

Green Computing, Technology Efficiency and Environmental Sustainability in E-Commerce-A Solutions Framework Perspective

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Abstract-Often interchangeably used, Green Computing, Green IT and Environmentally Sustainable Computing have invariably developed into the technical buzzwords for the Sustainable Development in today's IT enabled and technology driven corporate world. Undeniably, the practice has evolved into a major business paradigm due to this Millennium's ubiquitous global concerns of Environmental, Social and Governance (ESG) aspects for responsible business behavior. Essentially being an Innovation enabler and a technology driven industry, the E-commerce Industry has to recognize and adapt to the merits of Green IT even more. As a late entrant in the online bandwagon and as a strong under-tapped fastest growing online economy, India is in a potentially favorable position to stride towards the adoption of latest top tier global technologies and practices in Green IT to control its fast rising carbon emissions figures. Due to rapid digitalization in India, the E-commerce industry has a promising growth trajectory aiming to target an estimated 175 million online consumers by 2020 [1]. The E-commerce Industry's success roadmap would require a robust infrastructure strategy and planning for backend operations and the implementation of a combination of latest services, tools and deployments including cutting-edge Information and Communication Technologies (ICT), optimized value chain management and logistical delivery channel strategies to handle growing traffic in a sustainable way. This paper explores the available green IT technology and Sustainability solutions available for E-commerce, suggesting a solutions framework. The paper also examines the current IT practices and Sustainability initiatives of E-commerce players in India.

Keywords: *IT Efficiency in E-Commerce, Green Computing, Green IT, Sustainable E-Commerce, Environmental Sustainability in E-Commerce.*

I. INTRODUCTION

The Indian Information Technology (IT) startup ecosystem's growth is largely driven by the ubiquitous online presence of the E-commerce Industry. The Indian E-commerce industry growing at a blistering pace with a strong decadal growth and is growing at an annual rate of 51 percent, the highest in the world. With this phenomenal growth rate, the market is predicted to cross a whopping \$120 billion by 2020 and \$ 200 billion by 2026 [2]. By year 2020, E-commerce industry is predicted to add up about 4 percent to India's GDP [3]. Due to its promising Future prospects, the E-commerce businesses have continued to grab sizable amount of investors focus and funding from India's several blue-chip Private Equity firms. As well as foreign investors, due to the new FDI rules in E-commerce that allows 100 per cent foreign direct investment (FDI) in B2B E-commerce and in automatic route under the marketplace model of B2C E-commerce [2]. With more than 80 million huge customer

base, orders per million have more than doubled from five million in 2013 to 12 million by 2016, which means more opportunities for both consumers and e-Tail companies [4]. With Surge in consumers and sales, online traffic management has become a challenge. Due to large online transactional and processing volumes, the companies are facing technical glitches as their existing technology infrastructure is failing to cater to the demand of the online traffic peaks, making it tough for them to manage their technology backend. This pressure is driving for more investments to build an efficient and robust infrastructure. Since the year 2015, the E-commerce companies in India are strengthening the operational capabilities and IT infrastructure (front-end and back-end) with better technology, processes and strategies for achieving better speed, efficiency and growth to prep for burgeoning market. The main goal is to create open-standards based intelligent yet cost-effective and Energy-efficient offerings for mission-critical applications such as Datacenter, with a

lower Total cost of ownership (TCO). With India's rising power consumption coupled with the global climate change campaign led by United Nations' (UN) Global Compact' Sustainable Development Goals (SDGs) had turned the focus of all major stakeholders on evaluating the strategies for achieving higher energy efficiency and carbon emissions mitigation. The Green IT offers a long term sustainable solution that provides significantly optimized power consumption, reduced carbon footprint, cost savings, a healthier bottom line and better utilization of resources, helping companies achieve a technological competitiveness and leadership in the market. Therefore, a Green IT strategy can become technological advantage for the growing E-commerce sector which is leapfrogging with Infrastructural technological advancements. There is a scarcity of any major comprehensive research or any study on Green Strategy, Green Computing and Technology efficiency solutions focused on environment sustainability for E-commerce in India. Therefore, the study would focus on business need and benefits for E-commerce and evaluate the available Green IT and computing solutions for a Green strategy and environment sustainability for E-commerce in Indian context. The study would also explore the key practices of sustainability measures adopted by major E-commerce players in India.

II. NEED AND BENEFITS FOR ENVIRONMENT SUSTAINABILITY, GREEN COMPUTING AND IT EFFICIENCY IN INDIA

There are several serious issues and concerns that are driving the need for Environment Sustainability and Green Computing and IT Efficiency in India.

