Saving Energy through Scalable Architecture

John Lamb, Robert Epstein, Vasundhara L. Bhupathi, Sanjeev Kumar Marimekala

***Abstract*—**In this paper, we focus on the importance of scalable architecture for data centers and buildings in general to help an enterprise achieve environmental sustainability. The scalable architecture helps in many ways, such as adaptability to the business and user requirements, promotes high availability and disaster recovery solutions that are cost effective and low maintenance. The scalable architecture also plays a vital role in three core areas of sustainability: economy, environment, and social, which are also known as the 3 pillars of a sustainability model. If the architecture is scalable, it has many advantages. A few examples are that scalable architecture helps businesses and industries to adapt to changing technology, drive innovation, promote platform independence, and build resilience against natural disasters. Most importantly, having a scalable architecture helps industries bring in cost-effective measures for energy consumption, reduce wastage, increase productivity, and enable a robust environment. It also helps in the reduction of carbon emissions with advanced monitoring and metering capabilities. Scalable architectures help in reducing waste by optimizing the designs to utilize materials efficiently, minimize resources, decrease carbon footprints by using low-impact materials that are environmentally friendly. In this paper we also emphasize the importance of cultural shift towards the reuse and recycling of natural resources for a balanced ecosystem and maintain a circular economy. Also, since all of us are involved in the use of computers, much of the scalable architecture we have studied is related to data centers.

***Keywords*—**Scalable Architectures, Sustainability, Application Design, Disruptive Technology, Machine Learning, Natural Language Processing, AI, Social Media Platform, Cloud Computing, Advanced Networking, Storage Devices, Advanced Monitoring, Metering Infrastructure, Climate change.

I. Introduction

SCALABLE architecture is the key for attaining a sustainability model. The technology plays a vital role in bringing in the scalable architecture to meet the growing needs of the user population. To achieve this, effective modelling of the architecture is important and to achieve sustainability it is necessary to have an infrastructure that is susceptible to the changing technologies, adaptive to the population demands, sustainable to the environment and climate changes. This includes the equipment and systems that are modelled and designed for growing user needs and demands. Typical examples are roads, bridges, telephone lines, power stations, airplanes, IT data centers, cloud platforms etc. As there is an increased focus on reducing carbon footprint, a greater number of IT industries are focusing on bringing in new and renewable methods with modern technologies that could substantially reduce the carbon footprint. More industries are focusing and are adopting the reuse of recycled materials and incorporating Green IT solutions. Proper modelling of infrastructure is key for any IT industry, and it is critical to plan for the robust architecture that could envision the future demands (at least 10 years ahead) and to bring in sustainability. This can be achieved by considering the infrastructure and envisioning the population demands and adoption of modern technologies that drive sustainability model there by reducing carbon emission, promoting recycle and reuse and eliminating waste thus resulting in the cost savings. With the changes in the technologies, the requirement for infrastructure also changes. For example, aircraft are designed to accommodate as many passengers as they could in a limited space while providing best comfort to the passengers.

We all need to help combat global warming. Global warming is a worldwide issue. Both technical and non-technical people need to participate, since science and arts have always gone together. infrastructure is key for any IT industry, and it is critical to plan for the robust architecture that could envision the future demands (at least 10 years ahead) and to bring in sustainability. This can be achieved by considering the infrastructure and envisioning the population demands and adoption of modern technologies that drive sustainability model there by reducing carbon emission, promoting recycle and reuse and eliminating waste thus resulting in the cost savings. With the changes in the technologies, the requirement for infrastructure also changes. For example, aircraft are designed to accommodate as many passengers as they could in a limited space while providing best comfort to the passengers.

There are many aspects of achieving environmental sustainability through scalable architecture. Since the authors have all been involved with scalable architectures for data centers [1], [2], much of this paper is based on scalable data center architecture. Also, much of this paper is based on the July 2018 Springer book by authors Godbole and Lamb: "Making Healthcare Green: The Role of Cloud, Green IT, and Data Science to Reduce Healthcare Costs and Combat Climate Change" [6]. This book and an earlier book by John Lamb "The Greening of IT" [4] are the basis for much of our continued work on environmental sustainability and green IT.

II. Smart Solutions, Sustainable Environment and Green Energy

Data centers need a scalable architecture in order to maximize sustainability. Data centers use a great deal more energy per square foot than other sections of office buildings. Fig. 1 shows the distribution of space and energy costs at IBM buildings [2]. Although data centers are less than 5% of the space cost at IBM, they account for almost 50% of the energy cost.

