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A Smart Green Data Center of Energy Conservation in Cloud and Mobile Cloud Computing

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***Abstract* –** This paper focused to green system of the small data centers with sustainable energy power generation. The estimation must start with a baseline view of power consumption in every part of the data center. The primary vital issues of data centers are increasingly under intervention of their energy consumption and operations. This paper takes first step toward exploring green data centers powered by renewable energy system that include base load power supply, intermittent power supply and backup energy storage systems. The required energy assists in an embryonic attitude of data centers being saved energy with a "greener" consequence. Data centers are the factories of the digital world and the cloud is coming back to earth that ethereal place where data is being stored. The convention of renewable energy resources has been the vital role in our future development of modern technology and cloud computing is the fastest evolving paradigm of the modern age of computers. This requires more and more remote host machines such as servers. Naturally, data centers are required large amounts of energy to power the growing demand. Now, data centers are turning to energy-efficient data facilities to cut costs and green power for their operations. This paper presents small-scale routing algorithm used energy consumption by instead of using conventional energy, thus increasing the effective performance up gradation of the virtual data center. We bring new thought in energy saving of the data centers. This presents the technological way of power consumption in the records of data center.

***Keywords* –** Cloud data center, Small scale algorithm, Energy consumption, Renewable energy

I. INTRODUCTION

A small-scale, cloud computing data center, still, could advantage of modern technological inventions to alternately dependent on solar energy. Cloud computing has developed as new energy utilized technology and virtualization model for the computing world. It provides an appropriate service based on the request of demand in resource pooling and measured service in a highly customizable practice with least effort [1]. However, there is a growing concern to optimize the output of the cloud infrastructure and to make it more mobile to ease the burden on aging computer infrastructure. The Computer infrastructure is becoming outdated and is causing significant problems in the overall energy grid, and non-renewable energy is the energy which is currently used to power most of the world's electricity, only recently due to global warming and other problems such as economics, the need for renewable energy is necessary more than ever. The below Fig. 1 Cisco provides 77% of the traffic exist in the data center by 2020. Center to the center will characterize 9% of traffic with Fig. 1. The output of consumer workload is on the rise from 21% in 2015 to 28% by 2020 data run to end users getting 14% by 2020. Cloud computing explained as an orderly devised tool wherein the users can use the computing requests as and when they need, and they are made available in the cloud through a browser [2]. Cloud Computing is an enabling universal, accessible, on-demand network passage to shared devices like network, servers, applications, and services that vastly released with minimal management effort.

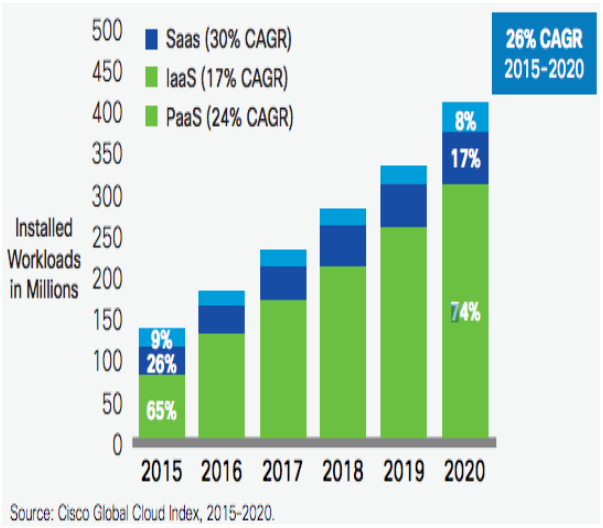

Figure 1. The output of consumer workload is on the rise from 21% in 2015 to 28% by 2020

In general, less energy consumption is obtained all the way through the high energy efficiency and diminishes wastage from conventional energy sources. Its significant reward consists of minimal cost with the storage of energy and the protection of global warming. The Mobile cloud architecture consists of infrastructures, communication network and mobile users. The researchers must forfeit proper interest in reducing and saving energy in MCC. The huge-scale of data computing in mobile cloud is the primary usage of today's mobile users.

There are many final ones of cloud computing is simple and most used one is the transfer of data from one mobile to another. It is pretty evident in everyday life as it frequently used in mobile devices and internet-based applications such as Google.