II.i. Carbon Emissions- As per Telecom Regulatory Authority of India (TRAI), around 4% of the Green House Gases (GHG) emissions in India are from the Information and Communication Technology sector which is around 80 million tons of carbon emissions every year. It is expected that with more datacenters installations, there will be 122 million servers in use by 2020, further increasing the carbon emissions [5]. This duly highlights a pressing reality that the Information and Communications Technology (ICT) sector is causing major GHG emissions that is responsible for global warming. With the growing E-commerce, the number of Datacenters and servers is going to rise, leading to more carbon emissions.

II.ii. Energy Consumption- It is expected that by 2030, the developing economies such as China and India will account for 45% of the increase in global primary energy demand, more than twice the surge in their energy use over that period [6]. In India, Datacenters growing at 22% CAGR (2015-2020), are expected to have an annual energy consumption of 12,200 TWh by 2017 itself,

plummeting further by 2020. With the escalating electricity and energy prices leading to high operational costs presenting a major business concern among E-commerce players as more datacenter deployments will create increased demand in energy consumption in future.

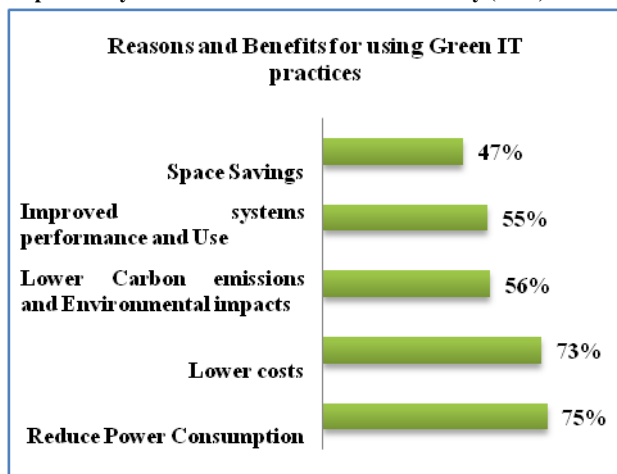
II.iii. E-Waste- As per a study, India is the fifth largest producer of e-waste in the world, generating roughly around 18.5 lakh tons of electronic waste each year, and is projected to generate 52 lakh metric tons (MT) per annum by 2020 [7]. The mounting E-waste figure has been a subject of grave concern in recent years; pushing the Ministry of Environment, Forest and Climate Change to mandate the 'E-waste management rules' in 2016 therein for the first time ever, fixing the manufacturer's role in the process with 'Extended producers' responsibility'. Further, in 2018, the law was amended to register companies as Producer Responsibility Organization (PRO) registration and fix targets for them for E-waste collection [8].

Driven by the rising electricity costs, Green legislation and Corporate Social Responsibility (Mandatory CSR law 2014), green IT is increasingly on many IT professionals' minds, particularly for the power-hungry datacenters, which is bound to increase further with the business and customer expansion. The E-commerce business being more tech-savvy than the traditional Retail format has higher expectations to go green. But, there green credentials are under close watch due to their 24x7 dependence on power guzzling technology such as servers, routers and storage arrays. As the datacenter demand for online services, applications and cloud-based infrastructure continues to plummet, there will be a correspondingly equal rise in the number of datacenters requisite to host and extent of Power needed to continue running them. Based on the facility's business model, Energy expenses have turned into the single largest component of Datacenter's total cost of ownership (TCO)'s, varying from 20% to 60% and this share of the total expenses will only grow to be bigger as the energy prices go up [9],[17]. Numerous Studies have highlighted the key environmental drivers for the E-commerce Industry, the Topmost are energy [10],[11],[12] and resource savings [10],[13].

Benefits- There are multiple benefits for the companies in adopting Green and Environmental Sustainable technologies. Controlling costs is the main critical factor driving the execution of green measures across the organizational functions, as they have a clear impact on the bottom line of the organizations. With IT such a large energy drain for many organizations, firms that cut IT power consumption will reap big benefits. Space comes at a premium due to high realty prices of office spaces, so space saving along with modularity and scalability also remains key concerns. Green computing products are not only scalable and energy efficient, but also are space saving due to high density, modular design and lasting

shelf life. As an energy efficient technology not only boosts the bottom-line of the company by reducing operating costs, but also in the long term, helps the environment (reduced environmental impact due to less GHG emissions, less E-waste, reduced health risk for computer workers and recyclers) and also saves businesses money, therefore it is profitable to go green. A lasting shelf life helps to achieve better returns on investments (ROI) due a longer replacement schedule and thus less waste. Green IT also helps companies to achieve its Corporate Social Responsibility and Sustainability commitments towards its stakeholders, by achieving its Triple bottom line goals (Profit, People and Planet). 'Profit' with reduced operating costs leading to better bottom line; 'People' with improved productivity and flexibility and 'Planet' with reduced carbon footprint and clean energy.