John Lamb is with Pace University, USA (e-mail: jlamb@pace.edu).

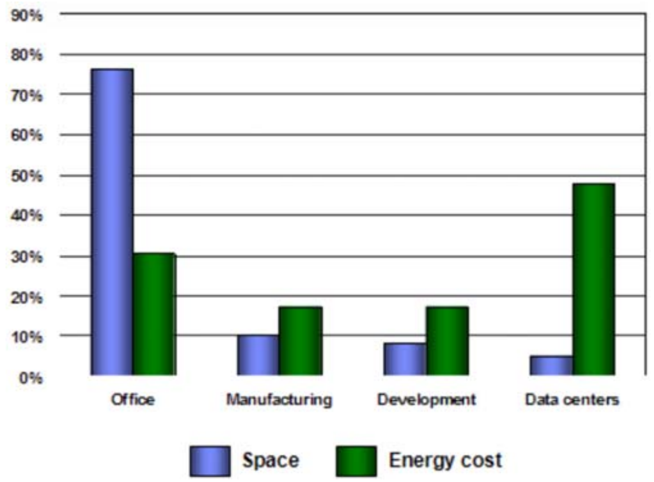

Fig. 1 IBM Distribution of Space and Energy Costs – Year-end 2010 (used by permission)

Studies of major companies indicate that it is not unusual for data centers to account for just 1% of a company's physical infrastructure space but consume about 25% of the power [4]. So, there is a great deal of financial incentive to create green data centers.

We all need to understand the basic aspects of data centers since data centers house the servers that we access when we use Google, Facebook, or any of the many Internet applications used by most IT users [1], [4].

Data Centers are the facilities used by companies that contain servers and other electronic equipment used for data processing, data storage, and communications networking. We all know that Data Centers have become common and essential to the basic functioning of business, communications, academic, and governmental systems. As our economy continues to shift from paper-based to digital information management, data centers have been growing and expanding very quickly. The energy used by data centers is very large. Based on an EPA report published in 2021, U.S. data centers were estimated to have consumed approximately 73 billion KWH in 2020 [11].

Data centers are found in all parts of the economy. The parts of our economy include financial services, media, high-tech, universities, and government institutions. Well-known web services such as Google, Amazon, and eBay, all show strong growth of servers at data centers. Recent estimates indicate that Google maintains over 450,000 servers, that are arranged in racks and located in clusters in cities around the world [18]. Google has data centers all over the world. In 2009, Google opened a data center in Council Bluffs, Iowa, close to many wind power resources for green energy and close to fiber optic communications links. Amazon.com, eBay, and many other companies also maintain thousands of servers in data centers around the globe. Despite these large numbers of current servers, IBM Consulting estimates that in the coming years server shipments will continue to rapidly grow. IBM Consulting also estimates that data storage will grow even more rapidly [4].

III. Scalable and Smart Architecture: Planning and Design

One of the most significant steps that an organization can make in moving to scalable architectures and green data centers is to implement virtualization for their Information Technology (IT) data center devices. The IT devices to be virtualized, include servers, data storage, and desktops used to support the data center. A recent significant change is the transition to a virtual IT world of the future using private cloud computing. Private cloud computing is becoming common in many of our data centers. Although cost reduction is usually the reason for virtualization, in many cases the main reason for the path to virtualization is IT flexibility. The cost and energy savings that come with consolidating hardware and software are very important benefits and are a nice complement to the flexibility benefits. The use of virtualization technologies is most often the first and most important step we can take in creating energy efficient and green data centers.

A. Many Reasons for Creating Virtual Servers

A good reason for creating virtual servers is indicated in the following scenario: We suppose that a company needs to add additional server capacity at the company's data center. Also we suppose that there are two identical servers at the data center, each running different Windows applications. Let's assume that the first server, Server A, is lightly used, reaching a peak of only 5% of its CPU capacity and using only 5% of its internal hard disk. The second server, Server B, is using almost all of its CPU (averaging 95% CPU utilization) and has almost run out of hard disk capacity (e.g. the hard disk is 95% full). Therefore, Server B has a serious problem. However, when we consider Server A and Server B as one big server, on average the servers together are only using 50% of their CPU capacity and 50% of their hard disk capacity. Now, if we could reconfigure the two servers as virtual servers on a large physical server, the problem would be solved since each server could be quickly allocated the resource each needs. In more recent virtual server technologies, with micro-partitioning, we can dynamically (instantaneously) increase the number of CPUs available on each virtual server by making use of the CPUs currently not in use by other virtual servers on the large physical machine. The basic concept behind this type of allocation, is that each virtual server can get the resource required by the server based on the immediate need of the virtual server.

