T-ISO: A Standard Proposal for Green IT Indicators Oriented to Higher Education Institutions

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Abstract — *This article shows the degree of maturity in relation to the implantation of Green Information Technologies (IT) in the higher level institutions of the São Francisco Valley, Brazil. From a standardization of indicators, it proposes policies of actions and good practices that allow these organizations to achieve excellence in IT sustainability. For this, we realized that it is necessary to adopt strategies of motivation and awareness for some managers who still have resistance in implementing Green IT and applaud others for the initiatives and sustainable thoughts already adopted. This research has an exploratory character through a bibliographical survey and interviews with the IT managers of the studied institutions. It is also qualitative-quantitative, for measuring and fostering the level of Green IT present in these institutions. Some results were collected immediately because some actions are already present and successfully adopted by some universities.*
Keywords— Green IT, Sustainability, IT Standard.

I. INTRODUCTION

In this article, we highlight the importance and the need to implement Green Information Technology (IT) practices for the well-being and sustainability of the environment.

Initially, a bit is discussed about the history and concepts of sustainability and green IT. Next, we present the degree of Green Information Technology (Green IT) used by higher education institutions of the São Francisco Valley, Brazil. Finally, we present a proposal for standardization through sustainable indicators focused on Green IT.

Concerned about the current world scenario, the motivation for carrying out a research project was raised, seeking to bring to light the current situation in the higher education institutions located in the São Francisco Valley, a Brazilian agricultural center. A region that should always be in tune with the environment and that needs to have a green thermometer in place. The research was based on a bibliographical survey and the results obtained from interviews conducted with the IT managers of the main institutions of higher education in the region. These institutions were chosen because we understand that they are protagonists of an active process with a great potential for cultural transformation related to Green IT.

With the thinking on this ability of managers to adapt and based on what Mr. Ban Ki-moon, senior UN chief, said, taking into account Gandhi's remark about the important message that "the land provides enough to meet the needs of all, but not the greed of all and that we must be the change that we want to see in the world " [01]. After reading this article, we hope to lead in some way a reflection on the current situation and question what we are doing to improve it, or even wake up the directors, managers and IT managers the feeling for education and green awareness.

II. THEORETICAL FOUNDATION

With the accelerated development of digital information technologies in the mid-1980s, the term sustainability has gained prominence by promoting a greater awareness of the importance of environmental preservation, as well as the management of resource consumption and thinking on species continuity [02].

From this, the term Green IT emerged in the period between 2004 and 2005. TI Green has been gaining space and force in the world since a very accelerated growth of the digital information technologies was perceived: the equipment began to stay more frequently obsolete, causing, consequently, a substitution and uncontrolled disposal of equipment, called e-waste. With this, there was concern and questions about where and how these products would be discarded, since it is known that electronic waste has many substances harmful to the environment, and that, if not disposed of correctly, they harm the lives of all living beings [03].

Today, electronic waste, also known as e-waste, which is all material waste produced by the disposal of electronic

equipment, has been treated as a major challenge by organizations, government and especially society, as it has become a major environmental problem in relation to the disposal of unserviceable goods in suitable places, since their composition is rich in non-biodegradable substances.

According [04]: A non-bio-degradable, or recalcitrant substance, as some call it, is that which does not rot, does not decompose.

Given this scenario, TI Verde creates forces as an instrument for solving environmental problems caused either in the manufacture of products, in the acquisition, efficient and economical use of equipment and especially in the process of discarding materials.

Their customers are increasingly seeking after companies that invest in the sustainability of the planet. We know that much of this is also due to environmental programs, standards and regulations. The environmental impact caused by mankind has been shown to be of global concern. It is certain, that commercial industries and companies can create and use technologies that help achieve their goals, without harming the environment. In other words, Green Technology becomes an ally of the business, because the corporate world makes understood and mainly uses good practices to meet the needs of the business in a sustainable way [05].

