

# Pre-eminent Strategy for Effective Utilization of Power in Data Center



Pushpalatha R, B Ramesh, K Thippeswamy

**Abstract**—Cloud computing is generating billions of dollars in revenue annually with very minor indication of slowing down. Today, most innovative technology is cloud-centric by retrofitting the technology to on-premises. Every IT business is also rushing from cloud-first to cloud-only concept. Data center are accounting for billions of kilowatt hours of electricity consumption every year. Huge costs spend for energy consumption than establishing the data center Infrastructure. In this paper we discuss some of the best practices to decrease energy consumption in data center. We can better control the things when we can measure it. So we also focus on seizing and measuring the energy needed for a typical data center. There is also environmental concern to be taken care with respect to data center because of CO<sub>2</sub> Emission in cooling system.

**Keywords**—Data center, Energy Consumption, Power usage efficiency (PUE), Energy Efficiency.

## I. INTRODUCTION

The public cloud market generated revenue of 138.4 billion USD in the year 2017 according to the statistical reports. There is high stack requirement and challenges are manifold in cloud environment. According to the review by the end of 2019 it is expected that 32% of 100 largest vendor's investment in the software will move to a cloud-only platform rather than the current trending cloud-first platform [14]. **The last five years have reported that around 4% of total energy consumption in US has been accounted by the data centers alone** [15]. As the population is increasing to the peak, usage of e-commerce, social networking, online banking, government project etc. is also increasing its cloud usage. The end users of cloud are increasing remarkably day by day because of its service. In future cloud will definitely become part and parcel of life to store own private data because of its privacy and security. Global analyst firm Gartner has estimated a 43 per cent growth in the public cloud services market in the country in 2017 to USD 1.9 billion. The highest revenue growth will come from cloud system infrastructure services (IaaS), which is projected to be 36.6 percent in 2017 to reach \$34.7 billion.[4]

Ranging from small computer to mammoth these data center will house millions of servers for data processing, storage, computational work and for network machines. Now a day's population of data center is tremendously increasing with huge consumption of electricity.

However the care taken to optimize the power consumption is not to the expected level. Data center electricity consumption is projected to increase to roughly 140 billion kilowatt-hours annually by 2020, the equivalent annual output of 50 power plants, costing American businesses \$13 billion annually in electricity bills and Emitting nearly 100 million metric tons of carbon pollution per year [7]. In this paper we discuss about the power wastage in datacenter and few methods on how to decrease the power consumption in data centers. This paper also discuss about the electrical efficiency measurements and sizing of it. Due to high data intensive and computational application there is huge demand for cloud data center. These data center house huge number of servers to meet the requirements as the number of servers is increasing; proportionally the power consumption is also increasing. Apart from server consuming the power for IT load, a lot more power is also consumed for non IT loads, like air-cooling, Peak power draw due to variation in critical loads, UPS inefficiency and battery charging, Lighting etc. The requirements to meet NEC (National Electric Code) and other regulators, three phase AC voltage, provided at service entrance UPS and for critical loads. Underutilized servers are energy hungry devices consuming more energy than active servers. Achieving energy efficiency has become vital role in cloud environment. Another disadvantage in cloud environment is emission of GHG (Green House Gas) and Carbon -di -oxide gas by the air cooler used to cool down the servers in the data center.

## II. INDUCEMENT FOR CONDUCTING THIS SURVEY

A small survey on workloads on cloud servers for every 60 sec is estimated to be as follows, 204 Emails are exchanged, 5 million searches are made in Google search, \$272000 in online shopping, 350000 tweets are sent to twitter, 15000 tracks are downloaded on iTunes, 1.8 million likes and comments on Facebook [5].

Data centers are becoming mainstay for worldwide economy. An energy efficient data center in itself is an incentive or a reward for the data center industry. It not only improves the overall energy efficiency but also increases the business productivity of data centers.