B. Setup Smart Meters and Gateways

In moving to green IT, it is important to first set up the measurement and monitoring process. It is necessary to first "baseline" the energy use at your data centers. The mantra in implementing green IT and green data centers is "You can't manage what you can't measure".

The place to start is with the data center. Energy use in data centers is mostly from servers and cooling. Fig. 2 shows the process used by IBM for creating energy efficient "green" data centers.

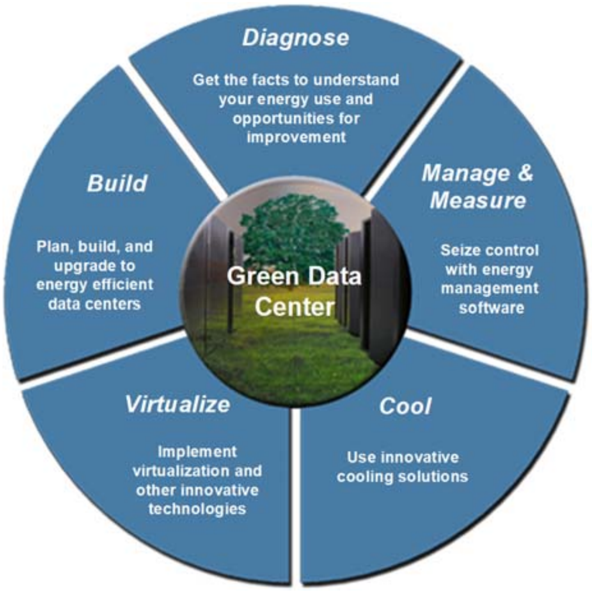

Fig. 2 IBM Project Big Green Approach to Data Center Energy Efficiency (used by permission)

C. Five Step Process for Data Center Energy Efficiency

As indicated in Fig. 2, the five process steps are: diagnose, manage & measure, use energy efficient cooling, virtualize, and build new or upgrade facilities when feasible.

1. Diagnose the Problems and Opportunities: This step requires one to do a data-center energy-efficiency assessment. Many data center energy consultants will bring in tools such as Mobile Measurement Technology (MMT) to help determine areas in the data center where energy is wasted. The areas could include places in the data center where cold and hot air mix too early and thus waste energy. The diagnosis could also include a list of unused IT equipment that can be turned off. Also, the diagnostic phase should be used to encourage organizations to remove software applications that are longer used. Organizations should also be encouraged to consider using more effective efficient software that would require fewer CPU cycles.
2. Manage & Measure: Many hardware products have built-in power management features that are never used. Most major vendors have been implementing such features for quite some time. The power management features include the ability of the CPU to optimize power by dynamically switching among multiple performance states. The CPU will drop its input voltage and frequency based on how many instructions are being run on the chip itself. These types of power management features can save a company up to 20% on server power consumption.
3. Cool: Frequently data centers use hot aisle/cold aisle configurations to improve cooling efficiency. However, there are also several small adjustments that data centers can make. For example, simple "blanking panels" can be installed in server racks that have empty slots. The blanking panels provide a way to prevent cold air in the cold aisle from mixing with hot air in the hot aisle sooner than it needs to. Data center companies should also consider installing chillers and other devices such as air handlers that use more efficient devices such as variable frequency drives which will adjust the speed that the air conditioning system's motors run when cooling requirements drop down.
4. Virtualize: Virtualization continues to be one of the hottest green data center topics. Vendors have said that current server utilization rates typically hover between 5% and 15%. Direct-attached storage utilization sits between 20% and 40%, with network storage between 60% and 80%. Virtualization has the ability to increase hardware utilization by five to 20 times and this will allow organizations to reduce the number of power-consuming servers. Such figures show why virtualization has become a significant topic at all computer conferences.
5. Build: Going Green is easiest if you are building a new data center. First, you make a calculation of your computer requirements for the foreseeable future. Next, you plan a data center for modularity in both its IT elements and its power and cooling. Then one uses data center modeling and thermal assessment tools and software – available from vendors such as APC, IBM, HP and Sun – to design the data center. The next step is to procure Green from the beginning – which partly means buying the latest equipment and technologies such as blade servers and virtualization [4], [7], [8].