Figure 1-Source: S. Murugesan, "Going Green with IT: Your Responsibility towards Environmental Sustainability (2007)



Also, several global studies have revealed that there is a higher consumer preference and confidence in buying from Green and environmentally responsible companies over other companies. Green IT helps to build a positive brand image & reputation by meeting the environmental compliances and the regulatory requirements, thereby giving extra an edge over the market competition. Though; at an initial stage the CapEx for Green IT is more, but in the longer run its overall benefits and cost effectiveness overcome this issue

III. E-COMMERCE- INFORMATION TECHNOLOGY CONSUMPTION AND IT'S TRENDS

A Fung global retail & technology 2017 research estimated in its India rising report that online retailers in India spent about \$1.8 billion on technology for running their websites and applications in 2015[14].As per 2016 Assocham-PWC study, with the E-commerce platform's rising popularity, the key Industry players are predicted to make investments in tune of \$6-8 billion in logistics,

infrastructure and warehousing over next few years [15]. The E-commerce industry primarily focuses on combining Technology and Data usage. With E-commerce's proliferation triggering voluminous transactions and a soaring consumer base, the necessity for high storage and computing power is becoming indispensable, consequentially leading to an exceptional growth of datacenters in India. The Indian E-commerce players are expected to induce more investments in building a robust and scalable infrastructure for their growing business needs, which is confronted by several infrastructure latency challenges and peak-season traffic loads and outages [16]. Today, the technology demand from E-commerce industry is driving growth trajectory of storage, server and security solutions market. There is a need for cost-effective, agile, scalable and flexible solutions with 99.99% uptime. To this effect, Virtualization and datacenter consolidation strategies facilitate the enterprises to streamline its IT resources and deduce maximum processing power of high-power server and storage devices [17]. As the datacenter demand for online services, cloud-based infrastructure and applications keeps mounting, the number of datacenters needed to host them will rise accordingly, along with their spiraling power needs to keep them running. This phenomenon has prompted several organizations to embrace the computing power of cutting edge software technologies such Cloud Computing, Artificial Intelligence, Big Data, predictive and prescriptive analytics, machine learning and SAAS. In 2016, Microsoft's Wakefield research about Cloud Computing observed that India has the highest rate of Cloud adoptions and is ahead of markets such as UK, USA & Japan in cloud adoption. E-commerce is among the five major sectors that are leading cloud adopters in India [18]. With its communication channels primarily such as SMS, Voice and E-mail, Cloud Communications solutions helps forge an indispensable link between the seller and the consumer [19]. E-commerce companies can ensure a tailored-made customer engagement programs with the execution of effectual and near real-time marketing campaigns using Cloud Communications as a significant enabler for the purchase cycle and marketing activities. There is trend towards Converged Infrastructure. The key factor that is driving the trend of shift towards converged infrastructures among Datacenters is the cloud-based platforms that integrate Big Data analytics [20]. Some other prominent tools such as Artificial Intelligence systems powered by machine and statistical learning in addition to other sophisticated methods such Big Data and Predictive analytics are essentially mechanisms that are helping companies delving through structured and unstructured data and inferring meaningful insights to help augment their business performance and Customer satisfaction levels, in terms of demand forecasting (including customer's next purchase and timing), inventory planning, customer service and engagement.

Further, the E-commerce companies are transitioning towards adoption of SaaS software as a cost-effective way to have real-time multiple user subscription based remote access to software, a shift from traditional information technology model that necessitated incurring huge costs to purchase hardware and license software. Like Cloud computing, SaaS is attaining popularity due to its more predictable fees, lesser upfront expenses and better flexibility for opting for software providers.

IV. FRAMEWORK-COMPONENTS & SOLUTIONS FOR GREEN, EFFICIENT & ENVIRONMENT SUSTAINABLE STRATEGY FOR E-COMMERCE

IV.I. Green Strategy-Experts believe that with business leaders looking towards reducing costs by minimizing energy, water usage and carbon emissions, sustainability and green IT (Green Computing) in E-commerce can be one of the most sustainable models for business growth in the future. Green IT is a key constituent and a substantial contributor towards sustainability strategy. The Green IT or Green computing is an Environmental sustainability strategy that focuses on responsible growth performance with reduced environmental footprint and the detrimental effects of Information and Communication Technology used in an organization. Green Computing, Green Power, Green Use, Green Design, Green Disposal, Green Manufacturing and Logistics are some popular aspects of Green IT. In an E-commerce set-up, the first three aspects can have direct link and can be achieved by:

IV.I.i. Green Design-Designing IT infrastructure using products, services and solutions that have low environmental impact.

a. Energy Efficient Datacenter Design- The energy efficient Datacenter design includes air management (cooling/HVAC), heat recovery and electrical configuration of datacenters (consists of high efficiency and density server and storage) in such a way that reduces the energy consumption to a great level. Modern datacenter design also includes on-site electricity generation and waste heat recycling [21]. Datacenter operators look forward for more efficient low power servers and modular datacenters that are high density, portable, scalable, designed for rapid deployment and are energy-efficient.). In an average Indian Datacentre, a HVAC system consumes nearly 35-40% of the total power demand, bringing forth a scope for substantial power savings. A reduction in cooling costs by over 30 percent can be targeted with the fitment of High-density Supplemental cooling units that can be installed on the top or at the sides of the equipment racks [22]. Another possibility of

significantly bringing down the energy costs by almost 50% and turning green by lowering the facility's carbon footprint is to potentially explore a solution that the datacenter no longer needs the air conditioners and chillers for cooling [23]. This can be likely possible with the use of Free or natural air cooling using outside air reducing the reliance on power hungry air conditioners for cooling. Storage consolidation using high-capacity hard disk drives & eliminating system redundancies, Efficient Server farms, centrally located printing and document management, Power Management and desktop virtualization are key technologies adopted by companies to turn green and reduce costs, resources and consumption. Some other initiatives that could bring Physical Infrastructure energy costs are More Power efficient storage system 6%, more power efficient network equipment 5%, Data storage management technologies 5% and Tiered storage 4% (2010). Furthermore, businesses help drive their Datacenter Infrastructure to be more green and energy-efficient by using tools such as Datacenter Infrastructure Management (DCIM) [17]. The Datacenter infrastructure management tools lead to a greater consolidation of components of IT infrastructure (datacenter design & capacity planning, systems management functions, asset discovery, cooling infrastructure and energy utilization.); efficient layouts; better datacenter availability; more sophisticated monitoring and reporting of energy usage and cooling needs of the infrastructure, which in turn brings down energy expenses. In their bid to boost their green IT efforts, Datacenter virtualization is estimated to be the most widely deployed green IT initiative. As it helps to reduce expenses on services, energy / power, cooling needs and also facilitate in the simplification of administration, management and maintenance, for moving a step more towards green IT [24]. Datacenter virtualization software helps in trimming down the power consumption by creating clusters of virtual resources with the consolidation physical servers. Notably, as the key elements for reducing the energy usage, the Server consolidation and virtualization aids in bringing the consumption down by about 46% and 40% respectively [25]. Also, the utilization of the existing assets is crucially enhanced from under 10% to over 40% with the implementation of Virtualization[9],[17]. Furthermore, Datacenter capital costs can be possibly brought down and energy efficiency can be further enhanced with the deployment of a combination of specialized servers, virtualization and low-latency and high-bandwidth network connectivity [17]. With implementation of best Green IT practices, Datacenter power/Energy consumption can drastically be reduced by almost 40-60%.

- b. **Cutting edge Software technologies**-The Software tools and other innovations that are available that helps improve the efficiency, reliability and cost of power use in the datacenter. Using Software Defined Infrastructure (SDI) for better management and control of IT operations thus ensuring high performance, control capability, optimize resource allocation & energy use & management and reducing wastage. Some of these software technologies include Cloud computing, SaaS, Big data, Artificial Intelligence and Internet of Things (IoT). By providing higher CPU utilization, Cloud computing ensures capital and operational cost efficiency, greener environment, scalability and IT flexibility [26]. After Public Cloud Computing, now Hybrid Cloud Computing is further upping the standards of delivery of digital transformation, with several substantial organizational and costs benefits. For example, one EFX cloud computing server can run about 10-20 virtual servers, thus creating huge savings on infrastructure and overall power consumption. As per Microsoft-Zinnov study, Cost savings varies between 5% and 30% for an enterprise varying in line with the growth of its virtual machines and allocation of workloads transitioning from private Datacenter to public cloud infrastructure. The study sheds light on several noticeable reasons for adoption of hybrid cloud solutions including, lowering the total cost of ownership (54 percent), facilitating innovation (42 percent), enhancing operational efficiencies (42 percent), and enabling companies to respond to and meet customer expectations more readily (40 percent) [27]. The use of Software as a Service (SaaS) eliminates the necessity of physical infrastructure such as the physical servers or the cloud-based software application, thereby reducing carbon footprint of the company. To tackle issues that contribute towards increased energy consumption in Datacenters, numerous companies are driven towards adopting cutting edge technologies, such as Artificial Intelligence etc [28]. There is potential of use of Artificial Intelligence in helping reduce power consumption in Datacenters as demonstrated by its application by Google in reducing its Datacenter Power Usage Effectiveness (PUE). On the other hand, Artificial Intelligence not only helping in enhancing the front-end and back-end E-commerce capabilities but also resulting in significant cost savings, by reducing data processing time and cycles in addition to inventory planning.
- c. **Converged IT Infrastructure**- A combination of servers, disk storage, networking and management software, the Converged IT infrastructure helps in achieving a Future-proof IT infrastructure with decrease in physical machines quantities, lowering the complexity and the maintenance costs. This