Energy efficiency has become one of the major concerns for today's cloud data centers. There is a huge demand on rolls today to reduce the power consumption and also to save huge amount of money may be several billion dollars.

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The data centers play a significant role in contributing for economy, powering businesses, communications, social networking, online banking, e commerce etc., and also helping make society more productive and efficient in many countries.

Also it should be noted that the data centers are the largest and quickly growing consumers of the electricity in the nation, and at the same time computations and information processing applications from various sectors and private organization is also increasing rapidly. The survey was conducted by the Right Scale in the month of January in the year 2017 for around 1,002 technical professional from wide domains of software regarding adopting cloud computing as part of their business models [5]. The survey resulted that almost 85% of these organizations are making use of multi-cloud strategy and almost 95% of the enterprises are using or experimenting IaaS as part of their business model which is a rise of 3% in total as compared to the data in 2016 [6]. With data center in India, it has been estimated that the energy currently used by a 10 MW data center each year is equivalent to the energy consumed by 73,000 typical urban Indian houses or equivalent to energy consumed by 17,520 typical Indian cars (USAID ECO-III Project, 2009). It is expected that by the end of 2020 the data centers in U.S.A alone will be consuming around 140 billion KW of power annually which equates to the output of the 50 large power plants generating around 500MW of power [5]. If all the data centers of the world can be considered as a country it will in the 12 position as to globe's power consumption stature.

Focusing the attention towards Indian data center, the power market is estimated at Rs. 2180 Cr (USD 325 million) in 2016. The increasing need of cloud storage has resulted in a large volume of data centers around the world, which in turn, consume a huge amount of energy. In order to reduce the power usage efficiency (PUE) ratio and increase efficiency, data center designers deploy advanced power management solutions such as intelligent rack PDU, smart UPS, and battery monitoring equipment, replacing Hard disk drive (HDD) by Solid state drive (SSD). SSD usage increased from 8% to 22% from 2012 to 2017[15].

Also the rising cost of energy and increasing awareness to save electricity has resulted in designers opting for intelligent power management solutions. Intelligent power strips, PUE monitoring devices, and battery monitoring devices are some of the newest technologies used to optimize energy consumption in data centers and reduce the PUE ratio. Overall, the number of data centers is expected to increase dramatically in the near future. In the month of January 2017 the survey was conducted for 1,002 software professionals by the Right Scale to get the statics on their adaption to cloud computing. The users of the cloud in this survey said that the cloud space provided was underutilized to say for around 30%. But the survey claims that the underutilization is almost 35% to 45%[5]. In spite of focusing on the management of the cost only a handful of companies are taking serious actions for the optimization of these costs by switching to less cost or required amount of cloud space or by turning of the workloads when not in use. Almost 30 stakeholders were interviewed by Natural Resource defense council (NRDC) for the surveying few of the issues and the following questions were framed and were asked to [5],

- a) What is the efficiency of the data centers in U.S?

- b) What are the important challenges existing in reducing power consumption in data center?
- c) What are the barriers capturing these opportunities?

Answering to these questions they identified two means to save energy

- **Complete utilization of servers.**

If the servers can be utilized to 100% by making them does more work the energy efficiency can be increased. In datacenter depleted staffs are busy upgrading/ monitoring in new products and new servers. They do not have time to address unused servers. In every data center we finally end up with more number of servers which are idle for long hours. As per surveyed found that 8 to 10% of servers are not used but still consuming more power than the highly efficient servers. In the data centers it is found that at least 15 to 30 percent of the equipment is functioning without doing any of the useful work which is contributing to the unnecessary energy consumption. Most of the time data centers are worried about Service level agreement (SLA).

- The bills to be paid for the energy consumption and the ones who take up the decisions which might affect the energy efficiency must be mutually aligned.

In many organizations the one responsible to pay the bill for energy consumption is different from the one who is managing the energy consumption and both have the different issues to deal with. The consumers are leasing the cloud space and the power in order to run their computing equipment hence the splitting the incentives have become important due to this multi-tenant data centers. Thus the alignment between the organization renting the space and power and the organization using the service should be done in order to eliminate the issues concerned with the implementation of common efficiency measures.