2.1 Sustainability and Green IT: Two concepts, one goal.
We have all heard about sustainability through the various media, but are we practicing what we hear? Are we thinking of our children, grandchildren? Or rather, are we thinking about the continuity of species?

According to [06], "it is a systemic concept, that is, it correlates and integrates in an organized way the economic, social, cultural and environmental aspects of society. The key word is continuity - how these strands can keep in balance over time. " That is, "that meets the needs of present generations without compromising the ability of future generations to meet their own needs" [07].

It can be seen that green IT has the same purposes as regards sustainability, but it is focused on the sphere of information technology, since it is an area that greatly harms the environment with enormous amount of resources extracted for clothing, in the use and consumption of energy, emission of gases and mainly in the discard (return to nature).

III. RESEARCH METHODOLOGY
In this work, initially a bibliographic research was carried out, followed by individual interviews, semi-structured, and based on a pre-established script, but with flexibility [08]. Through the deepening of several bibliographies and the experience with the subject, we identified the most important points and the greatest impacts to the

environment, and, based on these, the items were chosen to compose the list of indicators of the research and proposal for use of standardization:

1- Program of education for sustainability;
2- Use the hibernate function;
3- Use of some kind of alternative energy (solar, etc);
4- Energy consumption management policy;
5- In the purchase, sale, production of IT products is controlled emission of CO2;
6- Execution of adequate donation and disposal of equipment;
7- Option for products with green seal in the acquisition of new equipment;
8- Work home office;
9- Reconsider redundancy;
10- Outsourcing of printing;
11- VDI or Thin client project (mouse, monitor, keyboard);
12- Virtualization of servers and storages;
13- Clustering;
14- Computing in the cloud;
15- GED (Electronic Document Management);

To highlight the degree or level of green IT, 05 (five) higher education institutions were selected in the São Francisco Valley, Brazil, being possible only the interviews with the managers of four of these. They were chosen because they understood that they have or should have a large technological park and great equipment turnover. Moreover, they could serve as a model and motivation for other institutions and, through the human capital present in them, the propagation of knowledge regarding education for sustainability and consequently for green technologies.

After the collection, based on the indicators that emerged from the theory that guided this research, from the implementation of the methodology and the field of research itself, the data were tabulated from each institution and then the analyzes and inferences were made. This moment demanded knowledge of the area and a greater capacity for reflection.

From there, a valuation table was built as a proposal for annual monitoring that can be used by the institutions. We established the use of scores according to the status of the indicator: (0) Absence of the indicator; (1) started, for when the indicator is in the implantation phase; (3) partially, when the indicator is present but not yet fully functioning; and (5) fully, when the indicator is being used in its entirety.

After adding the scores found in each indicator, a degree of Green IT found in the institution was calculated so that, from there, managers could consolidate sustainable IT in institutions or serve as a starting point for the implementation of new indicators.

It is clear that there are practices that are easier to implement than others. Even if implemented, we must take into account the degree of implementation difficulty, the impact that is caused and the environmental return. In this way, institutions will be ranked more fairly. Then, a table was drawn up with the appropriate weights for each indicator, which is then multiplied by the valuation achieved through the institution mapping.

IV. LEVEL OF GREEN TECHNOLOGY IN HIGHER EDUCATION INSTITUTIONS OF THE SÃO FRANCISCO VALLEY

From the interviews, it was possible to perceive individually the scenario found before each perspective, since we will be able to show which practice is being applied the most, the ones that are less present, either due to difficulty of implantation or culture, so that it is in some way to other practices and to improve those already in use.

According to results obtained, about the knowledge about Green IT, half of the interviewees declared to have knowledge and the remainder divided into not aware with already heard: one of the managers had already heard about the term TI Green, two stated to have knowledge in the practice and one of them stated that they did not even have knowledge of the term, even though it is practicing some sustainable practices. The manager who informed that he or she does not know has no course focused on information technology within the courses offered by the institution to which it belongs. This means that the term green IT is still unknown by some managers and there is a gap to be filled in the sustainable scope.

