A Practical Guide to Green Computing for Manufacturers, Businesses, and Individuals

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***Abstract*—Concerns related to the environmental harm caused by the production, use, and testing of hardware as well as software, are widespread throughout the world. Additionally, there is a problem that the associated subtasks use more power than they ought to. Into this direction, there is a constant drive towards Green Computing since many businesses and organizations are extremely concerned about their carbon footprint and its associated environmental negative effects. The latter is a novel idea that has gained a lot of attention recently and is promoted as a fresh approach towards making computing more environmentally friendly by reducing the impact of computers on the environment. Given that manufacturers, businesses, and individuals have the opportunity to use technology to help the environment through programs and systems aimed at reducing power consumption and saving energy, a practical guide to Green Computing is proposed in this manuscript. This guide offers an overview of Green Computing, a description of its development, as well as a list of its services, depicting the obstacles to its goal. A list of related Green Computing efforts aimed at both large enterprises and individual users, is presented, whereas specific manufacturers and large businesses already performing Green Computing actions are discussed. The aim of this research is to give up-to-date practical guidelines towards a greener and more sustainable environment with reduced carbon emissions that are caused by energy-hungry computing actions and environmentally unaware decisions.**

I. Introduction

Green computing [1] (known as Green Information Technology (IT) or Sustainable IT) is the process of creating, using, and disposing chips, computers, peripherals, and other technological components in a way that minimizes any negative effects on the environment, such as cutting down on the carbon emissions and the energy used by producers, end-users, and data centers. Basically, this area of computing is concerned with servers, computers, monitors, printers, and related communication and networking systems, as well as the efficient and effective use, production, design, and disposal of Green IT systems with little to no impact on the environment. Hence, it involves creating, developing, getting rid of, and using computers and related equipment sustainably, with little to no negative environmental consequences. Fig. 1 depicts this concept, outlining the basic concepts affecting an IT system towards successfully contributing to Green Computing.

The practice of "going green" is becoming more and more popular as the preferred way to conduct business while protecting the environment [2]. The technique of integrating environmentally friendly strategies into computers' use and daily operations to correspond to the environmental measures requires to foster higher sustainability. Reduced electronic waste, use of renewable resources to promote sustainability, and selection of raw materials from sustainably suppliers are all included in Green Computing [2]. Additionally, it is frequently referred to as the process of designing and developing innovative ways to advance Green Computing technology, primarily targeting on how to enhance the design or production of computers to lessen their impact on the environment.

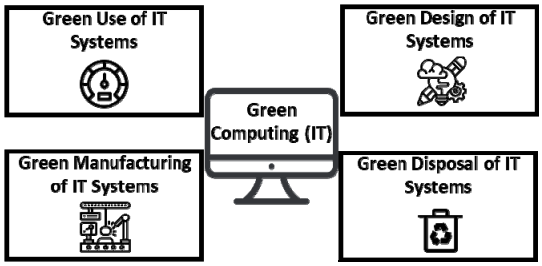

Fig. 1. Basic IT concepts towards Green Computing

In general, it is an undeniable fact that there is a lot of opportunity for Green Computing to benefit the environment. The Information and Communication Technology (ICT) sector is responsible for anything between 1.8% and 3.9% of global greenhouse gas emissions. In addition, data centers now account for 3% of all annual energy use, an increase of 100% over the previous ten (10) years [3]. According to [4], if climate change is to be slowed down in time to prevent irreparable environmental damage, the energy requirements and carbon production of computing and the broader ICT sector must be drastically reduced. Additionally, according to a research in [5], the energy expenditures of IT departments can make up as much as 50% of a business's total energy costs. Thus, businesses need to take sustainability into account when making choices regarding their operations, from their environmental impact to their global business practices.