Once you have the equipment, you integrate it into high density modular compute racks, virtualize servers and storage, put in consolidated power supply, choose from a range of modern cooling solutions and, finally, run, monitor, and manage the data center dynamics using sensors that feed real-time compute, power and cooling data into modern single-view management software that dynamically allocates resources.

IV. Case Studies for Smart Energy Efficiency Using Scaled Architectures

A. Case Study 1: OnPrem Hosting vs Cloud Offerings

In a 3-tier architecture, we typically have Presentation, Application and Data tiers [13]. The server is the presentation tier, the application server corresponds to the middle tier and the database represents the backend for the application. In the traditional hosting environment (OnPrem) to deploy an application and to host the applications requires multiple compute resources (CPU, Memory, and Disks) and if the application requires High Availability and Disaster Recovery capabilities then the number of compute resources will be doubled. This will cause an increase in the server footprint and computer resources. The server footprint is directly proportional to the complexity of the application. The more complex the application is, the more servers are needed in the traditional hosting environment. In this scenario the Datacenter requires an additional strategy for maintaining power supply in case of a disaster. Additionally, the IT and Facilities department must focus on keeping the site up at all costs even if there is a power outage. This causes a huge burden to the IT Industry sectors on investing in advanced technologies (both Hardware and Software). Usually, the life spans of such strategic solutions for HA and DR solutions are 3 to 5 years. With the growing competitions in the market the IT industries are facing technical debt in the traditional hosting environments, and this is driving the adoption of cloud-based solutions which are often Hybrid Cloud offerings. The Hybrid Cloud Platforms give the business and application team more flexibility to scale the architecture as needed. The RedHat OpenShift Container Platform is one of such examples. OpenShift gives development teams the power to automate, manage, and deploy applications with RedHat solutions [12]. Thus, it also accelerates the application deployments, provides enterprise grade container platform with no vendor lock in, enables DevOps and innovation. As this architecture is on cloud there will be less consumption of energy and effective utilization of resources. The application team can scale up or scale down the worker nodes (VMs) based on the user demand. If we compare the Hybrid Cloud vs Traditional Hosting, there are many advantages in bringing in the sustainability models. As we know that there are three pillars in the sustainability model (profit, people, and planet), the Hybrid Cloud Environment promotes sustainability by reducing the infrastructure and operational costs, fosters collaboration among various people building social networks and reduces the energy consumption and carbon emission. More studies are conducted in capturing Application Resource Management (ARM) and by using effective tools to capture resource usage and consumption and apply the Artificial Intelligence with predictive algorithms to take preventive measures. There is much focus on application modernization using scalable architecture with the target for modernization, by using cloud native technologies such as containers and microservices and strategize the application migration to the cloud environment [13].

B. Case Study 2: Building a Futuristic Data Center with a Scalable Architecture [6]

Monalisa Healthcare Services, which is located in India, arranges the delivery of healthcare services to people eligible for various government-sponsored programs such as “Health-for-All”, “Affordable Medicare”, and other similar ones. Through licensed health plan subsidiaries, approximately 70 million members are engaged in Monalisa’s healthcare services programs spanning across ten Indian states. Monalisa Healthcare Services also provides primary care through clinics in the states of Punjab and Karnataka through Monalisa Medical.

Monalisa has developed a strategy for the diversification of its IT (information technology) plan considering the new demands on the company’s existing data centers. Monalisa’s data centers deliver IT services to employees across approximately 10 states. To meet the challenges of growth and to be ready for delivering new healthcare services in the future, Monalisa recently built a data center in Noida (in north of India). In the first phase, they plan to consolidate into one data center the operations from five of their data centers. The new data center encompasses 18,000 square feet and houses 250-300 physical machines, 600-700 operating instances, and five storage area networks.

1. The Phases

In the initial planning phases, the design and functionality of data centers were influenced by a few business priorities. First, Monalisa wanted to engage in collaboration among its employees across the organization. They chose Cisco equipment to build their company’s main routing and switching infrastructure because of Cisco’s leadership position in the in the domain of networking solutions. The company (i.e., Monalisa Healthcare) has planned to expand its current communications solutions to include new capabilities, such as instant messaging and Web Conferencing facilities, in accordance with architectural sustainability.

