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# GREEN SERVICE LEVEL AGREEMENT

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## Abstract

*Nowadays, when most businesses are moving forward to sustainability by providing or getting different services from different vendors, Service Level Agreement (SLA) becomes very important for both the business providers/vendors and for users/customers. There are many ways to inform users/customers about various services with the inherent execution functionalities and even non-functional/Quality of Service (QoS) aspects through SLAs. However, these basic SLA actually did not cover eco-efficient green issues or IT ethics issues for sustainability. That is why Green SLA (GSLA) should come into play. Green SLA is a formal agreement incorporating all the traditional commitments as well as green issues and ethics issues in IT business sectors. GSLA research would survey on different basic SLA parameters for various services such as network, compute, storage and multimedia in IT business areas. At the same time, this survey would focus on finding the gaps and incorporation of these basic SLA parameters with existing green issues for all these mentioned services. Finally, this research would also focus on the integration of green parameters in existing SLAs, defining GSLA with new green performance indicators and their measurable units. This proposed GSLA could help and clarify different service providers/vendors to design their future business strategy in this new transitional, sustainable society.*

## INTRODUCTION

SLA is defined as *a formal document between an IT service provider and one or more customer outlining Service Commitment* [1]. The main issue is that, there were many ways to inform customers about various services with its inherent execution functionalities and even non-functional/QoS aspects through SLAs. However, these traditional/basic SLA actually did not cover eco-efficient green issues. Currently, cloud and grid computing and many data centres act as most promising service providers. These computing and communication industries provide different services in comparison to traditional computing with some scalability benefits. At the same time, cloud services are offered at various levels: Infrastructure, Platform and Software as a Service [2]. At each level, they maintained a SLA with respect to their parties. Therefore, this shows the growth rate of SLA in recent times as well as the need for Green SLA for sustainability. Presently, the revolution of ICTs in daily average life has also resulted in the increase of GHG, due to continual increase in “carbon footprint”. In 2007, the ICT sector produced as much GHG as the aero industry and is projected to grow rapidly [3, 4]. If ICT has a negative impact on the environment, it can be used for greening the other human activities (logistic, city, industry etc). Indeed, the dimensions of Green Informatics contributions are: the reduction of energy consumption, the rise of environmental awareness, the effective communication for environmental issues and the environmental monitoring and surveillance systems, as a means to protect and restore natural ecosystems potential [5]. At the same time, many IT companies or service providers think about their business scope in the light of a green perspective. Therefore, with the increased attention that green informatics is playing within our society, it is timely to not only conduct service level agreements for traditional computing performance metrics or only on energy or carbon footprint issues, but also to relate the effort of conducting green agreements with respect to 3E (Ecological, Economic and Ethics) sustainability pillars. Therefore, the journey of Green SLA is getting importance in the IT business world. This research did a thorough survey for finding more eco-efficient green performance indicators for network, storage, compute and multimedia services in ICT industry. Additionally, a new green SLA proposed which covers all the existing green performance indicators as well as some other missing indicators covering three pillars of sustainability.

The rest of the work is organized according to 3 sections- the next research review section discusses some existing scientific theory and practical works based on basic SLA which did not consider any environmental indicators and green SLAs for different services. Basic SLA and existing green SLA parameters also derive and organize in detail through an existing empirical viewpoint. The results and contribution section provides an idea of newly proposed green SLA for sustainability. The conclusion gives some discussion and describes a few challenges to make proposed SLA greener.

## RESEARCH REVIEW

This GSLA work did a rigorous literature review and survey based on existing work in the field of SLA, green SLA, green computing, energy optimization in IT industry, impact of ICT on environment and natural resource, IT ethics issues, IT for Sustainability etc. In the findings, green SLA research divides its work based on basic SLA and then existing green SLA for various types of services from their providers. The existing theory and empirical work on basic SLA and green SLA is discussed in the following sections.

### Literature Review

There are several works on basic SLA and green SLA for different services. Most of the researches regarding SLA were survey based on only one or two services. Some work has been done on modelling, monitoring or automating basic SLAs. There are very few specific works found only on Green SLA. Several specific papers are found regarding performance metric for distributed computing industry

(cloud and grid computing). Some researchers focus only on the importance of adopting Green issues including IT ethics in the ICT field.