Being aware of the current situation, nowadays both consumers and IT manufacturers are interested in this new approach to environmentally friendly technology, whilst many businesses in the IT sector are already working to develop Green Computing technologies that can help to increase the energy-efficiency or recyclable qualities of the various exploited systems (e.g., data centers, data platforms) and devices (e.g., sensors, wearable devices). The development of energy-efficient computer devices, the reduction of the use of hazardous chemicals, and the promotion of digital device

recycling are all ongoing investments made by numerous IT manufacturers and suppliers [6]. Thus, the fundamental objective of Green Computing is to improve the use of systems and devices that employ green technologies as well as the development of more environmentally friendly technologies that can assist in reducing emissions and increasing energy efficiency. Because of their increased energy efficiency and newly discovered low waste features, computing systems may be able to maintain their economic value with the help of a proper list of practices for Green Computing. By augmenting energy efficiency, enhancing data management, and supplying sufficient analytical capabilities, it may help enterprises to employ ICT in a more ecologically responsible way.

Every component of contemporary IT, from the tiniest chip to the biggest data center, comes with a carbon cost, which Green Computing aims to lower. Technology creators, as well as businesses, associations, governments, and people who use technology, all play a critical part in Green Computing. Green IT is multifaceted and requires numerous decisions at every level, from large data centers implementing policies to cut energy use to people opting not to use screen savers. Green Computing has the power to alter the environment significantly and favorably, eventually contributing to the reduction of 7% of the world's current carbon emissions [7]. At the moment, the ICT sector is accountable for up to 4% of global emissions, and data storage centers are growing to account for up to 3% of worldwide emissions [8].

Considering the objectives and vision of Green Computing, several research attempts have been introduced over the years, including the work of [9] where the authors present a handbook of energy-aware and Green Computing strategies, introducing specific platforms and architectures, energy-efficient storage techniques, green networking topologies and non-energy-harvesting algorithms, as well as related real-time systems. In [10], the authors have developed a methodology examining significant architectural construction points in the infrastructure, discussing holistic issues for sustainability. Furthermore, the research of [11] should be mentioned, in which the authors are discussing a step-by-step guide towards eco-friendly computing, emphasizing on current trends and related challenges in Green Computing. To this end, the work of [12] addresses the Green Computing vision by introducing its challenges and solutions in critical domain applications, including their research results in green and safe IT systems. Multiple researchers are dealing towards achieving the Green Computing vision, additionally including the works of [13], [14], [15]. However, since technology evolves, considering the most recent studies, a practical guide towards Green Computing does not exist, whereas through our analysis it was identified that most of the existing guides are outdated. Consequently, in this research an up-to-date practical guide to Green Computing for manufacturers, businesses, and individuals is presented.

Towards this direction, the remaining manuscript has the following structure. Section II includes an overview of Green Computing, depicting its evolution, as well as its wide application area. Section III contains the opportunities and the challenges of Green Computing, describing the limitations and the barriers to the ICT domain. Section IV presents the guidelines that could be considered from the side of manufacturers, industries, as well as individuals towards achieving the Green Computing vision. Finally, Section V contains a short discussion of the current research, including a list of conclusions, the lessons learned, and our next steps.

II. Green Computing Overview

A. Evolution of Green Computing

To promote and reward energy efficiency, the Environmental Protection Agency (EPA) launched the United States (US) Energy Star Program in 1992 [16]. This program served as the catalyst for the IT industry's adoption of the sleep mode feature and for several additional initiatives to step up efforts targeting Green Computing. Items that are Energy Star certified must adhere to specific operational requirements and may have features of power management that are missing from non-certified items. The Global Electronics Council received funding from the EPA to extend this initiative, which led to the creation of the Electronic Product Environmental Assessment Tool (EPEAT) [17]. Products that meet certain performance standards, such as those for materials, greenhouse gas emissions from product lifetime, transportation, energy use, to end-of-lifecycle management, are listed in the EPEAT product register.

Prior to Green Computing, the IT sector tended to place more of an emphasis on creating smaller, quicker devices than on increasing sustainability or lowering emissions. Traditional computing is connected with on-premises physical servers and technology, whereas cloud computing signifies a shift towards an ecological approach with a larger emphasis on efficiency. There are numerous projects and certifications aimed at enhancing Green Computing standards via the development of industry sustainability indicators. The Top500 [18] is a list of supercomputers and the applications for which they are employed, while the Green500 [19] is a subset of that list. The energy efficiency of the supercomputers is ranked by the Green500. A nonprofit organization, namely the Transaction Processing Performance Council (TCP), creates performance standards for the transaction processing sector. To increase productivity, SPECPower also develops benchmarks, addressing however the performance and power traits of servers.