Secondly, the data center was planned in such a way that it could attain gold certification from the LEED (Leadership in Energy and Environmental Design) Green Building Rating System, while supporting redundancy, business continuity objectives, and the company’s anticipated growth. Finally, in the third phase, Monalisa planned to expand its virtualized server environment from 66% to 90% virtualization and to be ready for cloud computing solutions in the future. The CIO (Chief Information Officer) Amar Devkar explains that the new data center of Monalisa Healthcare presents an opportunity to create a brand-new network poised to maximize the latest capabilities of today’s technology. He further explains that the new data center is instrumental in supporting the company’s growth without having to continually retrofit their data centers. Although Monalisa’s IT team is highly accomplished, the company wanted to seek technical assistance for the implementation of its new data center. The nature of the assistance sought included tasks such as managing the migration of their healthcare data and making the new data center fully operational. Monalisa contracted with their implementation partner for their end-to-end technological assistance in the achievement of said objectives (from data migration stage through the operational phase of the new data center).

2. The Approach

The Monalisa team worked with their chosen implementation partner to create an architecture that would meet the company’s current and future needs. Through the Data Center Planning and Design Service, they assessed the project requirements, application environment, and business requirements. Next, a high-level design and BoM (bill of materials) were prepared for the new infrastructure. During the migration phase of the project, physical infrastructure, applications, and data were successfully migrated. In the next step, Monalisa’s voice infrastructure and applications were shifted to the new facility. The implementation partner’s information security expert also aided in developing a strong information security design (as well as data privacy considerations) to meet Monalisa Healthcare’s needs for the protection of PHI (protected health information) i.e., authentication, authorization, and accounting; data integrity, forensics, and security policy and compliance; event management; and VPN requirements [9], [10].

As Monalisa Healthcare moves forward with its virtualization and collaboration plans, they have decided to continuously improve network performance, prepare the network for change, and help the Monalisa IT team succeed with new technologies. Monalisa management has gone for all the state-of-the-art technology, the latest generation switches and unified computing system which play essential roles in their new data center. The unified computing system enables Monalisa Healthcare to easily scale its data center capacity to meet changing business needs. The selected switches provide the high-capacity backbone of Monalisa's virtualized infrastructure while significantly simplifying system management.

The network design provides architectural flexibility to connect servers today with either 1-Gigabit Ethernet (GigE) or 10-GigE while preparing for deployment of Fiber Channel over Ethernet (FCoE) connectivity in the future. One operating system and a single point of management through the 5000 switches simplify provisioning, deliver operational consistency and transparency, significantly reduce the time required to add network capacity, and reduce the cost of cabling infrastructure. A single 10-GigE connection between servers and the computing platform supported Monalisa's virtualization strategy while greatly reducing the costs associated with ports, cables, adapters, and cooling requirements.

3. Achievements

The implementation partner helped Monalisa Healthcare implement its new data center on time and under budget while delivering right-sized capabilities for its needs. They consolidated multiple centers thereby extending its virtualization initiative and they simplified the management of their healthcare data. The objective for Monalisa management was to significantly reduce its circuit, facility, and energy costs. They are confident that having the right footprint on the network, storage, and server side will allow them to have a lower cost structure and be more competitive. Monalisa anticipates cost savings to the tune of 20% using unified computing architecture. The new data center provides a foundation for supporting Monalisa's growth over the next five years. With the state-of-the art switches and the use of unified computing systems at its backbone, Monalisa's infrastructure will enable them to reach its 90% virtualization goal and reduce operations costs while maximizing application performance. The new IT and networking architecture will also provide a transparent environment for scaling operations, allowing Monalisa Healthcare to easily add new product lines, deliver new constituent services, or integrate company acquisitions without having to redesign the network. The unified architecture will simplify management of all Monalisa's resources. The new data center also supports Monalisa's healthcare service collaboration initiatives. Together, these solutions create an integrated collaboration platform that enables employees to communicate more easily. After implementing collaboration technologies, Monalisa's staff is finding that meetings have become more efficient. The teleconferencing systems implemented are also helping the delivery of healthcare services through Tele-medicine practices.