#### **Basic SLA:**

Salman A. Baset [6] gave an idea for presenting SLA for different cloud service providers. He surveyed some well-known public IaaS providers and found a common anatomy of basic SLA with some common metrics. In [7], Hyo-Jin Lee *et al.* offered a general SLA monitoring system architecture that could be used to monitor service levels provided by some network, Internet and application service providers. Their work showed a much clearer idea of finding some QoS parameters, measurement metrics for various services. In contrast, Li-jie Jin *et al.* [8] presented another approach to model and understand the relationship between customers and some web service providers, which is very important for designing basic SLA and Green SLA. Adrian Paschke *et al.* contributed to a systematic categorization of basic SLA content with a particular focus on SLA metrics in IT industry [9]. They categorized five basic IT object classes and their performance indicators in SLA. Jani Lankinen *et al.* [10] surveyed security profiles of some existing well known storage service providers like Amazon, Apple iCloud, Dropbox etc. In [11], the paper presented SLA for voice and Internet services covering basic performance indicators.

#### **Green SLA:**

Klingert *et al.* [12] introduced the notion of Green SLAs. However, their work focused on identifying known hardware and software techniques for reducing energy consumption and integrating green energy. In [4] and [5], the authors showed the impact of ICT in a natural environment and resources in this world. Zacharoula S. Andreopoulou [5] proposed a model ICT for Green and Sustainability whereas SMART 2020 report [4] gave the idea of GHG emission from the ICT sector. Gregor Von Laszewski *et al.* [13] invented a framework towards the inclusion of Green IT metrics for grids and cloud computing. According to Md. E. Haque *et al.* [14], high performance computing cloud providers offer a new class of green services in response to practicing explicit sustainability goals in their field. Robert R. Harmon *et al.* [15] defined the term Green Computing as the practice of maximizing the efficient use of computing resources to minimize environmental impact. They also discovered that, sustainable IT services require the integration of green computing practice such as power management, virtualization, cooling technology, recycling, electronic waste disposal and optimization of IT infrastructure. Finally, the white paper [16] provided some qualitative parameters in cloud service SLA which was very important for proposing Green SLA. In [17] and [18], the authors discussed one of the most promising concepts in Green SLA- IT Ethics issues. In their research, they showed the concepts of organizing ethics programs in IT industry.

#### **Empirical Work Review**

In the findings on existing empirical work, green SLA research splits its work based on basic SLA and then existing green SLA for various types of services from their providers such as Network, Compute, Storage and Multimedia [19]. In the basic SLA section, findings are divided into four main services as network, compute, storage and multimedia [19]. Most of the performance indicators in basic SLA sections were quantitative parameters and they were simple to evaluate, control and monitor.

#### **Basic SLA for Network services:**

Usually network services include connectivity and switching as well as advanced network systems and management functions for well-known network service providers. The basic SLA for network specifies service level commitments which are applied to measure and evaluate network performance and give proper support for all clients. Usually, from different network service providers, the following

performance indicators [7, 9, 11, 13] found in their SLAs are- *Network Availability, Delay, Latency, Packet Delivery Ratio, Jitter, Congestion, Flow Completion time, Response time, Bandwidth, Utilization, MTBF (Mean Time Between Failure), MTRS (Mean Time to Restore Services), Solution time, Resolution time, LAN/WAN period of operation, LAN/WAN Service Time, Internet access across Firewall, RAS (Remote Access Services)*. Among these performance indicators, only *Internet access across Firewall* and *RAS* were subjective indicators- there is no standard procedure to evaluate or calculate these indicators. Some indicators like *Bandwidth, Utilization, and Congestion* are related to link capacity whereas *Availability, Delay, Jitter, Response Time* etc. are associated with time related information for different network service providers.

#### **Basic SLA for Compute Services:**

Most of the cloud and grid service companies provide computing service to their consumers. Recently, the Service Oriented Architecture (SOA) has also come into the computing field. The main point is that there is research on building middleware SLA infrastructure for computing services. Some of the current work: the European Union-funded Framework 7 research project, SLA@SOI, which is research on aspects of multi-level, multi-provider SLAs within service-oriented infrastructure and cloud computing [20]. The basic SLA parameter [9, 11, 13, 16] for computing services are- *Broad Network Accessibility, Multi-tenancy, Rapid Elasticity, Scalability, Resource Pooling Time, Solution Time, Response Time, Availability (MTBF & MTTR), Capacity, Virtualization, Delay, Resolution Time and Logging & Monitoring*. Here, *Broad Network Accessibility, Multi-tenancy* and *Logging & Monitoring* were informative indicators presented in their SLAs.