As seen in the above Fig. 2, there are computer infrastructures present, such as storage, a control node, and a client computer, these electronic devices use a significant amount of energy, all of which are running and consuming a bulky amount of energy. The green energy technology is one of the efficient techniques of fabricates electricity using renewable sources. Concurrently, power generations are dynamic green energy system. Mobile Cloud data centers consume a significant amount of energy which concerns both power cost and global warming. It reports that Google devour over 1120 GWh with 67 million dollars per year, and Microsoft consumes 600 GWh with 36 million dollars yearly [3]. In the United States, producing 100MWh energy was emitted 50 tons of carbon dioxide [4]. Based on this report, the massive amount of efforts was devoted to green data centers. The cost per kW produced by the PV solar panel is estimated as USD 0.055 / kW and it measure the current value of the solar photovoltaic energy [2] in roadmap technology.

Consequently, emerald green energy will be proficient power alternative for the next generation of green mobile cloud computing. Piro et al. [5] estimated that the CO_2 release hoard and the cost of power. It proves that a powerful system of mobile cloud data centre with emerald green energy .This produces a sustainable and realistic solution. Further Hassan et al. [6] was classified the scenarios of the system and the objectives on utilization of renewable resources in the field of mobile cloud computing. This paper depicts route of renewable energy sources usage with a distributed network in mobile cloud platform. The small data centers are located with the power generation plant. It was compiled in the escalation of the green renewable energy in the small-scale data center.

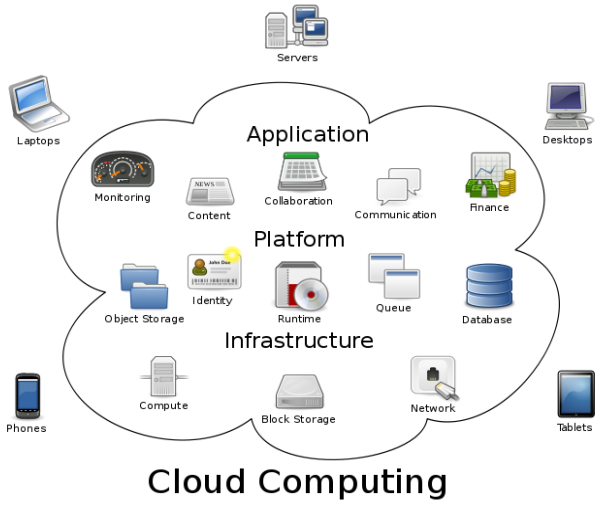

Figure 2. A simple diagram as to how cloud computing works

This paper mainly contributes the following: Section 2 represents the background of mobile cloud computing. Section 3 describes the energy consumption of cloud data centers. Section 4 explains the methodology of mobile cloud data center with a Solar PV generation model and small scale routing algorithm. Section 5 covers the results and discussions. Finally, the conclusions are specified in Section 6.

II. BACKGROUND

Cloud computing works under the three tiers as follows, IAAS, PAAS and SAAS

With IaaS, the users can perform the required software on the basis of a third party.
IaaS constructs the entire system, from the server to storehouse via data communication network [7].

PaaS maintains and constructs the various distributed services across the Web. PaaS provides facilities to deploy, test, host and manage applications. The observable immensity layer is Software-as-a-service (SaaS) to end users. SaaS is the one of the competent of entry services via a Web browser. The above three tiers are fundamental to the overall functionality of cloud computing. It needs the more efficient cloud infrastructure and so reducing the overall stress of the energy consumption. This energy demands can be made by implementing storage energy techniques which utilizes an alternative energy such as renewable energy. Green computing gives a device of renewable solar energy resources with carbon footprint [8, 9]. Power generation from coal, gas, and oil results to produced the required amount of carbon dioxide emissions. The invention of green energy is achieved from the various renewable resources such as solar, wind and biomass with almost zero carbon dioxide emissions [10]. The renewable energy is supplied by power generation load balancing systems of Cloud Data Centers [11]. Further, power grid strategy depicts onsite renewable energy resources. These resources are essential for 100% availability of cloud services [12]. Plentiful renewable energy resources are often situated away from commercial CDC sites. As a result, transportable mobile data cloud centers designs must be appropriate to discover CDC links in the vicinity of renewable energy resources [13].

III. ENERGY CONSUMPTION ANALYSIS

The current overall power consumption of computer infrastructure remains unknown, but we can estimate the usage. The analysis is that more than 10% of the world's energy use consumed by the IT world, which excludes machines that run computer code. We need considerably analyzing the overall functioning of the solar energy based cloud data centre infrastructure of equipment to reduce the carbon footprint it leaves behind and to improve the performance of the outcome. On average, most of our power consumed it made by fossil fuels such as oil and coal based power plant. We need to reduce this to avoid a serious problem such as global warming, which its effects are slowly hurting the earth and its surrounding areas. Hence, the major ways to convert solar energy used in the data centers, the overall IT world and can reduce the global warming.