C. Case Study 3: The Super Gem Hospital in India

In Case Study 3, we have a perfect example of how a hospital in India has modelled the hospital bed layout and architected the building to effectively utilize the resources and cut down energy costs by maintaining proper ventilation in the hospital building [3], [5], [6]. In this process the hospital has also used recycled materials and is the perfect example of sustainability model. This use case describes how the hospital took measures in reducing energy costs while adopting the latest technologies and efficient modelling of hospital beds for proper ventilation while conserving the energy,

This case study is on a sustainable hospital in India. It is the Super Gem hospital whose real name has been masked for privacy reasons [6]. The Super Gem hospital is in one of the suburbs of Mumbai, in the Maharashtra state of India. The Super Gem Hospital is a 227,000 sq. ft., 150 bed facility. It is housed in a building that has two basements and five floors. The hospital has obtained the highest rating possible (i.e., the platinum status) that is available under the LEED Certification scheme. The Super Gem Hospital is the world's second LEED-platinum certified hospital and Asia's first. This hospital has been awarded 54 credit points and is the only LEED certified hospital in Mumbai, India.

The management of the Super Gem Hospital understands that patient recovery is much faster when the hospital has connectivity with its external environment, the daylight is better, and the quality of the indoor air is better. In this multi-specialty hospital, a range of energy-efficiency measures have been implemented with the main objectives of reducing the overall energy consumption and decreasing GHG emissions. Of the construction material used for Super Gem Hospital more than 40% was recycled material. The foundation of the overhead tank was built with reused scrap material and frames were made by using salvaged wood; this helped to conserve trees.

The hospital design has incorporated the use of natural lighting in the patient areas to reduce the consumption of electrical energy. The large windows and open skylight not only keep the patient areas cool and ventilated but also connects the patients with their external environment. In the hospital building complex, recycled water is used for flushing toilets, cooling of the air-conditioning towers, Diesel Generator sets and for horticulture. This approach has helped them save 40% of the water.

The hospital has insulated walls with very low 'U' value. Its energy use intensity is 53 kilo-BTU per sq. ft. per year. There is an optimal window-to-wall ratio and uses shaded windows. High performance glass has been used for the windows of Super Gem Hospital. The hospital's artificial lighting constitutes 20% of the overall energy load. This has resulted in 50% savings. The use of LED and low LPD (Lighting Power Density) results in substantial reduction in internal heat gain. The hospital has an efficient system for handling the waste generated. 100% of the waste produced is recycled or re-used or given away for use by the local community. As compared to other building constructions, the hospital circulates 30% more pure air.

The time switches used in the hospital are programmable based on the timing of sunrise and sunset. These switches function without the use of light sensors. This not only saves the amount of electrical energy but also increases the life span of lamps, thereby further reducing the solid waste of the hospital. By virtue of being 'green', the building of Super Gem Hospital consumes 0.66 watts per sq. ft. as compared to a normal construction that would consume 2.0 to 2.5 watts per sq. ft. The green roof used for the hospital building provides insulation from the outdoor environment. Solar panels are installed on the top of the hospital building to harvest the solar energy derived from the sun. This solar energy is used in GEM hospital to heat water and to maintain the required humidity level in the operating theatres.

The HVAC (Heating, Ventilation and Air Conditioning) design of the Super Gem Hospital includes chilled water plants which consist of energy efficient screw chillers. These chillers are driven by VFDs (variable frequency drives). The building design of Super Gem Hospital is based on integrated building design system. All parameters of the HVAC are controlled by the BAS (Building Automation System). The BAS also controls electrical services utilized in the hospital, its elevators and fire protection system. The hospital's Direct Digital Control (DDC) system interfaces with sensors, actuators, and environmental control systems to carry out various functions of energy management, alarm detection, time/event/holiday/temporary scheduling, communication interface/control and building maintenance and report generation. The electrical system of the Super Gem Hospital uses the latest technologies and fundamental principles of energy conservation and safety to provide protection against thermal effects, electric shocks, over current, fault current as well as protection against over voltage. The use of light sensors is made in the hospital building to switch off lighting whenever space is not occupied or whenever natural lighting is available.

V. Different Ways to Promote Green Initiatives

In order to measure green IT, we must have standards as to what constitutes green IT. The standards are IT energy-use metrics. Promoting green initiatives is part of the social responsibility aspect of solving the climate crisis.

We have looked at the measurements for IT energy use. However, there are also measurements for green buildings. A very significant set of measurements for green buildings is provided by the LEED Green Building Rating System, developed by the U.S. Green Building Council (USGBC). LEED has a detailed list of standards for construction that is environmentally sustainable. LEED does not relate directly to green data centers, but rather to the overall building.