B. Green Computing & Traditional IT Systems

Traditional IT systems and Green Computing have a few differences. The main distinction between conventional IT systems and Green Computing, however, is the general ignorance of how technology affects carbon emissions. It is far simpler to place the blame for the causes of climate change on other aspects of daily living, such as peoples' meals or transportation, but people frequently overlook the importance of technology in modern life [20]. This is because conventional IT systems valued faster, thinner devices over the significance of sustainability in technology. On the other hand, Green Computing is committed to create energy-efficient technologies that support - rather than going against - the trend of climate change. These gadgets designed with Green Computing in mind might not have the same appearance or functionality as other "cutting edge" technologies, but over

time, they will have a hugely beneficial effect on the environment.

Because it is more ecologically friendly than conventional IT systems, Green Computing is also frequently referred to as sustainable computing. Many individuals frequently disregard the ability of IT to influence the rate of climate change, but Green Computing can persuade them that the advantages are numerous, such as product costs' reduction, energy conservation, and waste minimization.

C. How does Green Computing work?

Based on [21], there are four (4) basic ways towards Green Computing, and each way is always changing to be as efficient as possible.

- *Green Use*: To ensure that computers and their related devices are used in an environmentally sustainable manner, this approach to Green Computing aims to reduce the amount of electricity they use. For instance, a computer with a long-lasting battery will not need to be charged as frequently, requiring less electricity overall and turning into a more energy-efficient, sustainable technology.
- *Green Disposal*: In addition to being made in accordance with Green Computing standards, gadgets must be disposed of properly to safeguard the environment from dangerous elements like ozone depleting compounds and to avoid creating unnecessary waste. Reusing current Green Computing equipment or appropriately disposing of outdated technology are two (2) ways to engage in green disposal.
- *Green Design*: Design is not merely for aesthetic purposes. It may also contribute to a technology's increased energy efficiency, particularly in the context of Green Computing. To achieve minimal energy use, design teams should work to improve the design of Green Computing products like printers, projectors, or servers.
- *Green Manufacturing*: Finally, green manufacturing is a crucial element of Green Computing because, in the end, mass production is what causes the majority of emissions produced by any business. Therefore, it is crucial that businesses that are responsible for the creation of Green Computing technologies look for ways to lower their emissions throughout product manufacturing.

As more authorities work to regulate and promote the use of Green Computing over traditional IT systems, governments are also becoming more aware of the significance and advantages of Green Computing in addition to these four (4) strategies [22].

D. Applications of Green Computing

There exists a plethora of Green Computing applications globally, considering a variety of domains [23]. Nevertheless, all these applications have a common vision, minimizing carbon impact and increasing environmental sustainability.

- *Connected lighting and heating*: Smart thermostats and Light-emitting Diode (LED) lighting technologies are becoming more and more common as connected heating and lighting Internet of Things (IoT) equipment. Having control over them via a smartphone application can significantly reduce energy use.
- *Electric vehicles*: In order to run on electricity, vehicles can now be powered by electricity instead of gasoline. Green Computing is becoming quite popular since so many people are looking for ways to stop climate change. This explains why different manufacturers provide a variety of solutions contributing to electric vehicles, including Toyota, Tesla, and others [24].
- *Data centers*: Data centers are under a lot of stress from electricity use, and they are also pricey. The greatest technological businesses in the world, like Amazon, Apple, and Google, tend to construct energy-efficient data centers with a low impact on the environment and expense [25].
- *Alternative energy*: Large IT companies are now powering their data centers through alternative energy sources including solar electricity, and wind power among others [26].
- *Recycling devices*: Hazardous chemicals, valuable metals, and other contaminants are found in computers, cell phones, and other gadgets. Businesses are starting to recycle this waste since producing them on a large scale is risky.