Mass computer infrastructure requires a large load of current. The power equation is as follows;
Power = Work / Time

Where the work is many processes a computer does and time is how long it takes to process the code/functioning. To calculate an amount of power needed to computer peripheral. The amount of power is directly proportional to the work in the computer system does and in the case of cloud computing, it uses a significant amount of energy to keep the work in the computer stable condition and improve the output of the different services the mobile cloud computing initiatives use.

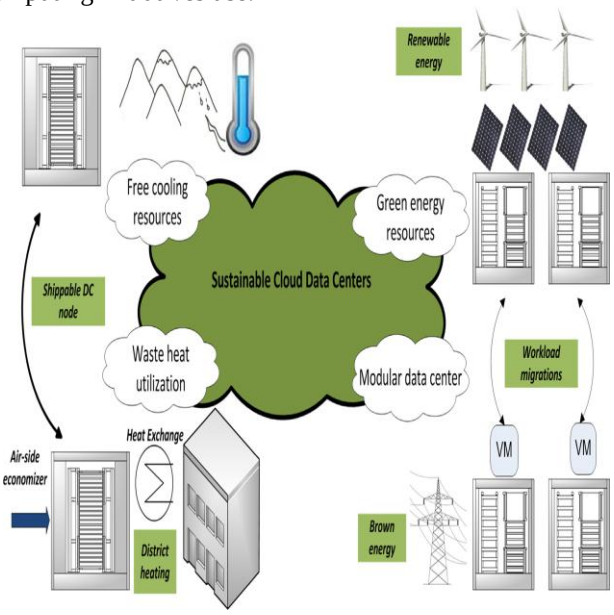

Figure 3**.** Sustainable green energy cloud data centre

The above Fig.3 the sustainable green cloud data centers with the utilisation of renewable resources. The survey on cloud data centre enclosed all the critical sustainability factors and green energy in the cloud. The Renewable systems can schedule the workload by dynamic load balancing technique. It coordinates the various task of the system and consistent in nature [10]. This approach is a transit of the renewable green CDCs. The generation of power production is based on scheduling. It implements scaling and transformations of power which satisfies renewable power with CDC workload. This scheduling technique is based on energy locality in CDC. So, the current technology adapts to this type of renewable power in CDCs. The three approaches to achieve renewable green CDCs are as mentioned below,

1. The data centre is situated with green power generation plant 2. Onsite renewable energy based electricity generation 3. Purchase of renewable power agreements from power generators [14, 15]. All of the above approaches are aimed to minimize power. Yanwei Zhang et al. [16] proposed a system requires with the renewable power cloud data centers. It is derived on the basis of dynamic time ratio of energy costs and geographical locations. Also this was determined the costs per kWh solar and wind energy in different geographic locations of Data centre .In this paper, we focused on the association of small-scale algorithm of renewable solar energy resources utilization and energy conservation of data centre. The result shows that control

programming based virtual machine arrangement algorithm can efficiently diminish energy consumption about memory [17].

IV. METHODOLOGY

A. Cloud computing data centers using a solar PV generation model

This focused on a solar panel of small-scale cloud data centre. The several recent expertises follow the low power consumption processor mechanisms of energy aware mobile cloud computing with DC power. At this point, solar power generation model of mobile cloud data center is shown in Fig 4.