#### **Basic SLA for Storage Services:**

The storage services are typically handled by the cloud storage provider. Interestingly, today's cloud storage SLA just ensure uptime guarantee but not data availability and data protection. In some cases, traditional SLA just mention about data storage security and backup but there is no proper authority or standard to check their commitments. Some common basic SLA performance indicator [7, 9, 11] for storage services are as follows- *Availability, Response Time, Maximum Down Time, Uptime, Failure Frequency, Period of Operation, Service Time, Accessibility, Backup, Physical Storage Backup, Transportation for Backup, Size, Data Accessibility, Security*. Among all these parameters, some of them are just informative such as *Accessibility, Backup, Physical Storage Backup, Transportation for Backup*, and *Security*. These parameters might vary according to human perspective too.

#### **Basic SLA for Multimedia Services:**

Multimedia service SLAs are classified into three broad areas- Audio, Video and Data. It is challenging to monitor and evaluate some qualitative indicator such as *Mean Opinion Score (MOS)* and *Lip Synchronization* for one way video, conferencing or in videophone. These could be varied between different consumers at the same time. Most of the SLA indicators for multimedia services for different applications are *Information Loss (PLR), Jitter, One way Delay, MOS, Lip Synchronization, and Security Policy* [21].

#### **Existing Green SLA:**

Most of the green SLA performance indicators correspond to traditional high performance distributed computing environment such as grid and cloud computing. Currently, several IT industries and businesses provide their SLA with green computing practice. Green SLA surveys show that most of their green SLAs are mainly focused on energy/ power, carbon footprint, green energy, recycling

issues. Additionally, several existing green SLA also demonstrated their productivity issues with a necessary monitoring unit. Table 1 depicted the performance indicators and their unit for different services considering green computing practices. The table has several headings. *Green Computing Domain* is the category of green computing practices in IT industry; *Performance Indicator Name* is the notion which used an evaluating, monitoring metric for defining performance in green SLAs, and then their short definition in various industries as the *Description* column and finally the measurable unit as the *Unit* column. All these performance indicators help various service providers and consumers either to design or to choose services mainly with respect to energy consumption, renewable energy usages, carbon emission issues and productivity issues in recent days. Here, some data centres' performance evaluating metrics are also presented. *Data Centre Productivity (DCP)* [22], *Data Centre Energy Productivity (DCeP)* [13, 22] and *Heating, Ventilation, Air-conditioning (HVAC)* [23] indicators are still difficult to assess and control in some data centres' SLAs as they do not have any measuring units. The *Analysis Tool* and *EnergyBench* [15] used to inform about productivity in grid computing also do not have any measuring unit to evaluate or monitor in their SLAs. In some cases, *Carbon Usage Effectiveness (CUE)* and *Green Energy Co-efficient (GEC)* [22] consider only on usages stages but these indicators are closely associated with some other indicators such as *Recycling* [19, 24], *e-Wastage* [24], *Energy Cost* [25], and *Total Power Consumption* [25]. Some of these performance indicators need to be defined newly and precisely and should state in their green SLAs according to government laws and standard. Some indicators could not be generalized as traditional green computing practices. Therefore, they just categorized as "others" in the tables.

**Table 1. Performance Indicator for different services considering existing green SLA**

Sl. No.	Green Computing Domain	Performance Indicator Name	Description	Unit
1.	Energy/ Power	Total Power Consumption [15, 25]	Amount of total energy consumed while providing services;	kW-h (Kilowatt-hour)
2.		PUE (Power Usages Effectiveness) [13, 19, 22, 23]	Fraction of total energy consumed by the service of a data centre to the total energy consumed by IT equipments;	Number (1.0 to $\infty$ ) Or Dimensionless
3.		DCiE ( Data Center Infrastructure Efficiency ) [13, 20, 23]	To calculate the energy efficiency of a data centre;	% (Percentage)
4.		CPE (Compute Power Efficiency) [22]	Total amount of power needed for computing;	Watts
5.		SPECPower [13, 22]	Power consumption per server on a given workload to complete;	Watt
6.		JouleSort [15]	Amount of energy required to sort different size of records in data centre;	kW/J (Kilowatt per Joule)
7.		WUE (Water Usages Effectiveness) [22]	Ratio of the annual water usages to the IT equipment energy;	Liter/kW-h