Additionally, there are several uses for Green Computing, including cloud computing, wireless networking, parallel computing, and edge computing among others. Given that Green Computing aims to improve the design, disposal, and eventual manufacturing of computers and its corresponding technological components, such as chips, screens, and hard drives, it is acceptable to assume that all its components can have a negative environmental impact. A Green Computing upgrade to the technology employed in such data management facilities would not affect it as they account for 2% of the world's overall emissions, making it possible to reduce emissions and increase energy efficiency [27]. The decision to look for raw materials that are sourced sustainably is one concrete illustration of how Green Computing works to stop the ongoing detrimental effects of technology on the environment. By doing this, Green Computing actively prevents the creation of excessive electronic waste, which, the longer used computer components are dumped in landfills, the greater the potential for greenhouse gas emissions. Moreover, one of the most well-known instances of Green Computing is the use of solar power in portable battery chargers and smartphone cases. Green Computing can also aim to power their gadgets utilizing renewable energy sources.

III. GREEN COMPUTING OPPORTUNITIES & CHALLENGES

Unquestionably, there are a lot of options for Green Computing, which is why more and more businesses and manufacturers are aiming for this objective. To start, Green Computing places a focus on technology that is energy-efficient, assisting in lowering the use of fossil fuels and greenhouse gas emissions. To safeguard the environment, it also aims to limit heat output in electronics like computers, whereas environmental economics promotes the intelligent administration of natural resources and their preservation.

Additionally, Green Computing gives emphasis to the use of non-toxic materials and supports material recycling and repurposing, which reduces technological waste and environmental contamination. It can not only lead to cost reductions because it uses less energy and cooling, but it can also hold the individuals responsible for the environment, creating the foundation for a future being more sustainable.

On the other hand, businesses who struggle to adopt Green Computing may experience several problems because of doing so. As a result of their disregard for the environment and the market's fierce competitiveness, businesses may fight the change. When considering climate change, few people consider the IT sector. The development of tinier, faster, and less ecologically harmful devices and components has taken precedence in the IT sector, along with a widespread lack of care. Technology makers must ensure that each iteration continues to fulfill eco-friendly criteria, since technology develops and changes so quickly, making it difficult to increase the longevity of products. Everyone must therefore bear the consequences. Consumers' awareness may be increased and people's ability to adapt to eco-friendly behaviors will be made possible by educating them about the hazards and advantages of doing so. Additionally, due to frequent technology changes without sufficient expertise and a potentially large initial investment, businesses and individuals may not know what to do. A further possible hurdle is the significant upfront capital investment required to convert a factory, data center, or corporate office from a conventional setup to a green one. Given this fact, there is a considerable knowledge gap among end-users, professionals, and enterprises about Green Computing, which has not yet been thoroughly studied. It should be mentioned as well that the sheer volume of data can make it tough to understand what is occurring in industries or to decide to make changes. Stakeholders must put in more effort to obtain and analyze data, understanding that their approach is profitable for their business and advantageous to the environment. Additionally, disparate data and diverse needs make it challenging for IT end-users across the board to make decisions. For instance, speed and performance are valued differently for a user at home versus in a huge data center. Users must therefore consider different issues at any given stage during the lifecycle of a computing equipment. When it comes to servers, security may be a bigger issue for a large firm than environmental impact. Additionally, a device being smaller or lighter may be more useful to a college student than one that can be entirely recycled, since it may be more convenient to be carried around.

IV. Best Practices Towards Green Computing

There exists a plethora of best practices that manufacturers, businesses, as well as individuals could perform to achieve the goals of Green Computing. They can be categorized into multiple clusters, depending on whether they are targeting the materials that are used for the construction of a product, or they are focusing on the energy that is consumed for the implementation, experimentation, and testing of a single analytics algorithm. These different practices are depicted in Fig. 2, being thoroughly explained in the following sub-sections for each of the different groups that they are targeting. To this context, it should be mentioned that this list has been extracted from actions that have been already put in place by large manufacturers and businesses and should be considered as a state-of-the-art Green Computing practical guide.

