an ability of Scalability. The delivery of IT resources such as computing power, bandwidth and storage from the right environmental position [9, 14]. The major service of cloud is to secure data centers around worldwide. The clouds can be private or public, based on the necessities and horror of the service. According to the skilled researches, the prevalent usage of cloud computing can lead to a saving of around 38% of the global data center energy depletions [15]. The benefits of cloud computing are Business continuity, Collaboration efficiency, Automatic updates, Backup and Recovery, Easy Access to Information and Quick deployment.



Figure 4: Cloud Computing

3.1. CLOUD COMPUTING: MAIN CHALLENGES AND ISSUES

The Cloud Computing has several challenges and issues such as:

- Consistency and high-speed internet connection is required for Cloud Computing.
-

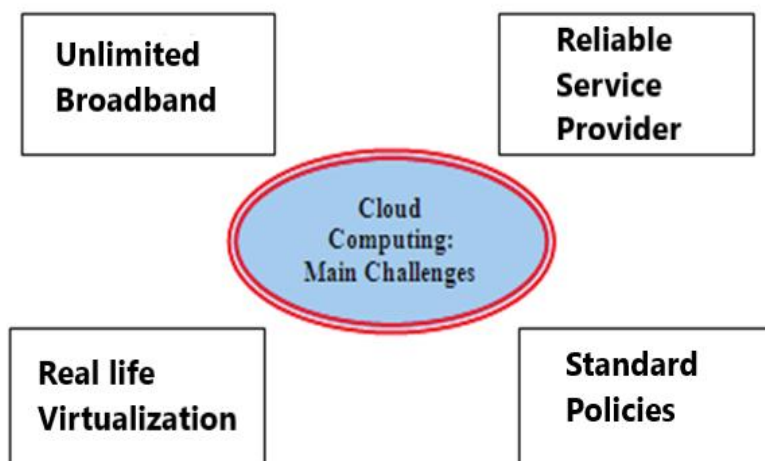


Fig. 5: The main challenges of Cloud Computing

- Information Security is important issue in Cloud Computing.
- There is no strong policies on Cloud Computing
- Cloud Computing mostly depends on computing service provider.
- Awareness of Virtualization is less.
- There are some problems during installation, maintenance and proper usage Computing.
- Cloud computing proficiency and accessibility of jobs are waiting.

4. CLOUD COMPUTING AND GREEN COMPUTING RELATIONSHIP

Cloud Computing play an important role for creation of virtualization designing and development in Information Technologies [10]. The main requirement of Green Computing includes the Energy management with less component uses and to create eco-friendly atmosphere. These two computing concepts are called as Advanced Computing Systems [8]. Both, Cloud Computing and Green Computing performed based on Virtualization. The method virtualization in green computing is important one, which falls under the category of cloud computing.

5. PARAMETERS USED FOR MEASURING POWER CONSUMPTIONS

Many techniques are used to measure the energy consumption which was emitted by electricity in the data centers. Some of the techniques are Thermal Design Power (TDP), Power Usage Effectiveness (PUE), Compute Power Efficiency (CPE), Data Center infrastructure Efficiency (DCiE), Green Energy Coefficient (GEC), Performance Per Watt (PpW), Water Usage Effectiveness (WUE), Energy Reuse Factor (ERF), Carbon Usage Effectiveness (CUE), Data Center Productivity (DCP). Among these techniques, in this article, we are going to discuss about Power Usage Effectiveness.

POWER USAGE EFFECTIVENESS (PUE)

The energy efficiency of a data center is determined by a metric called Power Usage Effectiveness (PUE). PUE is calculated by dividing the amount of power entering a data center by the power used to run the computer infrastructure within it. Therefore, PUE is as a ratio, with overall efficiency improving as the quotient decreases toward 1. PUE was created by members of the Green Grid, an industry group focused on data center energy efficiency. Data center infrastructure efficiency (DciE) is the reciprocal of PUE and is expressed as a percentage that improves as it approaches 100% . It is defined as

$$PUE = \frac{\text{TotalDataCenterPower}}{\text{ITDevicesPower}}$$

MEASURING AND IMPROVING OUR ENERGY USE

Our main aim is to reduce our energy use even though in the explosive growth of the Internet. Head to get power to their servers most of the data centers use non-computing or “overhead” energy (like cooling and power conversion). In this article, let us consider the Google server. At Google, this overhead is reduced to only 11%. We take detailed measurements to push down with less-serving along with the more users while wasting less energy. The performance of PUE is calculated using entire data centers around the world. Additionally, we include the continuously measure throughout the year. Therefore, we report a comprehensive

trailing twelve-month (TTM) PUE of 1.11 across all our large scale data centers (once they reach stable operators) in all seasons, including all sources of overhead.