Infrastructure medium offers an advantage of capacity flexibility with a faster return on investment (ROI). With the implementation of the converged infrastructure, apart from having faster application deployment, companies witnessed on an average 36% reduction in the operating expenses and an astounding 96% drop in IT downtime [11].

- d. **PC Management-Using efficient technology** at workforce level such as high efficiency PC systems (Using LED monitors over LCD) with PC power management feature in the operating system and efficiency certified power supply units. Reducing energy use by methods such as energy saving settings, turning-off idle computers, desktops and monitors, using sleep mode and avoiding screen savers. Using thin clients such as virtual desktop is another advanced method.

IV.Iii. Green Power-Renewable Energy Sources-The Replacement of traditional fossil fuel based utility power sources and backup mediums (Diesel gensets etc) with the clean Renewable Energy Sources, helps in reducing the carbon footprint of the IT operations and saving on the rising energy costs. This forms a significant constituent and a major building block of the overall Environmental Sustainability strategy. A Typical Green rated building running on renewable power could bring energy savings in tune of 20-30 % yearly.

IV.Iiii. Green Use, Green Disposal, Green Manufacturing and Logistics- Enterprises users can be pushed for promoting device longevity by prolonging the lifecycle of hardware assets and products. Products, Packaging and E-waste must be recycled and reused to lower environmental impact and energy used for new manufacturing, so that the toxic material does not get absorbed into the air, the water or the ground. Such as charities contributions or recycled using certified E-waste management and recycling bodies using proper disposal process. Energy Star Labeled green products (the more the number of stars, higher the efficiency) should be adopted. Manufacturers should focus on making devices better efficiency and recyclable, using less hazardous materials like chromium, lead and mercury in computing devices. In E-commerce, Logistics and Packaging forms a major part of operations, the former contributing to carbon emissions and later resulting in substantial non-biodegradable waste generation. The Green Readiness (g-readiness) of a business's is influenced by its green practice, combined with its supply chain both inbound and reverse logistics [29]. The E-commerce sector must prioritize on environmental sustainability by pushing logistic service providers to achieve sustainable solutions in transporting, rationalizing routes, providing other alternatives and reducing shipment returns, to facilitate a favorable environment and support their businesses [30]. The

companies should aim to access their logistical environmental impacts and reduce them with better planning, sourcing, stocking, shipping, freight, deliveries and returns with the utilization of technology for instance Predictive Analytics and Artificial Intelligence, thereby saving on costs and carbon emissions as well. The mounting tons of plastic and non-biodegradable packaging waste are creating an environmental menace and the wastage generation is expected to worsen with further business growth. Packaging options such as Eco-friendly recycled boxes (Paper and corrugated board), bio-based wraps and bags; inflatable packaging; Lighter packaging using optimal material and design, Bundling goods and E-

Receipts are several of the options to tackle packaging impact issues efficiently.

IV.Iv. Green Communications-Work and communication management using digital mediums such as making use of the internet, telephone and email and greener options such as Videoconferencing and unified communications are also some of the effective ways to bring down travel and commuting costs and its related carbon footprint. These technologies also help to improve work satisfaction and lower operational costs for office space, heat and lighting.

Table 1-Solutions Framework for Green, Efficient & Environment Sustainable Strategy for E-Commerce (Author's own)