### III. HOW TO DECREASE THE POWER CONSUMPTION IN DATA CENTERS

#### A. Upgrade and Consolidate the Technologies.

- a) Server Virtualization-With the help of Virtualization Consolidate number of servers performing different functions to one physical server with number of virtual servers running on it. This will help in efficient operation of servers and energy consumption will be reduced thus reducing the cost between 10 to 40 percent of the actual cost [1].And also we can achieve high server utilization, cut hardware and operating cost, finally reduction in electrical cost (Fig.1).
- b) Withdraw the comatose servers-the parts of equipment around 15 to 30 percent of the total equipment rented are not performing any task and this equipment is also consuming more energy than that equipment contributing towards computation tasks.
- c) Consolidate the servers which are lightly used-when the workload is decreased during non-peak hours lightly used servers can be consolidated for better maintenance. The utilization of the server is only between 5 to 15 percent but still it is found to be using large energy.

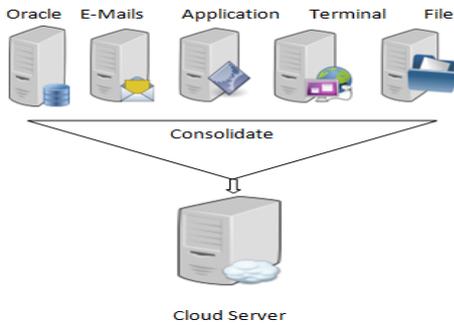


Fig.1. Server Consolidation

Have to care about Service level Agreement (SLA) during data center maintenance.

- d) Improvisation and organization of data stored-The utilization of data storage is only up to 30 percent. Elimination of duplicate or redundant data in the servers has to be done by following de-duplication methods. Usage of Energy efficient technologies such as “ENERGY STAR” computing server which utilizes 30percent less power than the traditional server machine. [1].

**B. Go With the Flow: Maintaining the Flow of Air**

It is necessary that the data centers should take the benefit of the “Cold Aisle/ Hot Aisle” layout Computer Room Air Conditioning (CRAC) is a traditional device used to monitor the parameters like temperature, humidity and also the distribution of the air at the data center and maintain them. Disadvantage in this system is cool air and hot air gets mixed up and decreases the cooling efficiency. Server racks arranged as per CRAC unit as shown in the (Fig 2) which is poor row orientation.

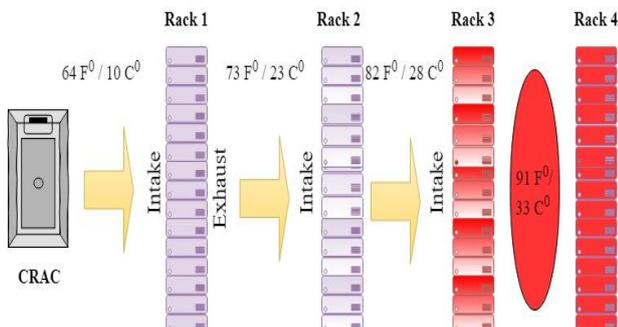


Fig.2. Traditional Arrangements of row

- a) Arrangement of servers-Severs are arranged such that front face of the server racks can be made to face each other so even the server back face will face each other. By doing this the cold and the hot air will be mixed and the energy efficiency can be improved as shown in (Fig 3). Perforated doors are necessary instead of Plexiglas or glass door.
- b) Cover the server racks in closed enclosures-To cover the server racks the curtains with the flexible strips or rigid covering can be used. This will further contribute in reduction of mixing of hot and cold air.
- c) Air flow should be assessed and then improvement suggested-In order to reduce the temperature of the air the blanking panels are installed at the server inlets this will also increase the air temperature to the CRAC, and

thus contributes for the reduction in the energy consumption. The cabling can be changed and structured it such that it will allow the air flow in to the servers.