8.		TDP (Thermal Design Power) [23]	Maximum amount of heat generated for which the cooling system is required;	Watts
9.		ERF (Energy Reuse Factor) [22]	Amount of reusable energy like hydro, solar, wind power etc used outside of a data center;	Number [0 to 1.0]
10.		ERE (Energy Reuse Effectiveness) [22]	Measuring the profit of reusing energy from a data center;	Number [0 to ∞]
11.		GEC (Green Energy Co-efficient) [22]	Amount of green energy used to provide services in green grid computing usually on usage stages;	Number [0 to 1.0]
12.		ITEE (IT Equipment Energy Efficiency) [26]	Ratio between IT equipment used and their energy consumption;	% (Percentage)
13.		ITEU (IT Equipment Utilization) [26]	Ratio between total energy (kWh) of all IT equipment and their total energy specification (Power rating in kWh);	Number
14.		HVAC (Heating, Ventilation, Air-conditioning) Effectiveness [23]	Ratio between the IT equipment energy to the HVAC system energy;	Dimensionless
15.		Cooling System Efficiency [23]	Characterizes the overall efficiency of the cooling system (including chillers, pumps, and cooling towers) in terms of energy input per unit of cooling output;	kW/ton (kilowatt per ton)
<b>Sl. No.</b>	<b>Green Computing Domain</b>	<b>Performance Indicator Name</b>	<b>Description</b>	<b>Unit</b>
1.	<b>Carbon footprint</b>	CUE(Carbon Usages Effectiveness) [22]	Calculation of greenhouse gases (CO <sub>2</sub> , CH <sub>4</sub> ) release in atmosphere usually on usage level;	KgCO <sub>2</sub> per kW-h
2.		DPPE (Data Center Performance Per Energy)[26]	Ratio between Data center's throughput (work) by carbon energy;	Number [0 to 1]
1.	<b>Recycling</b>	e-Wastage Or IT Wastage [23]	Amount of IT wastages per product, services, process, facility or even the whole industry;	Gm (Gram)
2.		Recycling [19, 24]	Percentages of IT equipment to be recycled at a given specified time period;	% (Percentage)
1.		DCP (Data Center Productivity) [22]	To calculate the amount of useful work done by data centre;	Not Available

2.	<b>Productivity</b>	DCeP (Data Center Energy Productivity) [13, 22]	Quantifies useful work compared to the energy it requires; it can be calculated for an individual IT device or a cluster of computing equipment;	Not Available
3.		Analysis Tool[15]	Performance per watt in green grid computing;	Not Known
4.		EnergyBench [15]	Throughput of work per Joule for computing;	Numeral Rating
5.		ScE (Server Compute Efficiency) [22]	To find the specific server's computing efficiency (Server Health);	% (Percentage)
1.	<b>Costing Information</b>	Energy/Power Cost [25]	Cost of power consumed per kilowatts hour used including renewable energy cost;	Currency [according to law]
1.	<b>Others</b>	SWaP (Space, Wattage and Performance) [13, 22]	Ratio between performance and space x watts;	Not Available
2.		User Satisfaction [11,13]	Satisfaction level of a user while getting services;	Number [0 to 5]
3.		Mean Opinion Score (MOS) [11,13, 27]	Human's view for measuring the quality of a network; specially for audio and video;	Number [1 to 5]
4.		Reliability [13]	Service delivery to the intended user without interruption;	Number [0.0 to 1.0]
5.		Air Management Metric [23]	Finding the difference between the supply and return air temperature in some data centre;	F (Fahrenheit)
6.		UPS System Efficiency [23]	Ratio of the UPS output power to the UPS input power;	% (Percentage)
7.		Risk Assessment [11, 13]	Percentage of systems are involved in security threat; very few SLA mentioned it;	% (Percentage)

## RESULTS AND CONTRIBUTIONS

In existing green SLAs, most of the performance indicators mainly focused on energy consumption issues and productivity concern in cloud and grid computing industries (Table 1). Most of them did not consider recycling, radio wave, toxic material usage, noise, light pollution for sustainable development. Moreover, people's interaction and IT ethics issues, such as user satisfaction, intellectual property rights, user reliability, confidentiality etc. are also missing in current green SLA. The next section discusses the proposed performance indicators of green SLA for achieving sustainability from the 3Es perspectives (Ecological, Economical and Ethical). Figure. 1 shows the concepts of 3Es relationship, that an ICT engineer can use as a guideline to respect all the facets of sustainable development. The following tables explain each of the performance indicators and their measurable unit for proposing new green SLA.