GREEN IT TECHNOLOGY DIMENSION	<ul style="list-style-type: none"> • Green IT Design-Server Consolidation and Virtualisation,Datacenter,Software,Power,Cooling,Convergence • Green Power sources • Green Use, Green Disposal,Green Manufacturing and Logistics • Green Communications
GREEN IT SOLUTIONS	<ul style="list-style-type: none"> • Energy efficient Data center- High efficiency and density low power servers and modular storage,Free or natural cooling,Data center virtualization and Infrastructure management,software technologies include Cloud computing, SaaS and Artificial Intelligence,Converged IT infrastructure,PC Management • Renewable Power-Solar Energy and Wind power • Green Use, Green Disposal, Green Manufacturing and Logistics-Better efficiency,Eco-friendly and recyclable, using less hazardous materials Products, Production, Packaging, E-waste and Value chain optimisation • Green Communications-Work and communication management using Digital mediums such as Greener options such as Videoconferencing and unified communications
GREEN IT BENEFITS	<ul style="list-style-type: none"> • Energy efficient Datacenters brings down energy consumption by 40-60%.- <i>Server consolidation and virtualization</i> are help in reducing energy consumption by 46% and 40% respectively.<i>Cloud computing cost</i> savings varies between 5% and 30% depending on cloud type. <i>SaaS (Software as a Service)</i> eliminates the need for physical infrastructure.<i>Artificial Intelligence</i> help reduce power consumption in Datacenters. <i>Converged IT infrastructure</i> 36 percent decrease in operating costs.<i>Cost Savings</i> are Power efficient storage system 6%,More power efficient network equipment 5%, Data storage management technologies 5% and Tiered storage 4%.Mitigating carbon emissions • Renewable Power-Helps in saving energy costs and reduce carbon emissions • Green Use, Green Disposal,Green Manufacturing and Logistics-Help reduce waste & harmful substances,reduce packaging,transportation and resources,saves overall costs, reduce pollution and carbon emissions • Green Communications-Helps saves travel costs & related carbon emissions,saves resources and time.

V. GLOBAL OUTLOOK ON GREEN IT AND SUSTAINABILITY IN E-COMMERCE

A Think ecological survey done in 2009 of 275 professionals (supported by the Business Performance Management Forum, Rackable Systems and Intel) highlighted several points. For Maximum nearly 97%, it was significant for Internet and E-Commerce related companies to cut down on their carbon footprint. Yet the report revealed that merely a slight percentage of the budgets were allocated towards green IT. Of the internet and E-commerce businesses, only 10% or less of the IT budget is being spent by a majority of 83% on purchasing and implementing environmental IT. However, the topmost expected benefits of improved ecological practice were 79% for reducing power and cooling costs and 78% for satisfying social responsibility commitments. The practices of virtualization (47%), consolidation (45%), and

server efficiency (39%) remained top ecological future plans for the next year as prioritized by the respondents [31]. Therefore, the study points to the fact that there are wide gaps between leadership, strategy, focus and adoption for Green initiatives and Sustainable practices in IT, though prioritization and intentions exist.

VI. INDIAN E-COMMERCE PLAYERS AND THEIR GREEN TECHNOLOGY AND SUSTAINABILITY EFFORTS

1. **Snapdeal**-The E-commerce player had not only pioneered the practice of energy conservation with several firsts in the vertical, but also prioritized it, not only for controlling its expenses, but also for its commitment towards carbon emission mitigation. Previously running on a Public cloud computing

platform, in 2016 Snapdeal moved to its own a highly energy efficient Industry's first hybrid cloud computing platform called 'Cirrus'. This led to a 75% drop in its monthly infrastructure costs, noticeably contributing to an enormous impact on its operating expenses and business optimization. Designed for infrastructural efficiency, reduced overall total cost of ownership, improved cost efficiency and scalability, it consisted of high density server racks and automated power management. It was an open source with largest OpenStack deployments (offering optimal performance with optimizes resources via interoperability) of a hybrid cloud anywhere in the World [32]. Snapdeal has developed into the first E-commerce player in India to employ green energy in its warehouse in Gurgaon and Hyderabad in 2016. With a plan for full solar roll-out for all its warehouses, the E-commerce company aims to significantly decrease its power consumption through the use of solar panels having a nearly 1MW power generation capability at peak performance, generating about 1.5 million units per year. Several other Green building design features were incorporated in its operations such as at bigger centers extensive application of sky lights, Roof heat Insulation, achieving 75% energy savings by replacing traditional lighting with LED lighting, to cut cooling and air conditioning costs use of HVLS Fans and installation of auto controllers for lighting systems (to maintain the needed lux levels and changing it as per operating lighting needs), making it to be first company in its field to adopt this technology. Moreover, the company promotes fuel conservation by optimally planning and scheduling the logistic delivery routes to reduce fuel wastage. There is an Off-site energy monitoring system & fuel management system that ensures closer remote monitoring and system alerts to plug excess consumption and leakages [33].