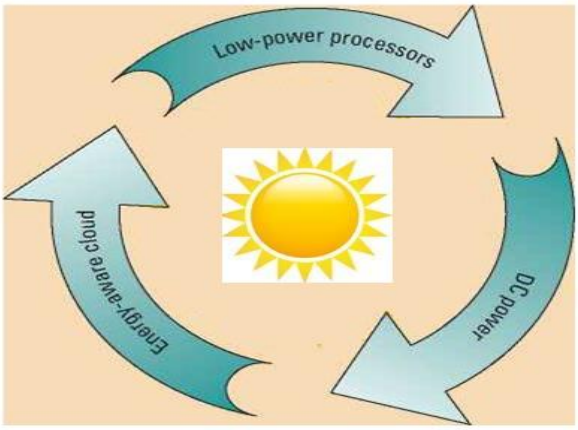

Figure 4. Cloud computing data centers using solar power

The above enclose involve the nearer user's site, mobile cloud Data centre, high data security and low cost of energy .This directs to save an environment. The current trend is focused on data server with power generation .This can reduce power of the overall functioning of the non-renewable system. The methodology is quite very simple and improves the overall cloud data storage power. It transforms the existing grid into renewable energy; this will decrease the carbon footprint not present by burning fossil fuels. The method here is to optimize the output of the computing related to cloud and to maximize the energy used by improving the way the power used. The power can be generated using renewable energy resources. Large computer rooms also need cooler temperatures compared to the surrounding environment as this is vital for the processing speed and the output generated. The solar photovoltaic (PV) generation system consists of the characteristic equations of current-voltage system which in turn associated with the solar cell parameters and ecological conditions, as adopted in the Differential algorithm [18]. The solar power output is calculated at the maximal power point (mpp) that extort from the PV panel. Alternatively, the scheduling system predicts the power generation by a function in reverse to cloud coverage. That is, $Ep(t) = B(t)(1 - Cloud\ Cover)$, where $Ep(t)$ is the calculated solar power at time t, $B(t)$ is the solar power generation and Cloud Cover is the approximate fraction of cloud coverage range (varies up to sunny days (within 0~1)). Specifically, the single phase diode equation is used to simulate the available electrical power produced from a single PV panel. Specifically, the characteristic equation of current-voltage of a PV panel is

$$i = I_{ph} - I_0 \cdot (e^{v+i.R_s / n_s . V_{th}} - 1) - v + i \cdot R_s / R_{sh} \qquad (1)$$

where Iph *is* the generated photo voltaic current, *Io* is the shady dispersion current concern ambient endure pattern. The single phase diode model describes both the sequence and parallel (shunt) conflict of the PV panel which is denoted by *Rs* and *Rsh*, respectively. *V th* is the thermal voltage, *i.e.*, $Vth = k \cdot T/q$, where k is Boltzmann's constant, q is the indict of the electron and T is the ambient temperature. *ns* is the count of total number of the solar cells in the PV panel associated within a series,(*e.g.*, *ns* = 72 in BP-MSX 120 panels). The active control locations of varied data centers which has the meteorological data from the Measurement and Instrumentation Data Center (MIDC) [19] of the National Renewable Energy Laboratory. In addition, today's mobile cloud data centers hold an unproductive power renovation. Power is scattered by AC (alternative current).The numerous transformation between AC and direct current (DC), resulting in energy loss (up to 30 percent). In upcoming days, technology turns into the imminent DC-Solar Photovoltaic based power distribution systems which can be improved by effective utilization of renewable energy and minimizes power consumption of system. The formulated power consumption is obtained by using mobile offloading as indicated below:

$$P_c\ X\ (C/M) - P_i\ X\ (C/S) - P_{tr}\ X\ (D/B) \qquad (2)$$

Where, C is the total count number of executable instructions, M is the speediness of mobile device (instructions/second), S is the hustle of the cloud data server (instructions/second), Pc is the consumption of power (in watts), Pi is the inactive status of power controller, Ptr is the power transmission (watts), D is the number of exchanged data(Bytes), and B is the bandwidth of network connectivity .The above formula contains various constants like Pc, Pi and Ptr., also the formula generate a positive number denoting for the minimal power consumption. Technique of Offloading can be used for saving energy in the case of the essential cloud data. Here, there is no need to transfer data from mobile devices to the cloud wireless network. DC power strength takes part in a vital role of efficient solar energy data centers .This is happened because of the most alternative energy source (like solar cell and fuel cell) produce DC current. The cloud data centers operates on DC current which reduces general system power supply stipulate by 25 to 28 percent [20].During summer period ,high amount of solar energy is generated . The energy receptive cloud computing system minimizes number of

sources and runs only essential services. This exists to be promoted to the direction of cloud verified energy equipment. Fig. 5 shows the interface between the energy-storage control system and the mobile cloud environment for recognizing and controlling the minimal usage of power. The outcome of the above is the less power consumption rates .The Virtualization technologies consent data center to be combined with different servers where each of the workloads are assigned onto a single server. This is further economically managed by separate server and reduces the overall power requirement [21].