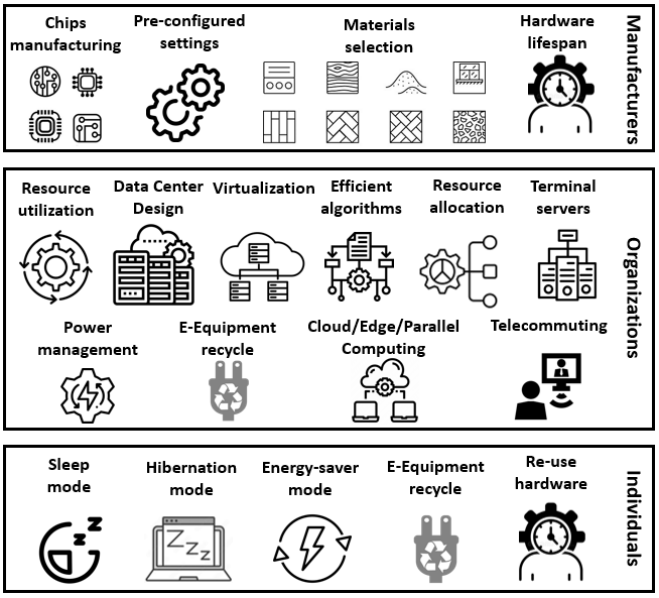

Fig. 2. Best practices towards Green Computing

A. Green Computing Strategies for Manufacturers

Manufacturing companies are the first to use Green Computing successfully, being able to perform a plethora of actions to give this technology a fair shot at success. One of the most important things manufacturers can do, for instance, is to *augment the chips' energy efficiency* used in various computing devices. The most well-known instance of this case are laptops; Apple's MacBook frequently extols the virtues of its updated and upgraded computer chips for laptops [28]. This is due to the fact that these chips will ensure that the computer system as a whole operates smoothly, efficiently, and ultimately more successfully - all of which can help to minimize the usage of energy, enhance performance, and make the device more sustainable.

Rather than the abovementioned, manufacturers have additional options that are less complicated than creating a brand-new, enhanced computer chip. For instance, customers frequently find that new devices already have *settings* and preferences installed when they acquire them to set up. The users will automatically use the manufacturer's settings unless they are willing to take the time and modify them to their taste on their own. Manufacturers should add energy-saving features like screen saver, sleep mode, and low-power mode before releasing the device to the market. Because the manufacturer will have already made the necessary adjustments, the users of the Green Computing gadget will not need to consider how they can modify their equipment to be more energy efficient.

Along with energy-saving settings, manufacturers must also work to improve the way they choose *materials*. While many laptop parts are energy-efficient, they eventually end up in

landfills and cause environmental issues. Therefore, before beginning the production process, it is crucial to ascertain the lifecycle of a product. Although this process - better known as green manufacturing [29] - is entirely distinct from Green Computing, it is nonetheless connected to the idea of enhancing technology's sustainability, and the two (2) ideas should be put to use in tandem to succeed in Green Computing.

Additionally, manufacturers of Green Computing products may try to *extend the lifespan of the hardware* contained in their finished products to cut down on electronic waste and avoid the need to produce more. As a result, users of Green Computing technology will not need to replace potentially inefficient parts like their laptop batteries as frequently, giving them a product with a longer lifespan. Modularity and upgradeability may also be emphasized by manufacturers in their advertising. Consequently, to upgrade the system, tiny modules or components may be produced and replaced rather than the system as a whole.

B. Green Computing Strategies for Businesses

Making sure applications only use the *resources they require* is a realistic primary step that can have an immediate and noticeable impact on the energy of consumption of any business. This significantly lowers waste in data centers and the public cloud in terms of cost and carbon footprint. A solution like IBM Turbonomic Application Resource Management [30] can make it easier to achieve that aim by continuously evaluating the resource usage of applications to make sure they have what they need to function while abiding by business regulations. Businesses may automate tasks and reduce resource congestion across a hybrid cloud environment with a thorough understanding of the infrastructure and application stack, starting larger expenditures in sustainability.