2. **Flipkart-** Flipkart has moved a long way from initially using outsourced Datacenters in an International location, then shifting to India to eventually managing its own Datacenters, and from first using its own private cloud, then combining its capabilities with the computing benefits of a public cloud platform. All this done, to leverage on the Artificial Intelligence, Machine learning and Analytics capabilities for better operational efficiency and achieve scale. In its first Datacenter, the company adopted a high-performance scalable architecture with highly optimized servers and storage that lowered energy consumption by less than 14% at peak performance, along with the lowering of cooling costs and complexity. The optimized hardware was backed by software for resilience, getting the company a computing capability at the least likely price. Recently, the company moved ahead with its new Tier-4 rated Green Datacenter that is claimed to be one of the most energy efficient datacenters in India. A Renewable energy powered Datacenter, it has an overall low PUE equipped with an intelligent power and cooling features, and such as artificial intelligence and machine learning capabilities backing its storage. The company uses energy efficient LED Bulbs (that utilizes 75% less energy than incandescent Bulbs) in

their operations. In an initiative to promote paperless billing, the company launched an online payment solution, PayZippy that caters to card payments for domestic merchant websites and mobile sites. It also employs Artificial Intelligence for effectively improving shipping and deliveries for its logistics and fulfillment operations, its FLIP (Flipkart's mapping platform) considerably resolves the concerns of address –pincode mismatches by reducing misrouting of couriers and improving reliability, assured delivery time and saving on the last mile carbon emissions. The company is coming up with a 100 Acres of Sustainable logistics park near Bangalore, that will be run on Solar Power (Net Power Exporter). It will be a carbon neutral and water positive site using Rain water harvesting techniques along with waste recycling techniques. With the execution of mechanized warehousing and by leveraging technology for intelligent transport management at the site claims to be focused on enhanced supply chain efficiency and reduced expenses [34].

3. **Make My Trip-** Faced with the challenge of frequent travel prices fluctuations from its suppliers impacting its revenues, and with a futuristic plan of outgrowing the market growth within the emerging online travel sector in India, the company planned an efficient IT infrastructure to maximize its profit margins. The company worked towards consolidating its Datacenter that was running its private cloud, on high performance servers and storage. The servers delivered higher performance and could take more loads without increasing density or Energy consumption. The company adopted 12th generation servers (that offered it the advanced power capping options that helped to reduce the costs by limiting peak energy consumption at blade chassis level, server level and Datacenter level during a specified time period) and storage (storage consolidation), provided a virtualized infrastructure that has helped the company to perk up its operational efficiency while reducing management time by 50% and 30% better performance to the site, when compared with the existing hardware. By way of maximizing the compute power on its servers, the company experienced substantial power efficiency and space savings impacting its bottom line immensely [35].
4. **Amazon-** The Company has developed Amazon Web Service (AWS) and Simple Storage Service (SS) as its main system. AWS claims to be a web service that drives efficiencies and offers significant Total cost of ownership (TCO) savings (up to 80% over a 3 year period) to its cloud customers. Amazon Webs Services, the Industry pioneer hyperscale datacenter and cloud services arm of Amazon relies heavily on virtualization based cloud computing using virtual servers catering to more than 75000 customers in India. The service claims to reduce the power consumption considerably, reducing physical infrastructure and auxiliary services such as cooling services promising on an average customer a decrease of 88% CO₂ emissions and 84% less power consumption [36]. In 2011, Amazon Web services was rated second among world's top 10 IT companies with high clean energy index of 26.8% for using clean

cloud power by Green Peace Foundation. In line with its year 2020's global commitment and vision of solar systems deployments on its fifty fulfillment and sortation centers globally, it is making investments in solar energy systems installations in its Indian operations. The Company's two Fulfillment centers (Hyderabad and Delhi) are powered by solar energy generating a total of 1600 kW Solar Energy. The company's seven more Operation sites (5 more fulfillment centers and 2 sortation sites located in Bangalore, Mumbai and Chennai) are expected to go green with large-scale solar power systems generating 8000kW of energy. These Solar panel roof-top installations would be spread over 1 Million Square Feet contributing towards reduction of 9000 tons of carbon emissions in a year. To increase its green quotient, the company is planting more than 10,000 plant saplings around its fulfillment centers. At a Larger level, the Company in partnership with the Government of India has committed to produce 100 GW of solar power by 2022. The Company sensitizes its employees on efficient energy usage of lighting and systems. Amazon also promotes its global Innovations in Environmental friendly Packaging in India, called the Frustration Free Packaging Program (FFP). It is a 100% recyclable simple to open packaging (that promotes no plastic bindings, wire ties, and clamshell casings) with 95% less plastic pouches for Invoices inserts. The packaging claims to eliminate the need for secondary shipping box as Products are shipped in their original packaging. As compared to 2016, by October 2018 the company insists to have shipped about four times the number of products in their own boxes, bringing a reduction in the paper and plastic packaging consumption. In last and two-and-a-half years, for every shipment the company has brought down its plastic usage by over 13% and corrugated boxes usage by over 15%. Furthermore, the Company promoted the bundling of products shipment and by 2017, doubled the instances of a customer receiving a box with multiple products in it, thereby the reducing packaging waste. In 2018, with more box variation options, the Air inside the Amazon packaging boxes were reduced by 30%, making it lighter in weight for better efficiency. The company is exploring packaging-free shipments (reusable crates) option for the selected product categories, delivering within a radius of 70 kms from its fulfillment centre in Bangalore [36], [37], [38], [39].