**Figure 1. 3Es for Sustainability**

### **Ecological Point**

*Recycling-* The recycling of ICT equipment impose into their whole life cycle. This is a very complex indicator and needs to be sub-divided as reuse, refurbish, sub-cycling and up-cycling. According to [19, 24], the Recyclability Rate of an equipment ranges from 0 to 1. Again, at each stage of recycling, it needs to consider the *CUE*, *GEC*, *Energy Cost* (Table 1) because recyclability includes energy consumption and carbon emission simultaneously. Recycling information should be put into green SLA according to government laws, directives such as Waste Electrical and Electronic Equipment (WEEE) Directive (2012/19/EU) by European Union (EU). There are also some voluntary recycler standards in US like e-Steward and Responsible Recycling (R2) Practices.

*Toxic Material Information-* Electric and Electronic products contain several toxic materials such as Beryllium, Cadmium, Lead, and Mercury etc. These chemical elements and their compound both cause serious health hazards and also make the environment polluted. Beryllium is used in manufacturing computer motherboards and is acutely and chronically toxic to humans, mainly affecting their lungs [28]. Cadmium and its compounds is used in some switches, many laptop's batteries and in some older CRTs monitors as phosphor coating. These materials and their compounds are also toxic to humans, affecting kidneys in the long run [28]. Lead is usually used for primary electric solder on printed circuit boards. Lead could damage to the nervous system and blood system in human body [28] and also causes severe air pollution. In some switching devices and batteries, mercury could be used which is highly toxic. Mercury has a high level impact on human nervous system [28]. All these toxic materials should have a safety limit which need to be defined or restricted by a third party or governing body such as Directive on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (2002/95/EC) from the EU, commonly known as RoHS Directive. The information about the usage of these toxic materials in IT and ICT field should be stated clearly for making SLA greener.

*Obsolescence Indication-* The services, process, product or technology used or produced by a company for profit will become obsolete after certain period. Therefore, it is a matter of urgency in ICT industry to indicate or label product's life time with obsolescence indicators [29] according to the product's raw materials' scarcity, demands, usages limit etc. at different stage of product's life cycle. These indicators should be stated in a proposed green SLA to create awareness for both customer levels and company levels for achieving sustainability. It might be complex to indicate or determine the obsolescence of ICT equipment because it depends on different variables associated with equipment's production cost, raw material scarcity, energy issues and user's interaction. Additionally, Optimum Obsolescence [30] indication would help to decide when an ICT equipment product needs to be reused, recycled or land filled. There is no standard to indicate this parameter in SLAs until now but it might be related to product life cycle costing and recyclability rate indicators.

*Radio Wave Information-* The electromagnetic radiation emitted by electronic equipment in IT industry, is a controversial topic in the scientific community. The health effects of radio waves were intensively studied and most of these studies found that the EMF (electromagnetic field) is thermal

and also associated with frequency ranges and energy [19]. These radiations might cause severe health hazards such as brain cancer, heart diseases and even leukaemia. To avoid this electromagnetic effect, the government of each country defines the maximum level of EMF generated by wireless antenna and their maximum *Specific Absorption Rate (SAR)* value [19]. The EMF levels and safety [according to SCANTECH, Australia] use the following measuring units- *Gauss (G)*, *Tesla (T)* for EMF values; *Gray (Gy)* and *Sievert (Sv)* for measuring radiation effects on human tissues. This radio wave information should be stated in the green SLA according to government's defined level clearly and precisely.

*Noise Pollution*- The network engineer who works in a data centre might need guidelines and regulations to control noise pollution in his/her workplace. The noise generated from a data centre causes hearing loss permanently [31]. OSHA and NIOSH- these two US government agencies look after the limit of noise level in work places. The noise pollution level might be stated on a green SLA using adecibel (dB) measuring unit. Moreover, the noise created by ICT equipment such as the ringtone of a cell phone might also responsible for some sort of pollution as it can become disturbing and irritating for other people. This type of pollution might be subjective and easily prevented by increasing awareness among the cell phone users.

*Visual Pollution*- The aesthetic aspects of ICT industry, for example- installing an antenna in a beautiful landscape or on a roof top. This could create the hypersensitivity affect [19] and these might be very much subjective to each human being, such as the Perception of Affective Quality (PAQ) [32] is an individual's perception of an object's ability to change his/her neurophysiological states as feeling either good or bad.