Considered together, data centers consume between 100 and 200 times more energy than conventional offices globally [31]. As a result, businesses should consider the best data center design techniques in various locations. Green Computing can be used by data centers to build infrastructures being environmentally friendly. It must take into account all the factors of energy consumption, including building construction and position, as well as equipment and IT devices for ventilation, air conditioning, cooling, and heating.

Additionally, important techniques for *developing and deploying software* should be put into place, such as:

- *Performing virtualization*: It has to do with creating virtual computers or virtual machines (VMs) by abstracting or splitting computer resources (e.g., storage, memory, processors). A single reliable physical system can support running two (2) or more virtual instances. Because original hardware is not required, cooling and power consumption are decreased along with resource utilization. Additionally, it lessens the requirement to create additional hardware [32].
- *Creating efficient algorithms*: Efficient algorithms have an impact on the quantity of resources required for a computational function. For example, accelerating an algorithm with search capabilities can significantly minimize the usage of resources. Therefore, IT companies need to make sure that their engineers produce better, more effective code, utilizing proper programming languages [33]. Recent years have seen a major increase in the research of energy-efficient algorithms, with the most prevalent algorithmic challenge that takes energy into account as a resource, being the query of how to control power directly at the processor level [34].
- *Allocating resources strategically*: Data can be routed to a data center with cheaper electricity by using Machine Learning (ML) algorithms, which will reduce the cost. They could also use this technique to divert traffic from a data center in an area being warmer.
- *Using terminal servers*: A terminal server is a type of hardware or server that offers a single connection to terminals like computers, cellphones, tablets, printers, and other devices. The requirement for a terminal to have a card, modem, or network interface removed by terminal servers. As a result, deploying terminal servers can help businesses into saving costs and energy.

Power management is another important step towards computing being environmentally friendly, in addition to software deployment. Any business, no matter how large or small, can work towards this concept and consider the environment. However, computers can autonomously turn off their components, including screens and hard drives, without user intervention thanks to an open standard known as the Advanced Configuration & Power Interface (ACPI) [35]. Someone can put a computer into hibernation mode when most of its parts, including the CPU and the RAM, turn off. Additionally, some programs let manually alteration of CPU voltages to reduce heat production and energy consumption. Additionally, smaller hard disk drives require less energy than bigger ones. Flash memories or Dynamic Random Access Memories (DRAM), which use even less power, are used by Solid-state Drives (SSDs) to store data. Since they do not have any moving parts, they use considerably less electricity. Among the most power-hungry computing components, Graphics Processing Units (GPUs), require attention from businesses' IT departments. They might employ energy-saving strategies such as not using graphics cards in place of a desktop sharing client or shared terminal, instead of employing those devices. Choosing a GPU with lower electricity consumption while idle can be a smart decision.

Recycling electronic equipment is also a reliable way to practice Green Computing into businesses. It will stop dangerous substances like cadmium, lead, and mercury from ending up in landfills. Equipment can also be recycled by businesses rather than being manufactured from scratch, conserving energy, and cutting emissions. IT companies may also donate obsolete computers to charitable and non-profit groups or reuse them, whereas they may recycle old computer components including batteries, and printer cartridges.

Additionally, businesses should consider switching to *parallel, edge, and cloud computing*. By solving issues with resource usage and energy use, cloud computing [36] helps IT companies to adopt Green Computing. Cloud computing can

reduce energy use and carbon emissions through virtualization, power-saving data centers, multi-tenancy, and other techniques. The use of cloud computing eliminates the need for data centers that use a lot of energy. Additionally, edge computing [37] enables businesses to spread processing close to customers, cutting expenses. It makes it possible for data centers to be smaller and use less energy and money. To do this, parallel computing [38] also contributes to decreased energy consumption by enabling a number of small-scale computations or operations to be executed concurrently on many processors that communicate through shareable memory as opposed to separate power-hungry hardware.

Finally, *remote employment* is becoming popular, particularly since Covid-19 [39]. Benefits of telecommuting, teleconferencing, and working remotely include employee convenience, lower travel emissions, and improved business margins due to the reduced maintenance of the office.