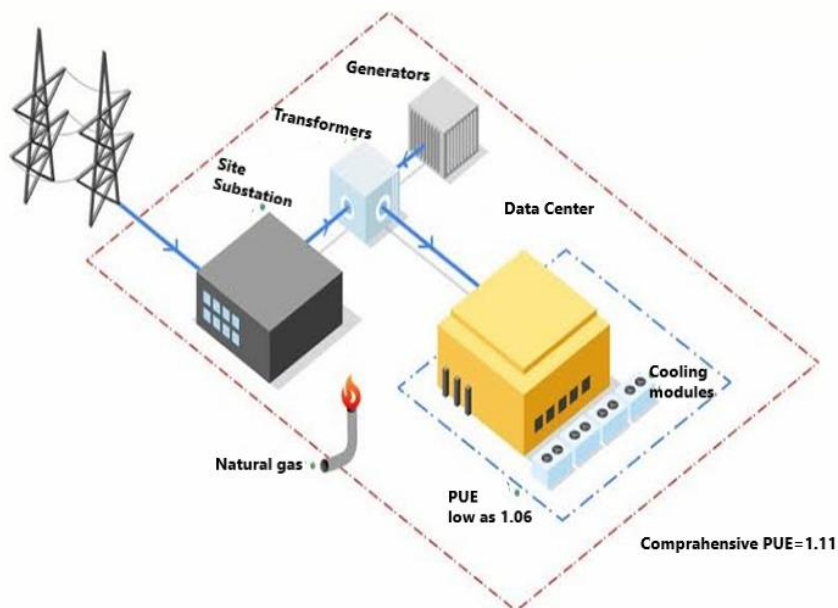


Fig. 6: Google Data Center PUE measurement boundaries. The average PUE for all Google Data Centers is 1.11, although we could boast a PUE as low as 1.06 when using narrower boundaries

Google Data Center PUE Performance

Year	Quartely PUE	Trailing Twelve-Month(TTM)
		PUE
2008	1.16	1.2
2009	1.16	1.19
2010	1.13	1.16
2011	1.12	1.14
2012	1.11	1.12
2013	1.11	1.12
2014	1.11	1.12

2015	1.11	1.12
2016	1.11	1.12
2017	1.1	1.11
2018	1.1	1.11
2019	1.09	1.1
2020	1.09	1.1

Table1: Yearly Performance Report of PUE data for all large-scale Google Data Centers

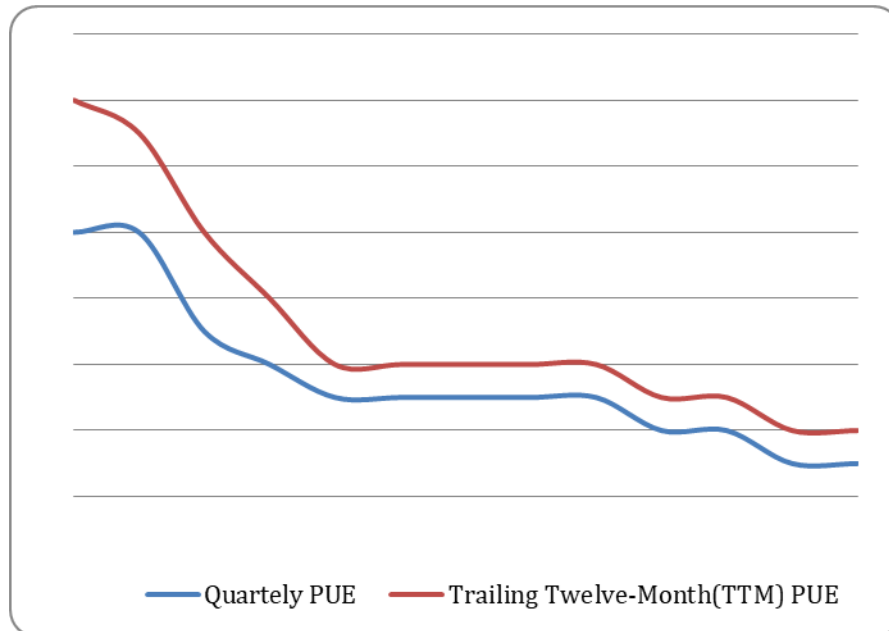


Chart1: Yearly Performance Report of PUE data for all large-scale Google Data Center