Another metric for green IT is EPEAT, the Electronic Product Environmental Assessment Tool. EPEAT was created through an Institute of Electrical and Electronics Engineers (IEEE) council because companies and government agencies wanted to put green criteria in IT requests for proposals, such as SPEC marks and the metrics being developed by the EPA. The EPA is pushing for metrics for all aspects of data center use and the EPA metrics should be the guideline for green data centers.

The Standard Performance Evaluation Corp. (SPEC) benchmark information has been used for years to compare servers from a power aspect. Based on the author's experience, companies are very interested in SPEC marks when comparing new servers. Companies use SPEC marks to compare the relative power usage for the new servers they are considering buying. A reference for the SPEC homepage is [17].

A. Energy-Use Dashboards at Montpelier, France

There is an IBM demo data center in Montpelier, France, called the PSSC (Products and Solutions Support Center) Green Data Center of the Future [4]. The main idea was to create a customer friendly real-time green showcase production data center that will demonstrate a large percentage of the currently available best practices in IT and facilities energy conservation, integrating at least one bleeding-edge major conservation technology. Live camera, or a thermal camera, and green IT energy use real-time dashboards, are interesting innovations that can help communicate the energy efficiency of the data center to all interested employees.

The Power Usage Effectiveness (PUE) is the metric used to measure the energy efficiency of a data center. Both IT and non-IT resources' energy consumption are gathered. Two PUEs are measured: overall and high-density zone.

B. Smartbank – Smart Green Infrastructure Monitoring at the Solution Level

Smartbank is a monitoring system that will perform monitoring at the Solution Level. Monitoring of an entire solution can be done using Smartbank. Another tool called Active Energy Manage can be implemented for energy management of Z10 and Blades.

VI. New Technology for Green IT

Here are some of the emerging technologies that could be used to improve green IT at an organization.

A. Fuel Cells for Data Center Electricity

Fuel cells have been used to power some data centers. In many cases, the polluting diesel back-up generators on which most data centers rely, could be replaced by fuel cells. In 2008 Fujitsu began using a fuel-cell generator to power its data center in Silicon Valley. Fuel cells could also be used in an emergency or during peak demand in order to take some of the load off the grid. Hydrogen powered fuel cells are very environmentally desirable since the only output, in addition to energy, is water.

B. Other Emerging Technologies for Data Centers

Energy costs will most likely continue to rise in the future as will the computing requirements of most organizations. If you take steps today to increase the efficiency of the cooling system, you can offset the impact of rising energy costs when newer, higher-efficiency technologies are deployed. Three technologies that have potential to significantly enhance data center energy efficiency are:

- Multi-core processors

- Embedded cooling
- Chip-level cooling
- SSD (Solid State Device) technology

Most newer servers are now based on multi-core processors which allow a single processor to handle several separate tasks at the same time, or run multiple applications on one processor, or complete more tasks in a shorter amount of time. Chip manufacturers state that multi-core processors can reduce power and heat by up to 40% [4].

An important emerging technology for data centers is embedded cooling. This technology allows the cooling infrastructure to provide high efficiency cooling directly inside the rack. This technique brings cooling very close to the source of heat and provides the ability to have the cooling system optimized for a particular rack environment. This type of system will prevent heat from the system from entering the room by removing the heat before it leaves the rack.

Chip-level cooling is a technology that takes the embedded cooling approach to the next level by helping to move heat away from the chip. As embedded and chip-level cooling solutions are deployed, a highly efficient three-tiered approach to data center cooling will emerge. In this approach, heat is effectively moved away from the chip and then cooled in the rack, with stable temperatures and humidity maintained by room air conditioners. These developments are not expected to reduce data center cooling requirements. Instead, they will result in an increase in the amount of computing power that can be supported by a particular facility. Thus, any efficiency improvements made at the present will continue to reduce energy use well into the future since the new developments will allow existing data centers to support server densities that are not possible with the current technologies.

The cooling system serves as a very important opportunity to improve efficiency. Often, quite simple, and non-expensive changes - such as improving room sealing, moving cables or other objects that obstruct airflow or installing blanking panels – will provide immediate dividends.