C. Green Computing Strategies for Individuals

From their side, individual computer users can take several actions to lessen their environmental effect and incorporate the principles of Green Computing into how they utilize technology. For instance, one of the simplest things users can do is to enable their computer to go into hib*ernation or sleep mode* if they leave their laptop. This is because a computer's energy that is reserved can be readily depleted even when it is not in use due to the bright screen and backlit keyboard. Users should also conduct research to find the most energy-efficient laptops available, as opposed to desktops, which demand more power and are best reserved for heavy-duty processing tasks.

Additionally, most laptops have an *energy-saving mode* that enables the computer to use less electricity or shut down idle processes to save energy without the user having to consciously turn those processes off. Ensuring that outdated gadgets are safely disposed of, switching off electronics at the end of the day or when not in use, and investing in refurbished technology are further things that users can do to advance the principles of Green Computing. Moreover, as in the case of manufacturers and businesses, by the time that end-users possess and own a specific device (e.g., laptop, tablet, smartphone), they could always *recycle* the entire devices or specific parts of them, whereas using hardware with extended lifespan could be also beneficial.

In conclusion, Green Computing is crucial for more than just businesses and manufacturers. The values portrayed in Green Computing should also be put into practice by regular computer users. There would be a significant reduction in the amount of laptop charging required if millions of individuals all around the world turned their laptops to *sleep mode* every fifteen (15) minutes [40].

V. DISCUSSION & CONCLUDING REMARKS

Green Computing provides the ability to minimize the impact of computers to the environment. The ICT sector, however, can take additional actions by employing technology to support the environment via systems and programs targeted at reducing the consumption of power and implementing energy conservation methods through virtualization.

The market for sustainability and green technology is expected to reach $74.64 billion by 2030, expanding at a Compound Annual Growth Rate (CAGR) of 21.9% from 2021 to 2030 [41]. To achieve this, Greenpeace examined the environmental record of seventeen (17) technical businesses [42], with Fairphone coming out on top, followed by Apple, Dell, HP, Lenovo, and Microsoft. Other businesses, such as Intel and Samsung, have been working hard to minimize their environmental consequences, even as these six (6) brands continue to make every effort to be as environmentally friendly as possible. These are the top eight (8) environmentally friendly technology businesses operating today, going to great lengths to ensure that their operations and supply chains cause as little harm to the planet as possible.

Considering all this motility, in this manuscript a practical guide towards Green Computing has been proposed, including an overview description of the Green Computing capabilities, its offerings, as well as its barriers. Actions of specific manufacturers and large businesses were provided towards the notion of successfully adopting Green Computing, while a list of related Green Computing actions has been provided for the latter, as well as for individual users. This research's aim is to give up-to-date practical guidelines for a greener environment with reduced carbon emissions led by energy-hungry computing actions and environmentally unaware decisions.

Our next steps include performing a thorough analysis on the actions that are being taken towards the Green Computing paradigm by both large industries and smaller ones, to categorize them and sort them considering specific criteria (e.g., costs, efficiency, practicality), towards enhancing and improving the current practical guide. Specific actions will be included and introduced towards energy efficiency, with emphasis on providing the best practices for energy-efficient software development (e.g., algorithms design and execution) considering both the quality of the end-result it provides, and the number of resources that it requires to return such an end-result. The aim of this extended research will be to merge these solutions along with related research projects, such as:

- *FAME* [43] that aims in delivering a set of tools with energy-efficient analytical solutions among others;
- *PolicyCLOUD* [44] that targets on building policies using the cloud computing paradigm performing energy efficient analytical functions;
- *CrowdHEALTH* [45] that aims on delivering health related policies that have been provided through energy efficient health analytics procedures;
- *beHealthier* [46] that targets on constructing an extended version of Electronic Health Records (EHRs) including health-related variables being extracted via energy-efficient data extraction techniques;
- *InteropEHRate* [47] that targets in offering energy-efficient health data exchange between healthcare practitioners and patients.

Concluding, Green Computing is an excellent illustration of how one simple modification may have a significant impact.

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