5. CONCLUSION

According to the IT society, both the Cloud Computing and Green Computing are similar. We have several challenges and issues in both the computing process. There is also many advantages and disadvantages but, we need to keep in mind the computing methods for healthy information society. Hence, Green Computing aims to produce an eco-friendly and diminish the detrimental effects of computers on the environment. According to the yearly performance report, the trailing twelve-month (TTM) PUE of 1.10 across all our large scale google data centers has been proved the efficiency of green computing. Today, the Green Computing will be a correct choice because it mainly focused on the reduction of CO₂ emission and less energy efficient computing to make IT industry as a pollution free industry.

REFERENCES

1. Dan Lon and, Chia-Tien and kai Qian(2010).Green Computing Methodology for Next Generation Computing Scientist. 34th Annual IEEE Computer Software and Applications Conference.
2. Dr.BobSteigerwald and Abhishek Agrawal Software and Services Group, Developing Green Software, 2011, Intel Corporation, Folsom, ca, USA.
3. Gaurav Jindal.; Manisha Gupta, “Green Computing “Future of Computers”, International Journal of Emerging Research in Management &Technology, December 2012.
4. Jaya Prakash.S.; Subramanyam.K.; Prasad.U.D.S.V. ” Toward energy efficiency of green computing based on virtualization”, International Journal of emerging trends in engineering and development, vol 7, issue 2, nov 2012,pp.1-5.
5. Kong, Anna(2011).Green computing. Available at <http://annadetine.blogspot.com/2011/01/green-computing.html> Green Computing.
6. MeikelPoess, Raghunath Nambiar, KushagraVaid, John M. Stephens, Jr., Karl Huppler, Evan Haines, Energy benchmarks: a detailed analysis (e-Energy 2006),ACM. ISBN 978-1-4503-0042-1.

7. Nidhi Jain Kansal.; Inderveer Chana., Cloud Load Balancing Techniques : A Step Towards Green Computing, International Journal of Computer Science Issues(IIJCSI), Vol. 9, Issue 1, No 1, January 2012.
8. Prothero, Andrea and James A. Fitchett(2000). Greening Capitalism: Opportunities for a Green Commodity. Journal of Macro Marketing, Vol. 20(1): 46-55.
9. Ranjith, D., J. Balajee, and C. Kumar. "In premises of cloud computing and models." International Journal of Pharmacy and Technology 8, no. 3 (2016): 4685-4695.
10. Siddhartha Hansel," Green Strategy for Reducing E-Waste", International Journal of Advanced Research in Computer Science and Software Engineering, vole 6, issue 3, June 2013.
11. Talebi, Mujtaba and Thomas Way-Methods(2009). Metrics and Motivation for a Green Computer Science Program. In Proceedings of the 40th ACM technical Report, GRLTN-05-2006.
12. Williams, Joseph and Lewis Curtis (2008).Green: The New computing Coat of Arms? IT Professional, Vol.10(1), pp. 12-16, Jan-Feb. 2008.
13. Priya, V., Subha, S., & Balamurugan, B. (2018). Analysis of performance measures to improve the quality of service in cloud based e-government web portal. Electronic Government, an International Journal, 14(1), 32-50.
14. Priya, V., Subha, S., & Balamurugan, B. (2017). Analysis of performance measures to handle medical E-commerce shopping cart abandonment in cloud. Informatics in Medicine Unlocked, 8, 32-41.
15. Karthikeyan T., Sekaran, K., Ranjith D., Vinoth Kumar V., & Balajee J M. (2019). Personalized Content Extraction and Text Classification Using Effective Web Scraping Techniques. International Journal of Web Portals, 11(2), 41–52.