VII. Conclusions

In this paper, we have focused on the importance of architecture and how scalable architecture can drive the sustainability model across an enterprise. With our use cases, we have learned that technology and scalable architecture play a vital role in creating a sustainability model. With the growth in user population there is always a constant demand and need for developing important measures to save energy, cut down greenhouse gas emissions and adopt Green IT solutions that drive the sustainability model across the enterprises. In this journey we all have a vital role to play in bringing social awareness about recycling, reuse, and conserving energy. The future depends on how effectively we focus in making use of Green IT solutions with a vision of scalable architecture that is resilient to population demands focusing on sustainable environment.

Going forward, we in IT all have a role in helping improve the outlook for Green IT by contributing to IT infrastructure electric energy sustainability, and the continued improvement in cloud computing for IT cost reduction along with improved data protection. As discussed in this paper, a scalable architecture, for the building, your data center (using cloud computing and virtual servers) can have a very significant impact on environmental sustainability in an enterprise. Climate Change, and the use of IT energy efficiency and other solutions to combat the impact of climate change, will continue to receive much needed attention [14]-[16]. All of us need to help combat climate change.

References

[1] N. Godbole and J. Lamb, “Using data science & big data analytics to make healthcare green”, CEWIT 2015, October 2015.
[2] J. Lamb and S. K. Marimekala, "Smart Green Infrastructure for Innovation and Transformation Hosting Environments", CEWIT 2013, October 2013.
[3] N. Godbole and J. Lamb, “The Triple Challenge for the Healthcare Industry: Sustainability, Privacy, and Cloud-Centric Regulatory Compliance”, CEWIT 2013, October 2013.
[4] J Lamb, The Greening of IT: How Companies Can Make a Difference for the Environment, 1st Ed., IBM Press, 2009.
[5] N. Godbole, and J. Lamb, “Calculating a Hospital’s IT Energy Efficiency and Determining Cost Effective Ways for Improvement”, CEWIT 2014, October 2014.
[6] N. Godbole and J. Lamb, Making Healthcare Green: The Role of Cloud, Green IT, and Data Science to Reduce Healthcare Costs and Combat Climate Change. Springer, July 2018.
[7] J. Lamb and N. Godbole, “Smart Energy Efficiency for a Sustainable World”, IEEE UEMCON 2019, October 2019.
[8] M. J. Franchetti, Carbon FootPrint Analysis, 1st Ed, CRC Press, 2013. ISBN 978-1-4398-5783-0.
[9] N. Godbole, Information Systems Security: Security Management, Metrics, Frameworks and Best Practices, chapter 29 and chapter 30, (2009) Wiley India Pvt. Ltd, ISBN 13: 978-81-265-1692-6
[10] B. Dietrich, E. Plachy, and M. Norton, Analytics Across the Enterprise, IBM Press, 2014, ISBN 13:978-0-13-383303-4
[11] EPA. https://www.epa.gov/newsreleases/energy-star-expands-efforts-improve-energy-efficiency-us-data-centers August 2021.
[12] RedHat. https://www.redhat.com/en/resources/openshift-container-platform-datasheet
[13] IBM Information on cloud and three tier architecture. https://www.ibm.com/topics/three-tier-architectureSec
[14] EPA report on data center energy efficiency August 2021, https://www.epa.gov/newsreleases/energy-star-expands-efforts-improve-energy-efficiency-us-data-centers
[15] Romm, Joseph, “Climate Change – What Everyone Needs to Know” Oxford University Press, 2016. ISBN 978-0-19-025017-1.
[16] Gates, Bill, “How to Avoid a Climate Disaster” Alfred A Knopf, 2021, ISBN 978-0-38-554613-3
[17] Standard Performance Evaluation Corp. (SPEC) benchmark homepage: http://www.spec.org/
[18] U.S. Dept. of Energy. Zero Energy Buildings Resource Hub. https://www.energy.gov/eere/buildings/zero-energy-buildings-resource-hub/
[19] Snow, J. “How Artificial Intelligence Can Tackle Climate Change”. Retrieved August 2019, from National Geographic: https://www.nationalgeographic.com/environment/2019/07/artificial-intelligence-climate-change/
[20] Madni, Azad M, et al., “Leveraging Digital Twin Technology in Model-Based Systems Engineering” MDPI, January 2019.
[21] Verdouw C. N. and Kruize, J. W.., “Digital Twins in Farm Management” Precision Agriculture Association of New Zealand, 2019.
[22] David Rolnick, et al. “Tackling Climate Change with Machine Learning”. 2019. https://arxiv.org/abs/1906.05433
[23] https://www.nec.com/en/global/solutions/energy/index.html