



Sustainable Computing in India-A comparative study of Power Awareness of Individual users and Computer Professionals

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Abstract-

Owing to the stupendous growth in technology sector, the computers, software and hi tech devices are witnessing an onward trend. Along with these devices computing power is also increasing. The hindsight of this growth is heavy energy consumption by these devices, softwares, datacenters and networking devices. Our laptops, mobiles and computers are consuming unexpectedly high amount of power. Sustainable computing is a flourishing area for research in Computer Science and Engineering and Electrical Engineering. It is a junction of the two areas-Computing and Power Engineering. The prime objective of Sustainable Computing is to highlight the need of power awareness in computing. When the whole world is pursuing the SDG goals, directed by UN for creation of sustainable and futuristic environment, it becomes essential for the hardware and software creators to develop their products and services with prime focus on environmental and societal concern. Sustainable Computing involves synergy of environmental, Power, Thermal and computing Sciences. This paper aims to highlight the scope of creating Power aware hardware and software for computing. Impact of current computing devices on environment are also discussed in detail in this paper. Through this paper an attempt has been made to compare the views of users and computer professionals on

power consumption . Sustainability and environment are the two important carriers for future, which belongs to advanced data science techniques along with other upcoming fields like machine learning and artificial Intelligence. With rising need of computational devices and software, need of environmental friendly product and services is also on the rise. The prime focus of this paper is on the need for Power saving devices and methods ,which don't contribute in global warming or undue heating of the environment.

Introduction-

Computers have become an integral part of our lives today. They save considerable time and efforts and help in making our lives easier. Along with these benefits the hindside is that they consume a lot of power, generate significant amount of heat and they are responsible for affecting the environment adversely in many ways.

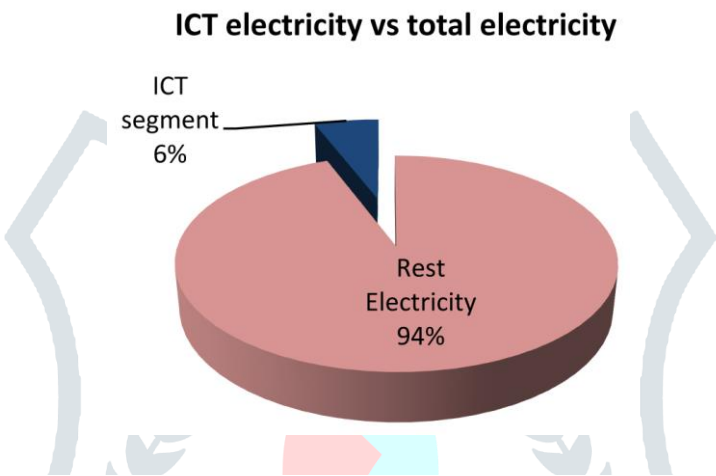



Exhibit 1-Global electricity consumption vs. total ICT sector electricity consumption.
Source publication(1)

ICT Industry consumes 6% of the total global power consumption and demand of power in this sector is steadily increasing with time.





Global energy demand 2015-2021

This table shows energy demand in data centers worldwide from 2015-2021, by type and in terawatt-hours.

Year	Traditional Data Centers	Cloud (Non-Hyperscale) Data Centers	Hyperscale Data Centers
2015	97.62	61.97	31.11
2016	83.72	70.33	41.21
2017	70.11	75.14	49.78
2018	60.55	76.27	60.87
2019	50.42	71.7	69.72
2020*	41	72.9	76.23
2021*	32.61	71.62	86.58

*ESTIMATES. FIGURES ARE IN TERA-WATT-HOURS.
SOURCE: "GLOBAL DATA CENTERS ENERGY DEMAND BY TYPE 2015-2021," STATISTA INC., SEPTEMBER 30, 2021, ICON: PRESSURE/UA/NETTY IMAGES


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Table 1

The earlier years in table 1 shows increased energy requirement by traditional data centers followed by lower energy consumption in later years. This is because of the fact that traditional data centers used for storage are replaced by cloud based datacenters, which consume less power. In 2014 the demand from traditional data centers was 97.6 Tera watt Hours ,whereas in 2019 demand got reduced to 50.4 Tera Watt Hours.(2)This is the proof that by using more energy efficient storage and networking devices and applications.