- d) The server arrangements in a data store or data warehousing is placed in such a way that both the frontend and backend faces each other as shown in (Fig. 3).

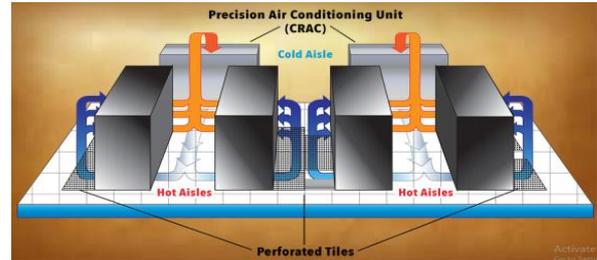


Fig.3. Servers Arrangements

**C. Adjust and Improve HVAC System**

- a) Maintaining the parameters humidity and temperature at data centers-The specified range of the humidity and the temperature into the server inlets by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) should be maintained.
- b) Variable speed fan drives for the air condition to be installed-In order to change the cooling load at the data centers the Retrofit kits with two year guarantee for CRACs have to be installed.
- c) Installation of an air-side optimizer-This is method wherein the outer cool air is brought into the data center. Since the data centers has to be maintained at a cool temperature throughout the year every second these installations will make the data center temperature cool at both winter and hot seasons and also in the day and at night. This reduces the power consumption.
- d) Installation of water-side optimizer-During the winter season the evaporating cooling effect is used in order to produce the cold water. This will reduce the power consumption by the water side plant by almost 70%.

**IV. ENERGY EFFICIENT MEASUREMENTS FOR DATA CENTER**

As we know, we cannot control what we cannot measure. It becomes very necessary to measure the Electricity consumption in highly available data center. Initially a benchmark has to be set or designed to measure the power usage and to measure the efficiency of data center. We need standard language and tools to describe the data center. Also the standard method to specify, analyze, measure the efficiency of datacenter. In this paper we try to put light on parameters to measure the electricity in the data center. PUE (Power usage Effectiveness) Metrics has become the de facto standard to measuring data center efficiency. PUE is expressed as ratio of total input power to IT load power. For instance everyone want the PUE value to be number one, why?

$$PUE = \frac{\text{Total Input Power}}{\text{Powe for IT Load}} = 1 \tag{1}$$

Unfortunately data center operators are unclear about the PUE and its calculation. If the PUE value is 1 the data center is called to be perfect. Which indicates that all the power used in data center are used to manage critical loads like servers, networks, routers, telecommunication equipment, storage device etc. and also power consumed for safety purpose like alarm, fire and monitoring system without wasting energy for other non-critical load as shown in (Fig. 4). Examples for non-critical loads are the data center physical infrastructure maintenance like are lighting, cooling, UPS inefficiency, switchgear etc. If the PUE value is 2 it means that for every watt of IT power additional one watt is used for cooling and non IT usage instead of computing. The best PUE value is achieved by Google data center in the year 2016 is 1.12.

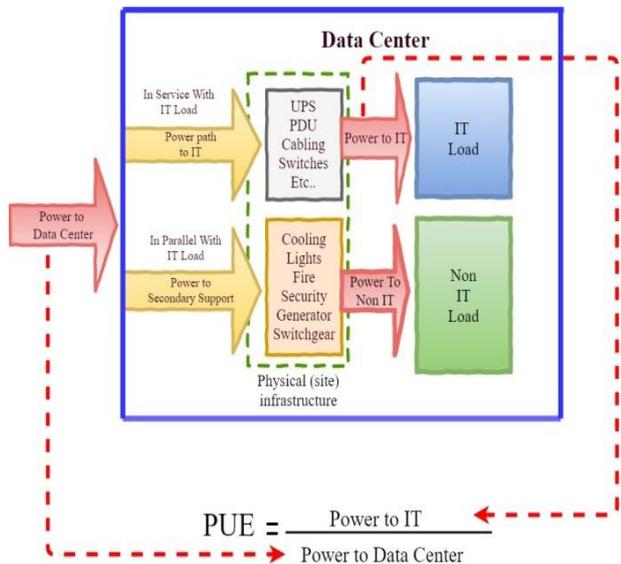
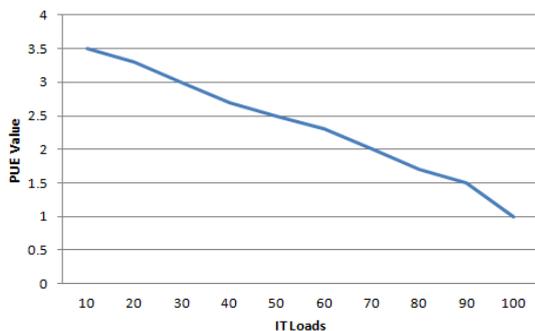