5. **OLX**-The Online trading platform's business model of online purchases of second hand goods, claims to have helped reduce the carbon emissions based on its 'Resell-Reuse-Reduce' business philosophy. A second hand product once sold, gets an extended lease of life for reuse, thereby reducing an item from production cycle and bringing down its supply chain, manufacturing and logistics linked carbon emissions. This is a sustainability based business model, which promotes sustainable consumption, reduces waste and GHG emissions substantially.

Table-2[Source:-OLX- Centre for Environment Education (CEE) study-OLX's Carbon Emissions Reduction through Used goods Sale]

Year	Total Carbon Emissions Reduced (Co ₂)
2014-15	2.4 million tons
2015-16	3.3 million tons
2016-17	6.6 million tons

VII. CONCLUSION AND DISCUSSION

This study found that the green IT and Sustainability practices is limited to a few bigger Indian and International E-commerce players, instances of industry-wide practices and implementation of technology was found missing. Also, it was observed there are no fixed standards or frameworks available, which are followed by these companies, but a customized approach that suits their business need is followed. Prima facie, their primary motive for adoption of Green IT, Technology efficiency and Sustainability measures suggests the motive is to achieve cost-efficiency driven competitiveness. Their existing IT measures & strategies are more focused towards achieving business proficiency rather than Greening operations, though these companies seems to be moving from standalone efforts to a formal strategy. These Top Players have created a Technological differentiation through their sustainability efforts viz a viz hundreds of E-commerce websites that have mushroomed in hundreds. Therefore, a solutions framework for green, efficient & environment sustainable strategy for E-commerce has been proposed involving best technology and Industry practices to achieve desired cost and energy efficiencies. In spite of their financial challenges and lack of structured strategic planning; Ecommerce players are taking effective steps to cut costs and power consumption, by achieving remarkably lower PUE (Power Usage Effectiveness) scores though it seems more of an ad-hoc Policy.

Compared to the international markets, a decade old Indian E-commerce is a late entrant in the arena and nevertheless is in an emerging stage. At present, even the largest home grown E-commerce players do not possess the same capabilities as their international established counterparts, they have yet to grow large enough to justify deployment of environment friendly technology as a key business and strategic Enabler. The E-commerce companies need to implement Green IT as a strategy at an organizational level. Research into companies that are leaders in environmental performance management shows that Information technology is critical to making green initiatives pay offs. Being an IT enabled industry, E-commerce need do more on sustainability front such as Converged IT Infrastructure, Green energy, and using organization's existing Data mining and sophisticated modeling techniques for solving the environmental challenges and unsustainable business practices. By providing systems to track and manage corporate environmental performance, E-commerce players can mitigate the risks and identify the opportunities that environmental challenges present. On other front, there are multiple aspects that can and should be improved over time such as resource efficiency of Datacenters and offices, Shipping, (Sustainability Shipping Index (SSI), Delivery, Better Packing and managing electronic, chemical and toxic waste responsibly and intelligently.

Today, Sustainability has evolved into a key business imperative, as Environment friendly Green computing can help organizations to grow and shape the future by propelling companies ahead of their competitors, serving as a major differentiator in the Industry vertical by driving performance and fuelling top line progress. With ambitious plans like Digital India, Smart cities, Sector Foreign Direct Investment (FDI), 5G Technology etc are expected to provide necessary investments in India's technology infrastructure and help build a robust and reliable communication network infrastructure all over the country, firming the foundation for India's digital economy. A policy framework for Green Datacenters backed by strong industry wide consultations and research is being developed by Bureau of Energy Efficiency (BEE), duly supported by Indian Green building Council (IGBC), which will further push for adoption of greener IT technologies. The Digital Economy is projected to get bigger in leaps and bounds offering a bright landscape for future growth. Therefore, to create sustainable and innovative legacy online firms should spend judiciously on Sustainable and Green Infrastructure with a vision of reaping wide-ranging long term exponential benefits from digital economy of future. Green IT has immense potential to become the game changer practice for the Indian E-commerce Industry with bottom line cost savings, as a carbon mitigation strategy and as a 'sustainable strategic competitive advantage' for differentiation. This study would help the E-commerce companies to evaluate and benchmark the benefits of Green computing, Technology efficiency and Environmental Sustainability in a all-inclusive manner and help them implement it as an organizational 'strategy' and benchmark against the best practices available in the market.

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