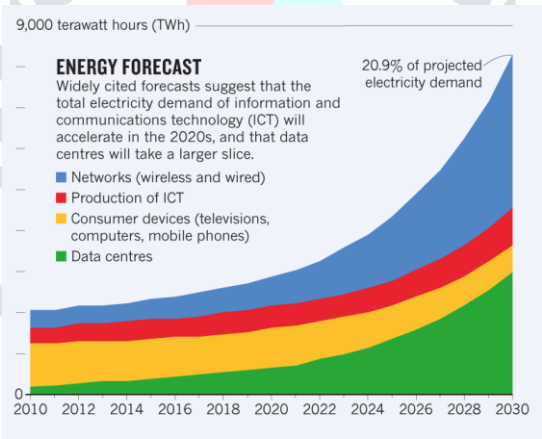


Exhibit 2 Actual and estimated energy demand in ICT from 2010-2030(2)

The energy forecast suggests that there will be demand of 9000 TWH upto 2030 ,maximum of which will be needed by Datacenters and networking areas,followed by devices and production of ICT.(3)Hence there is a need for sustainable computing,which may solve our computational purpose as well as may help in preserving our environment. Alongwith power saving there are numerous advantages of sustainable computing hence there is a need to rethink and reengineer the computational devices and our mindset to adapt to these changes.The various advantages of sustainable computing can be illustrated with the help of following diagram.

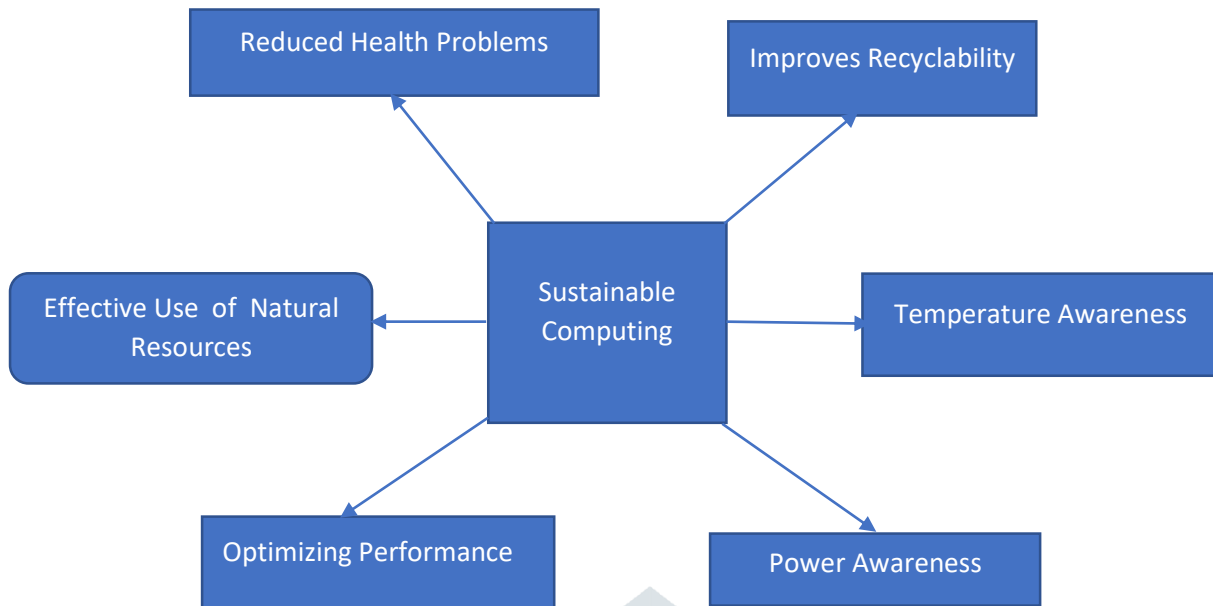


Diagram 1- Advantages of sustainable computing

An important aspect of sustainable computing is Power Awareness. The digital and electronic devices consume a lot of power, therefore their usage can be modified in a way to reduce power consumption. (3)

Due to cost saving as a result of less power consumption and usage of temperature aware systems, there is less need of repair and maintenance and the performance of devices and equipment get enhanced. (4)

The main source of IT energy consumption are networks, datacenters and devices. 36% energy is consumed by communication networks, 30% by data centers and 34% by computers. In fact 70 billion kilowatts power a year are required to run the internet alone. Out of total energy consumption 55% energy is consumed by users and 45% by manufacturers. Thus a lot of world's power is consumed by computing devices, internet, networking devices and datacenters. This data points out the pressing need for opting sustainable methods for computing, which can save power and in turn other resources. Therefore an important aspect of sustainable computing is Power Awareness. The digital and electronic devices consume a lot of power, therefore their usage can be modified in a way to reduce power consumption. (5) With the help of reduction in power organizations may achieve the goal of optimizing performance of devices easily.