Fig. 4 Estimation of PUE value in Data Center

In the event that the IT stack were to shift through the span of a day because of changing IT process workloads, the graph.1 demonstrate PUE curve showing lower efficiency at lighter loads. And we can expect a variety of the momentary PUE throughout the day. This implies the immediate PUE would not equivalent the everyday PUE. This has important interference in how we measure the energy efficiency and how we interpret the measurements.



Graph.1. PUE Values v/s IT Loads

PUE depends on the workload which is dynamic in nature. However the efficiency varies over the time as IT load varies. The PUE value measured for a particular time will NOT be equal to the annual PUE. Any particular one time measurement of data center efficiency is just a snapshot which cannot be used for future prediction. To conclude on

this any single measurement (PUE) on data center efficiency will be inherently inaccurate and cannot be considered as the benchmark for efficiency measurement.

Table-I. PUE Values for Data Centers

0.01-1.0(Impossible)	4%
1.01-2.01	83%
2.01- 3.0	13%

**A. Where does the Power Wasted**

Data Centers have the dynamic loads. Once the data center is established the IT equipment’s will be in good condition for the maximum years or for its life time. Its refreshment can be done for every 3 years. Therefore any future load can be calculated at least for three years. Future loads are

- a) UPS loads: The non-critical load must include the factor of UPS which will be inefficient sometime at the point of operating. The realistic and efficient UPS has an approximate value of 88% on proper installation.
- b) Lighting: Every Data Center Infrastructure Management (DCIM) should have proper lighting for the safety of operators in Data center. In a Pragmatic way the lighting load consumes a power of 2W/sq foot or 21.5W/m<sup>2</sup>.
- c) Cooling loads: As the number of servers in data center increased, there is lot more requirements for Air cooler to maintain the temperature in the data center which again leads in Carbon release.(Fig.5) illustrates the typical breakdown of how electrical energy is divided as many various loads in data center.

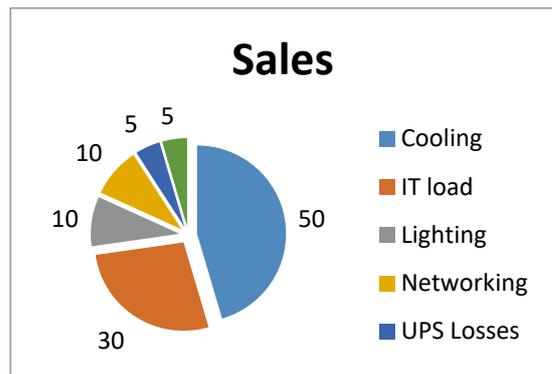


Fig. 5 Breakdown of Data Center Electrical Requirements

**B. Weigh Up the Electricity Usage in Data Centers.**

The electricity usage can be measured as follows.