*Light Pollution*- Computer screens generate light pollution affecting health [19]. According to the American Optometric Association, Computer Vision Syndrome (CVS) causes headache, blur, dry eye, eyestrain, sleep disorder etc. The safe computing practice and awareness might help to decrease CVS. There is still no standard or measurable unit for light pollution level but it should be mentioned in proposed green SLA.

The next Table 2 demonstrates the proposed green SLA from ecological point of view and their proposed measurable units.

**Table 2. Green SLA proposal considering the Ecology pillar for sustainability**

Sl. NO.	Performance Indicator Name	Description	Domain	Unit
1.	Recycling Rate (RR)	Reuse Refurbish Sub cycling	Amount of ICT product reuse/ percentage of ICT equipment refurbished/ percentage of IT equipment sub cycled or up cycling;	Network, Multimedia, Compute, Storage gm (gram) OR % (Percentage) OR RR[0~1] [19]
2.	Toxic material limit/ Toxic material Usage Level	Information about using toxic material in ICT products and their limit level;	Network, Multimedia, Compute, Storage	Preferred/ Acceptable
3.	Obsolescence Indication	Indication about the perfect time to change ICT equipment;	Network, Compute, Storage,	Labeling according to laws

4.	EMF Level/ Radiation Effect Level	Amount of electromagnetic energy radiation; usually the strength is measured by frequency;	Network, Multimedia, Compute, Storage	T (Tesla) / G (Gauss) OR Sv (Sievert) / Gy (Gray)
5.	Noise Pollution Level	The noise emitted from ICT equipment e.g. ringtone of Cell phone, noise in data centre;	Network, Multimedia,	µdB/dB (micro decibels)
6.	Visual Pollution Level	The aesthetic aspect of ICT industry e.g. installing an antenna in a beautiful landscape or roof top;	Network, Multimedia, Compute, Storage	Subjective OR PAQ [31]
7.	Light Pollution Level	The light pollution generated by ICT equipment e.g. Computer Screen;	Network, Multimedia, Compute, Storage	Subjective

### Economical Point

*Carbon Taxation-* A number of countries have implemented carbon taxes [33] or energy taxes and *Cap and Trade System* [34] that is very effective to reduce Green House Gas (GHG) emissions while stimulating technological innovation and economic growth. The taxation may create political or social unrest in some countries; therefore it may be difficult to impose. In the 1990s, a carbon/energy tax was proposed at the EU level but failed due to industrial lobbying, but in 2010 the European Commission implemented a pan-European minimum tax on pollution under the European Union Greenhouse Gas Emissions Trading Scheme (EU ETS) [33] which is quite successful. According to this new plan, 4 to 30 euro would be charged per tonne of carbon emission. On the other hand, in US, the *Cap and Trade* gave more assurance to decline GHG emission and also have some political advantages [34]. Therefore, according to different countries' economic, social or political culture, carbon taxation or *Cap and Trade* policy should need to be established and this information needs to put in a green SLA.

*Building Design Cost-* Information for designing cost, manufacturing cost, renovation cost and finally dismantling cost of a data centre should also be included in the proposed green SLA. The cost of building design indicator also associated with carbon emission indicators in each steps. Therefore, it might not be difficult to assess and monitor.

*Cooling Cost-* The cooling system costing information needs to be mentioned in the proposed green SLA. It includes energy (electric power, renewable energy) costing, infrastructure (humidity, temperature monitoring) and transportation costing for cooling the whole site. This indicator becomes complicated because of *HVAC*, *Air Management Metric* and *Cooling System Efficiency* indicators in existing green SLA (Table 1) and these might need to be newly defined. Moreover, carbon emissions also need to assess the transportation of cooling equipment for the sites.

*ICT Product Cost-* ICT product costing considers the whole life cycle of a product such as manufacturing from raw materials, transportation, usages and dismantling. This indicator is also associated with the carbon emission indicator from existing green SLA. Additionally, recycling indicators also pose a concern when dismantling a product is considered. The Life Cycle Assessment LCA [35] needs to be considered in this parameter. ICT Product Cost indicators thus become very complex to assess and monitor in green SLA.

Table 3 shows the economic performance indicators and their measuring unit for evaluating proposed green SLA.