Gupta et.al. state that due to cost saving as a result of less power consumption and usage of temperature aware systems, there is less need of repair and maintenance and the performance of devices and equipment get enhanced. (6). Thus Power saving needs to be incorporated in ICT objectives to achieve sustainability goals. It is the duty and responsibility of individual users and Computer professionals to adopt and find new methods for reducing power consumption. Thus this study may prove to be an attempt to find methods and devices to reduce power consumption in ICT industry.

Literature Review

Enokido et.al. identified the areas in which research is going on in sustainable computing. The major research areas include- synthesis of power aware Software and middleware, use of sensors for environmental sustainability, smart control and green data centers(7).

Veenaa Deeve et. Al. Suggested measures like, alternative displays, new search engines, Virtualisation and telecommuting to decrease power consumption and also recommended recycling of hardware components to go for sustainable computing(8).

PL Epler et al. Suggested use of smaller screens and inkjet printers to reduce power consumption, less use of printouts and using recyclable options are also highlighted by them. However he also pointed out the limitation in the way of green computing. These limitations are resistance to change and high initial cost. An organisation must deal with these limitations before initiating sustainable computing. Another roadblocking factor identified by him is resistance to change from users side(9)

Shaikh et al. [10] emphasized about green Internet of Things by discovering methods of efficient utilization of various technologies like cloud computing, sensors and smart devices. The sensors to detect overheating due to extra heat generated by overuse of devices or due to running some specific applications may be detected through sensors and corrective action may be taken immediately. They also suggested energy efficient cloud computing devices for storage of huge amount of data.

Basmadjian et al.(11)suggested an innovative model to save energy in cloud computing. They suggested that it is possible to save energy by use of a single-site private cloud data centres.

Further in this field Heiko Koziolk(12) discussed that software architectures need to be integrated with an architecture-level metrics when evaluating implemented systems to enhance their capabilities. He aimed at measuring the sustainability of a software architecture both during early design using scenarios and during evolution using scenarios and metrics.

In his study Keith Sherringham (13) pointed out that if any business wants reduction in its environmental impact through the use of Green ICT, a holistic transformation of business will be needed and its approach towards environment need to be incorporated in all its operations. Such a transformation includes changes to business models, a redefinition of business processes, a realignment of information exchange, and integration of unified communication. Without the right impetuses and catalysts, a strategic transformation of a business may take a long time or, at worst, may not occur because of incumbency, cost, and risk. Like other strategic changes,

For the green computing technology and sustainable social and economic development problems Xiaoman Wu advised using building back propagation (BP) neural network model and analyses the topological structure of the network model as well as the impact of the training errors allowed by the network on its performance.(14)

Research Methodology-

Objectives

To assess the awareness about ICT power Consumption of the 2 groups-common users and Computer Professionals.

To identify if there is significant difference in power awareness of the two groups -Individual users and Computer Professionals

To Find out the behaviour of the two groups with regards to power consumption.

Need of the study

Sustainable computing is the paramount research topic in computing these days. Most of this research is aimed at finding better computing systems and scheduling techniques, which can maximise the performance of data centers, networking equipments and systems. Technical considerations are important but social aspect is no less important either. It is the social responsibility of individual users and professionals to be able to identify the domain through which they can support the great cause of sustainability. This study is aimed at bringing up human side of the computing sustainability and emphasizing on the need of generating awareness. It also aims at contributing in sustainability war positively through the weapon of green or sustainable computing.

Research Design

To find out the power awareness in individual users and computer professionals and to compare their behaviour about sustainable computing, an exploratory research was planned to gain an insight in the area of sustainable /green computing. This exploratory research was based on interview technique, in which an attempt was made to find out the factors which contribute in power saving in Computing. This exploratory research was followed by a descriptive research design to arrive at the difference in behavior of the two groups-Individual users and computer professionals, with regards to power saving. For this purpose the factors identified in exploratory research were used to measure difference in behaviour of the 2 groups. To get the exact behavioural pattern of individual users and computer professionals, these factors were measured on a likert scale (1-4 Scale)

Sample design

Using Random sampling technique, two samples were planned for data collection-This was stratified sampling, where a sample of 250 respondents was taken from each group-Individual respondents and computer professionals. The response of 500 respondents was studied to arrive at generalisation of the hypothesis taken for the study.

Hypothesis-The Null hypothesis is taken as -There is no difference in the power awareness of individual users and computer professionals. The Alternative hypothesis states that there is a significant difference in power awareness of individual users and computer professionals.

H0: There is no difference in power awareness of individual users and Computer professionals.

H1: There is a significant difference in power awareness of individual users and Computer professionals.