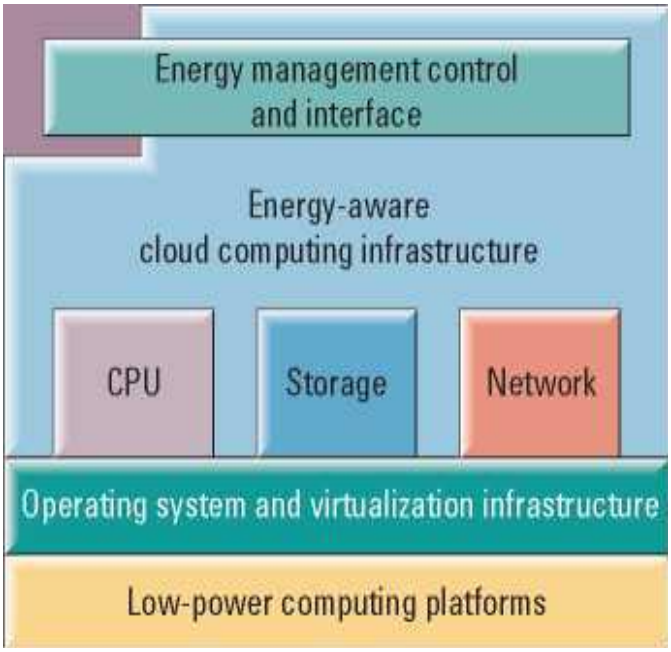

Figure 5. Cloud computing and energy management system uses the lower power

The below table 1 explains and helps answer a few methodological questions:

Table 1. Methodological Motivations

Questions:	*Motivation:*
Why is energy efficiency important?	Energy efficiency is important to improve overall understanding of the way energy consumed and to preserve the way energy used.
Renewable or non-renewable energy?	Renewable energy is more viable and reliable even though it is costly. Non-renewable energy resources release harmful gases into the environment which is not excellent.
How is cloud computing valuable in energy efficiency?	It is beneficial as computing with clouds has surfaced as a valuable standard for controlling the energy consumption and in distributing with the increasing demand for power. There are many different techniques which focus on high power consumption in the overall cloud sector.
Methods to Apply?	Implement the concept of renewable energy schemes in both the large and small data centers which can assist restrain of energy requirement.
IT industry roles?	The IT industry's roll is simple, they can create more evolved techniques to help reduce the overall energy consumed by their big data equipment and to improve on their energy efficiency technologies.
The role of cloud computing?	Cloud computing helps play an excellent part in the world of technology. We can implement larger drives to improve the way energy is harnessed and consumed.

The change of energy is vital for the saving of energy, here are a few energy saving techniques that can use:

Challenges of installation of solar panel for huge data centers

1. Improve the surrounding areas, by developing more evolved data centers. It means improving the output and energy consumed.
2. Implementing greener energy solutions such as solar and wind technology to generate the energy needed to keep large computer systems operational.
3. To maximize the output and improve the computers processing output.
   A. How much power generated by solar panel?
4. Implementing cruel laws and regulations are on IT companies to apply green energy to help decrease the load on the already overloaded electricity grid.
   B. How much power consumption by CDC?
   C. Does A=B?

B. Implementation of small scale routing algorithm
This algorithm minimizes energy consumption by instead of using conventional energy, thus increasing the effective performance up gradation. The Pseudo code has the following steps as given below,

1. Create the network connectivity from Cloud Providers to Data Centers
2. Initialize the source of Solar Energy and Power reading info
   A = Calculated Solar energy (1359.77 kWh generated by 1 m^2 solar panel)
   B = Power consumption rate of small scale (CDC 1360 kWh)
   C = Yes A ⇔
3. Send the request from cloud provider to data center
4. By applying the sampling data technique ,it returns to the cloud provider
5. Get the Power screen Log information for a particular time
6. Set the range of solar power generation equal to 1 CDC
7. Based on the routing and estimate the solar power consumption
8. Get the optimal Green Power path
9. Get the measured route table
10. Power on/off
11. Return the path way

Table 2 shows the data of power consumption by means of iteration 1 at a small scale cloud data center. Cloud providers carry out this task by executing iteration 1 &evaluate the result of idle state and active state of power consumption. Here, the power consumption is measured; all the interfaces powered by the effective utilization of energy source. Consequently the power consumption of a crossing point can be recognized. This Virtualization cloud data centers are well suitable in two areas. First it associates with several workloads onto a small number of servers, lifting operation levels and increases efficiency. Second, the cloud data center make scheduling decision for allocating resources & run task. It is a vast extent and more active because cloud technologies promote dominant device portion within a single server [22].