- a) In order to meet the standards prescribed by the National Electrical Code and similar regulatory bodies the total power required in KW is multiplied by 125 percent.
- b) The utility companies should find out the 3 phase AC voltage at the entrance of the data center. In U.S this Voltage is 480V and in rest of the countries it is 230V.
- c) In order to find of the current in terms of amperes to be supplied to the data center the following equation is used.

$$\text{Amps} = (\text{kW} \times 1000) / (\text{Volts} \times 1.73) \quad (2)$$

The above equation provides an estimation of the electrical service required to support cooling, IT loads (critical loads), and building functions of Data Center. Data center power requirement calculation worksheet in Table 2 will help to estimate and calculate the electricity usage [16]. The electricity consumed by computing devices or equipment's is expressed in watts (W) or volt-amps (VA). The power in watt is a real power drawn, whereas VA is apparent power. VA rating is used for wiring, sizing and for

circuit breakers. Watt and volt amps are same for electrical loads like incandescent light bulbs, but vary significantly for computer equipment's. The ratio of watt and volt amps are called 'power factor' expressed as 0.7 or 70%. Capacitor input supplies have a characteristics that watt rating is in the range of 0.55 to 0.75 times the VA rating, which is an average 0.67. The other constant values are taken as per the data center's configuration and physical characteristics.

**Table –II Estimate Calculation of Electricity Power Requirement for Data Center**

Electrical Demands	Data	Calculation	Sub Total in KW
<i>Power requirement – electrical</i>			
Critical load- sizing calculator value from Schneider Electric website	Rating of each IT device	( Calculator total in VA x 0.67 ) / 1000	<u># a</u> in KW
For equipment not listed in the sizing calculator, critical load	Subtotal VA (include fire, security and monitoring systems)	( Subtotal VA x .67 ) / 1000	<u># b</u> in KW
Future Loads	VA of nameplate of each anticipated IT device	[ (Add VA rating of future devices) x .67 ] / 1000	<u># c</u> in KW
Peak power draw due to variation in critical loads	Total steady state critical load power draw	( # a + # b + # c ) x 1.05	<u># d</u> in KW
UPS inefficiency and battery charging	Actual Load + Future Loads (in kW)	( # a + # b + # c ) x 0.32	<u># e</u> in KW
Lighting	Total floor area associated with the data center	0.002 x floor area (sq ft), or 0.0215 x floor area (sq m)	<u># f</u> in KW
<b>Total power to support electrical demands</b>	<b>Total from # d, # e, and # f above</b>	<b># d + # e + # f</b>	<b><u># g</u></b> in KW
<i>Power requirement – cooling</i>			
Total power to support cooling demands	Total from # g above	For Chiller systems # g x 0.7 For DX systems # g x 1.0	<u># h</u> in KW

**V. IMPACT OF INCREASE IN ENERGY CONSUMPTION LEVEL**

Increase in energy consumption is resulting in CO2 and GHG (Green House Gas) gas emission into the environment. The major content of GHG is Carbon di-oxide (CO2), Methane (CH4), Nitrous Oxide (N2O) that contributes greenhouse effect which is majorly released from data centers. The major source of GHG is Electricity production, the poisonous gas which comes from burning fossil fuel and natural gases. Carbon-di-oxide is released during the manufacturing process of data center components like servers, UPS, and building shell etc. it has lifecycle of 100 years with major global warming effects [9]. Cooling techniques used in data center are responsible for huge consumption of energy and also contributing towards carbon emission, the gas is released by Air Conditioner used to cool the servers in data center.

According to the Environmental Protection Agency (EPA), from U.S current efficiency trends lead to the increase of annual CO2 emissions from 42.8 million metric tons (MMTCO2) to 67.9 MMTCO2 in 2011.

**VI. CONCLUSION**

Data centers are facing towards virtualized environments. IT and data center professionals are very familiar vitalizing Server, Network, Storage, Resource etc., to maintain hardware. So why not use the same virtualization principles in optimizing power consumption? All power distribution designs, and associated resiliency software tools, must be compatible with major virtualization vendors to future-proof the infrastructure.



This approach will make data center operators to constantly maintain systems, thereby mitigating the risks associated with out-of-date infrastructure. Effective power management is a must have, not a nice to have.

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