Data Analysis

On the basis of exploratory research awareness level of both the groups was compared using chi square test. In exploratory research 10 factors were identified, which would save considerable amount of power, used in computing. These factors are termed as power saving factors in this study. For each of these factors Likert response were assigned a numerical value from 1 to 4 ("strongly agree," 1; "agree," 2; "disagree," 3; "strongly disagree," 4), and "can't say" responses were excluded from these calculations. We used descriptive analysis for each of the survey factors to view behavioural patterns and conceptions of individual users' and computer professionals' for power saving factors in sustainable computing. In addition, Mann-Whitney U test was used to analyze the effect of different parameters on behaviour of the two groups. Mann-Whitney U test, a nonparametric alternative test to the independent t-test, was used due to the ordinal nature of the data. The data was analyzed using the R statistical package. The power saving factors identified in exploratory study are-

- We should use peripherals having 4 or 5 star energy levels
- Dark themes preferred over light colour themes to save power
- we should use apps and software consuming less energy
- we should use LED instead of CRT monitors
- Sleep Mode must be on if taking a break
- we should close application not in use
- We should save power by reducing monitor brightness
- We should use energy efficient printers, recyclable papers & Cartridge.
- We should avoid usage of screensavers to save heat and power
- WE should buy products from power aware companies

Results-

Majority of the users and professionals in our study were aware about the environmental disturbances created by traditional computing methods. Majority of individual users believed that green computing involves reducing power consumption, decreasing temperatures through proper scheduling and increasing performance of equipments. A great percentage of computer professionals also believed that these parameters were important for saving environment and lead to sustainability. 86% of individual users and 91% of computer professionals indicated that computing requires a lot of world's power consumption. The result are shown in following table and depicted in following graphs as well-

Are you aware that computing need a huge amount of world’s power	Individual users (% Yes)	Computer Professionals (% Yes)
Aware	86%	91%
Unaware	14%	9%

Table 1.1 Showing power awareness of Individual users and computer professionals for sustainable computing

Do you think that a lot of power can be saved by effective computing	Individual users (%)	Computer Professionals (%)
Yes	78	85
No	22	15

Table 1.2 showing percentage of people positive for power saving through effective computing

From the above chart it is clear that both individual users and Computer professionals are highly aware about the power consumption in computing and also aware that a lot of power saving can done through effective computing.78% of the individual users are aware that substantial power saving can be achieved through effective computing.85% of computer professionals were aware about power saving through effective computing.

The response of individual users and computer professionals on various parameters stated for research ,were recorded and tabulated in the following table.The results of exploratory research were used to define the parameters on which further study was conducted to identify if there is significant difference in the attitude of individual users and industry professionals towers power saving and power consumption. The results obtained are as follows-

parameters to enhance performance,reduce power/heat	U statistic	p-value
We should use peripherals having 4 or 5 star energy levels	525.8	0.0645
Dark themes preferred over light colour themes to save power	435.9	0.5754
we should use apps and software consuming less energy	474.3	0.3897
we should use LED instead of CRT monitors	424.6	0.7335
Sleep Mode must be on if taking a break	399	0.8473
we should close application not in use	423	0.2644
We should save power by reducing monitor brightness	387.5	0.8367
WE should use energy efficient printers ,recyclable papers & Cartridge	388.5	0.8835
We should avoid usage of screensavers to save heat and power	348.8	0.6203
WE should buy products from power aware companies	332.8	0.5412

Table1.3 showing Mann-Whitney U test comparing Individual users and Computer Professionals

Mann-Whitney U test results exhibited there was no significant difference between individual and computer professionals perception on power awareness and power saving behaviour.(as per table 1.3)Thus there is no significant difference in perception of both the groups for Power awareness. Individual users are following steps to reduce power consumption on the same lines as Industrial users. Both the groups believe in following the above parameters which can lead to less power consumption and higher computing sustainability.

Conclusion-

The analysis in the study supports the greater cause of sustainability and serves as a socio technical model and will serve as a pointer in the direction of achieving sustainability through saving substantial power in computing. The optimum use of resources is the key to achieve the goal of sustainability. However it will not be an easy task as there are various obstacles on the road to sustainable power consumption. The resistance to change is the biggest obstructing factor from point of view of both the company and the individual users.(15). If we as individuals can take the responsibility and remove this obstacle ,it will be a major victory as attitude change can give way to other changes but its not easy to change the attitude of individuals and organization. Another obstructing factor is cost of searching and installing alternative equipments and materials, which are environment friendly. The companies must take up challenge to reduce power consumption in computing seriously as power conservation is the key to sustainable development(16).

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