Table 2. Iteration 1 information

Small scale data center	
IP access controller	Virtual Machine
Controller Port	8086
Power consumption	1359.77 kWh
Energy Source ID	
Solar power generation	1360 kWh
Solar power price	Rs. 3.5 /kWh
CO2 emission rate	0.010 kg/kWh

V. RESULTS AND DISCUSSIONS

A. Small scale routing algorithm
Small Scale Routing (M, r, bw).

Input:

M (V, E, L) Cloud data center network Structure and link;
r: Flow Request
bw: band width for the flow

Output:

P: Path for flow
1. PathX: Get_all_path(M,r)
2. PathY: Get_available_path(PathX; bw)
3. if PathY is empty then return Zero
4. else
5. for pathy in PathX
6. I←0
7. M'=Add_network_utilization(M, pathy, bw)
8. Pow[i]=Get_pow(M')
9. I←I+1
10. end for
11. index←Get_Index (min(pow))
12. return PathX[index]
13. end if

Determine the routing path for each & every step flow of execution. It is necessary to spawn a subset of the network structure in All Pairs of paths. This algorithm is an easy and simple solution for power consumption (See Algorithm1). For each flow, the algorithm determines that all possible paths (lines 1–2); also it traverses all pairs of paths and makes decision to choose an optimal feasible routing path with the least usage of total network power consumption (lines5–13). The evaluation of power consumption method is mainly depends on the power models derived from measured data (line 9).

The foundation requires the locality planning and data center design. It does not require an external cooling system. During that work progress, if any conflicts rose, then the complete data centre is to be replaced. Thus, the renewable power plant is executed under the exact location of the data center. It will reduce the considerable negligible losses in the system. This is happened in the conventional way of renewable power resources. Whereas, the green data centre is described with the routing path algorithm for the minimum cost, energy consumption and an adverse effect of an environmental impact. Hence, data centre with renewable

power resources that take less execution time. The Small capacity of mini data centers can be connected with the power grid which enhances higher efficiency. Small battery storage, high power turbines were used to stable transmission and also drawn out the execution.

Despite, low efficiency of this renewable energy conversion in the solar panels are required large footprints. It conserves renewable energy in medium to large size of data centers. Still, the small data centre provides for the much more extensive usage of renewable energy. Green mobile data centre is mandatory because of the Earth's population approximately as 7 billion. There are 1 billion people without electricity, mobile phones, and almost 4.7 billion people without computers and the Internet [23, 24]. Today's mobilization World with energy consumption is known to be major enablers for a higher quality of life and so need for the generation of electricity overgrowing. This innovative concept is designed in the way that it facilitates broad access to data information. Mobile green computing is proceeding in economic growth by decreasing its costs and winning energy precincts.

The outcomes are analyzed and evaluated by the criteria of power consumption in mobile cloud environments. This is done by examining the impact of solar photovoltaic system configurations. This Solar DC power supply in the data center overcomes all the issues of an inefficient transformers .Also it results in less cost and minimum number of data center footprint [25]. The green solar power system estimated the entire data center cost. It shows that, 42% of the power by the air conditioning systems [26]. The first section mentioned about the application of solar power in the system. Free Launch [27] is a mobile cloud data centre architectural design with the viability of green cloud data center elements. The free launch is based on three starts up of sustainability: (a) use of onsite solar power within remote cluster of Corporate Data Centre, (b) high speed network connectivity between two CDC centers, and (c) Virtual Machine system based on workload progress. This study was explained that the importance of virtualization concepts, mobile cloud data centre structure and solar technologies for sustainable CDCs. This assures that the developing demands of mobile cloud computing [28]. It needs the system of energy features which has received less attention [29]; as that can be munificent with the challenges in the working environment [30]. The requisite of energy efficiency at different bands of the cloud environment is recognized significantly, as demonstrated by Djemame et al, [31]. It analyzes on energy efficiency at all bands of the mobile cloud data center and the entire cloud. This cloud computing services are based on the provision of the system through relocation of data centers [32].

The major discussion needs to address concerning the integration of solar power to cloud data centre. We have explained the energy consumption in cloud infrastructure.

It shows the less energy usage and increased efficiency in the utilization of computing devices and execution time. It was achieved by high solar energy and less power consumption. Today's Mobile environment focused to concentrate on proper mobile resource management. The shortest path routing algorithm was applied in all mobile cloud platforms It produces high throughput during data transmission. It is not power-aware, but it could be with less execution time. Emblematic examples entail the environment. It looks over email and matching it through Wi-Fi network during night times. The various ad-hoc methods are available to decrease power consumption by these applications. But, this is inefficient to keep adequate energy on mobile devices. Mobile clouds services are carrying out computing infrastructures, networks, and mobile devices. MCC data centre is composed of data centre networks and its components. Energy consumed by mobile network is the same as for both download types of data and information. The requirement of mobile data center consumes large amount of energy based on the user's demands. The cloud merchants need to secure the retrieval of data when there is a data loss. Also, they have to get the data in the cloud cannot be hacked by any offensive users [33].