**Table 3. Green SLA proposal considering the Economic pillar for sustainability**

Sl. NO.	Performance Indicator Name	Description	Domain	Unit
1.	Carbon Tax	Tax for carbon content on fuel in most cases; this should be charged according to government laws;	Network, Multimedia, Compute, Storage	Currency (dollar)
2.	Building Design Cost	Information about an energy efficient building infrastructure and their costing including dismantling;	Network, Multimedia, Compute, Storage	Currency (dollar)
3.	Cooling Cost	Amount of cooling cost in a data center or percentages of renewable energy usage for cooling;	Network, Multimedia, Compute, Storage	Currency (dollar)
4.	ICT Product Cost	Considering the life cycle assessment of an ICT product and their costing;	Network, Multimedia, Compute, Storage,	Currency (dollar)
		Manufacturing		
		Transportation		
		Usage		
		Dismantling		

### Ethical Point

Mostly, the green computing practice focuses on the ecological and economical point but usually neglect humans' interaction and ethical aspects [19]. The use of ethics in IT and ICT field covers many indicators such as *Satisfaction level, Intellectual Property Right, Reliability, Confidentiality, Security and Privacy, Gender/Salary/Productivity Information*. All of these indicators are usually subjective metrics, thus making green SLA assessment difficult. The ICT Company should analyze social responsibilities towards *Customers, Employee and Community* [19, 36]. Table 4 gives the idea of these responsibilities as performance indicators with respect to ethics for greening SLA to achieve sustainability.

**Table 4. Green SLA proposal consider Ethics pillar for sustainability**

Sl. NO.	Performance Indicator Name	Description	Domain	Unit
1.	Satisfaction level [Customer, Employee, Community]	Whether the customer, employee and community are satisfied with; [usually defined by third party or community]	Network, Compute, Storage	Rating OR CSI [37]
2.	Intellectual Property Right [Customer, Employee, Community]	IPR means copyright, patents of users' data; no hacking; royalty etc.	Network, Multimedia, Compute, Storage	YES/NO
3.	User Reliability	Whether customer reliability preserved by the company; reliability between employee and company;	Network, Multimedia, Compute, Storage	Rating
4.	Confidentiality	Information should be kept confidentially and also available for	Network, Multimedia,	Rating

			customer, employee or for community;	Compute, Storage	
5.	Security & Privacy	Authentication & Authorization	Rules regarding security and privacy should clearly be stated and defined or not; usually it could be defined third party or government law.	Network, Multimedia, Compute, Storage	High / Medium / Low  OR Preferred/ Acceptable
		Access Control & Privilege Management			
		Data Geographic			
		Data Integrity			
		Transparency			
		Physical Security			
		Termination Management			
6.	Gender Balance Information		The information about gender balance in an organization;	Network, Compute, Storage	YES/NO
7.	Salary Balance Information		The salary balance of an organization in IT industry;	Network, Compute, Storage	YES/NO

## CONCLUSION

This green SLA research surveyed different basic SLA parameters for network, compute, storage and multimedia services in IT and ICT business arena. The research review section demonstrated most of the basic SLA performance indicators and their measurable unit but did not cover any eco-efficient green computing practice. On the other hand existing green SLA covered most of the current green metrics and their measurable unit which are presented using Table 1 in different computing industry. Additionally, Table 1 also showed today's concerns were mainly on energy issues and productivity through the greening lens. Missing performance indicators and their influences on green SLA with respect to 3Es were discussed in the results and contributions section. Table 2 to Table 4 lists all proposed performance indicators and their measurable units. Parameters suggested for making SLA greener may cause some challenges in future. For example, new green SLA might be too complex to assess, control or monitor; some performance indicators need to be defined accurately, which has association with other indicators; most of the subjective, qualitative indicators related with ethics issues need to be standardisation or governed and authorized by proper laws and directives. Moreover, it is very important to mention here that the definition of Green SLA is crucial in development of Green ICT solutions and requires a long time to be standardised. The standardisation of green indicators is the main issue as mentioned by the ITU-T report (2012). Sometimes it is difficult for an ICT engineer to respect all the performance indicators mentioned in basic SLA and the ones in green SLA. In this regard, some models should be developed to help ICT engineers to mitigate the complexity of managing all the indicators and their interactions in green SLA and thus the proposed green SLA would be realistic for consumers in a short time. However, this research would provide a new dimension and strategy for well-known service providers to achieve a win-win situation with their consumers for achieving sustainability in the near future.

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