VI. CONCLUSION

We have explained in this paper about the solar energy usage and the total power consumption in mobile cloud environments. The green data center model present an entirely new move towards mobile cloud data centre network execution with green renewable energy power plant. In this concept, we described an energy consumption and mobile offloading storage. Moreover, we present universal power generation models of idle and active server of networks. We also discuss the evaluation and assortment of small-scale routing algorithm. This is an initial prototype of energy consumption model. This prototype version explains that the computation of the energy, cost and sustainability under cloud service providers. The small-scale routing algorithm determines that the minimum shortest path of optimal energy. This research is essential for developing potential energy focused on minimization of power consumption under cloud environments. The future work, we will explore for numerous mobile cloud environments and propose green energy power concept with less emission of the carbon dioxide in mobile cloud environment. The solar-powered cloud data centre network can be the next generation of escalation in our global mobile communications world.

REFERENCES

[1] P. Mell, T. Grance, *The NIST definition of cloud computing*, National Institute of Standards and Technology, Vol.53, Issue.6, pp. 1-7, 2009.

[2] D. Gielen, *Renewable Energy Technologies: Cost Analysis Series*, Solar Photovoltaic's, Vol.1, Issue.4/5, pp. 1-52, 2012.

[3] A. Qureshi, *Power-demand routing in massive geo-distributed systems* (Ph.D. thesis), Massachusetts Institute of Technology, 2010.

[4] C. Ren, D. Wang, B. Urgaonkar, A. Sivasubramaniam, "*Carbon-aware energy capacity planning for data centers"*, In the Proceedings of the IEEE MASCOTS, IEEE Computer Society Washington, DC, USA. pp. 391-400, 2012.

[5] G. Piro, M. Miozzo, G. Forte, N. Baldo, L.A. Grieco, G. Boggia, P. Dini, *Hetnets Powered by Renewable Energy sources: Sustainable Next-Generation Cellular Networks*, IEEE Internet Computing, Vol.17, Issue.1, pp. 32–39, 2013.

[6] H. A. H. Hassan, L. Nuaymi, and A. Pelov, "*Classification of Renewable Energy Scenarios and Objectives for Cellular Networks*," Proceeding of the IEEE PIMRC '13, London, UK. pp. 2967-2972, 2013.

[7] https://apprenda.com/library/architecture/the-three-tier-model-of-cloud-computing/

[8] E. Masanet, A. Shehabi, J.Koomey, "*Characteristics of low-carbon data centers*, Nature Climate Change", Vol.3, Issue.7, pp. 627-630, 2013.

[9] A. Uchechukwu, K. Li, Y. Shen, "*Improving cloud computing energy efficiency"*, Cloud Computing Congress (APCloudCC). IEEE Asia Pacific. pp. 53-58, 2012.

[10] W. Deng, F. Liu, H. Jin, B. Li, D. Li, "*Harnessing renewable energy in cloud data centers: opportunities and challenges",* IEEE Network, Vol.28, Issue.1, pp. 48-55, 2014.

[11] S. Mustafa, B. Nazir, A. Hayat, S.A. Madani, "*Resource management in cloud computing: Taxonomy, prospects, and challenges"*, Computers & Electrical Engineering, Vol.47, pp. 186–203, 2015.

[12] E. Or o´, V. Depoorter, A. Garcia, J. Salom, "*Energy efficiency and renewable energy integration in data centers. Strategies and modelling review"*, Renewable and Sustainable Energy Reviews, Vol. 42, pp. 429-445, 2015.

[13] I. Goiri, K. Katsak, T.D. Le, Nguyen, R. Bianchini, In: SIGARCHA CM, editor. "*Parasol and greenswitch: Managing data centers powered by renewable energy"*, ACM SIGARCH Computer Architecture News, Vol. 41, Issue. 1, pp. 51-64, 2013.

[14] D. Ren, B. Wang, Urgaonkar, A. Sivasubramaniam, "*Carbon-aware energy capacity planning for datacenters*", International Symposium on Modeling, Analysis & Simulation of Computer and Tele-communication Systems (MASCOTS), pp. 391–400, 2012.

[15] I. Goiri ´, W. Katsak, K. Le, T.D. Nguyen, R. Bianchini, "*Designing and managing data enters powered by renewable energy",* IEEE Micro, Vol.34, Issue.3, pp. 8-16, 2014.

[16] Y. Zhang, Y. Wang, X. Wang. "*GreenWare: Greening Cloud-Scale Data Centers to Maximize the Use of Renewable Energy",* 12th International Middleware Conference (MIDDLEWARE), Dec 2011, Lisbon, Portugal. Springer, Lecture Notes in Computer Science, LNCS-7049, pp.143-164, 2011.

[17] C. Pandi selvi, S. Sivakumar, "*Constraint Programming approach based Virtual Machine Placement Algorithm for Server Consolidation in Cloud data center"*, International Journal of Computer Science and Engineering, Vol.6, Issue.8, pp. 91-95, 2018.

[18] M. R. Sudha, M. Sornam, "*Differential Evolutionary Algorithm for Energy Efficiency Improvement on Mobile Cloud Computing"*, International Journal of Control Theory and Applications, Vol.9, Issue.40, pp. 1149-1156, 2016.

[19] Measurement and Instrumentation data center, http://www.nrel.gov/midc/

[20] S. Bergqvist, "*Energy Efficiency Improvements using DC in Data Centers*," master's thesis, Uppsala Universitet, 2011.

[21] G. Laura Grit, I. David, Y. Aydan, C. Jeff, "*Virtual Machine Hosting for Networked Clusters: Building the Foundations for Autonomic Orchestration*", 2nd International Workshop on Virtualization Technology in Distributed Computing (VTDC 06), ACM, pp. 7, 2006.

[22] E. Berl, M. Gelenbe,G. Di Girolamo, H. Giuliani, M. De Meer, K. Quan Dang, Pentikousis, "*Energy-Efficient Cloud Computing"*, The Computer Journal, Vol.53, Issue.7, pp. 1045-1051, 2010.

[23] S. Dutta, W. H. Dutton, G. Law G. "*The new Internet world: a global perspective on freedom of expression, privacy, trust and security online",* World Economic Forum; pp. 1-35, 2011.

[24] C. Sharma, "*Global Mobile Market Update*", http://www.chetansharma.com/GlobalMobileMarketUpdate2012.htm, 2012. [(accessed 9.12.12)].

[25] M. Ton, B. Fortenbery, W. Tschudi, "*DC Power for Improved Data Center Efficiency*", Lawrence Berkeley National Laboratory, pp. 1-74, 2008.

[26] *Guidelines for Energy-Efficient Data Centers*,white paper, The Green Grid Consortium, 16 Feb. 2007; www.thegreengrid.org/~/media/WhitePapers/Green_ Grid_Guidelines_WP.pdf?lang=en.

[27] S. Akoush, R. Sohan, A. Rice, A.W. Moore, A. Hopper, "Free lunch: exploiting renewable energy for computing", Proceedings of the 13th USENIX conference on Hot topics in operating systems, pp.17–17, 2011.

[28] R. de Lemos, H. Giese, H. Müller, and M. Shaw. 10431 Report - Software Engineering for Self-Adaptive Systems. In R. de Lemos, H. Giese, H. Müller, and M. Shaw, editors, "*Software Engineering for Self-Adaptive Systems"*, number 10431 in Dagstuhl Seminar Proceedings, Dagstuhl, Germany, 2011.

[29] N. Qureshi and A. Perini, " *Engineering adaptive requirements*", ICSE Workshop on Software Engineering for Adaptive and Self-Managing Systems, IEEE, pp. 126–131, 2009.

[30] Camara, R. De Lemos. "*Evaluation of resilience in self-adaptive systems using probabilistic model-checking*", 7th International Symposium on Software Engineering for Adaptive and Self-Managing Systems (SEAMS), IEEE, pp. 53–62, 2012.

[31] D. Djemame, R. E. Armstrong, A. J. Kavanagh, D. G. Ferrer, D. R. Perez, J. C. Antona, C. Deprez, D. Ponsard, M. Ortiz, J. Macıas, F. Guitart, J. Lordan, R. Ejarque, R. M. Sirvent, M. Badia, O. Kammer, E. Kao, A. Agiatzidou, C. Dimakis, Courcoubetis, L. Blasi. "*Energy efficiency embedded service lifecycle: Towards energy efficient cloud computing architectur",* In the Proceedings of the Workshop on Energy Efficient Systems (EES'2014) at ICT4S, Stockholm, Sweden, pp. 1–6, 2014.

[32] K.K. Nguyen, M. Cheriet, M. Lemay, V. Reijs, A. Mackarel, A. Pastrama, *Environmental-aware virtual data center network*, Computer Networks, Vol.56, pp. 2358-2550, 2012.

[33] S. Edel Josephine Rajakumari, T. Daisy Premila Bai, H. M. Leena, "*Analysis of Cloud Computing and Its Challenges*", International Journal of Computer Sciences and Engineering, Vol.6, Issue.12, pp.326-329, 2018.

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