On implementing Green IT practices, half stated using paper reduction strategies (double-sided printing, for example) and the other half was divided between the use of A3P[1] program and educational strategy (energy consumption). The best-known practice used by managers is to reduce paper consumption through two-sided printing. It is perceived that there is a very great disparity between some universities - federal public institutions are better organized in relation to state and private institutions.

Most institutions recognize the advantages of deployment and the gain that this can bring, but they run into internal rules and regulations of their respective headquarters or other general regulatory frameworks, even if they are oblivious to public norms. We note that there is resistance coming from the convenience of the collaborators. For example, some users can not unlink from a printer on their desk. On the other hand, it is noticed that the adhesion of the green IT practices are isolated attitudes and it meets some rules, regulations, contradicting with the statement: Green consumption is one in which the consumer, in addition to seeking better quality and price, includes in its power of choice the environmental variable, giving preference to products and services that do not harm the environment, both in production and distribution, consumption and final disposal [09].

Looking at table 1, according to the interviewees, all institutions have some kind of educational program focused on sustainability, although not specifically green IT. Sometimes even by intuition, but not by institutional policy. It is possible to realize that there is a massive practice regarding the use of the hibernate function of desktop computers, but it is not active in 100% of the institutions. Regarding energy management, we can see that 50% of the institutions carry out this type of control, although they are implemented through sustainable committees and extension projects.

Table.1: Institutional indicators

Indicators	%
Program of education for sustainability	100%
Use the hibernate function	75%
Use of some kind of alternative energy (solar, etc)	0%
Energy consumption management policy	25%
In the purchase, sale, production of IT products is controlled emission of CO2	0%
Execution of adequate donation and disposal of equipment	75%
Option for products with green seal in the acquisition of new equipment	25%
Work home office	0%
Reconsider redundancy	0%
Outsourcing of printing	0%
VDI or Thin client project (mouse, monitor, keyboard)	0%
Virtualization of servers and storages	50%
Clustering	25%
Computing in the cloud	50%
GED (Electronic Document Management)	25%

All of them do not control CO_2 emissions in the acquisition, sale, production, and disposal of IT materials. "A computer connected one hour a day consumes 5kwh / month, and at the end of a year it emits 18 kg of CO^2 in the environment, which means that reducing one hour of the operating time of a home computer implies the reduction of emission of CO^2 equivalent to the emission of a gasoline car traveling 120 km / h. " [10].

The disposal of waste equipment is carried out by 75% of the institutions, but none of them has its own waste

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[1] The Environmental Agenda in Public Administration (A3P) is a program of the Ministry of Environment which aims to stimulate public agencies in the country to implement sustainability practices.

disposal project. The equipment is collected through specific projects of the respective parent institutions, located in the capitals, which in turn, in contract with third companies or the army battalion itself handles the disposal properly. The remaining 25% focus on reuse and donation. In this case, the institution that is contemplated with the donation of the equipment becomes responsible for the final disposal to the environment.

For the purchase of products with a green seal, that is, products with green technology and that have a lower incidence of environmental aggression, the universities stumble across regulations and bidding processes that prevent them from choosing them.

In college environments, it is common to find some teachers who use their personal computer to work from home. However, in all the universities interviewed, the employees must attend the workplace, not characterizing, as a rule, the home office.

Today, 100% of the institutions do not reconsider the physical redundancy of IT equipment, that is, they prefer to consume more resources than to consider the possibility of a possible loss of data or interruption of some critical service, since information is much more important than sustainable gain in this regard, according to IT managers. On the other hand, 50% of universities use the virtualization process (machines that work virtually using the resources of a physical machine), regarding the contingency of servers and storages, thus reducing the use of physical machines and consequently energy consumption, CO_2 emission, and future discard reduction.

In the current scenario, only 25% of universities have a clustering system. This system allows computers with reasonable processing power, work synchronously, together, thus forming a machine with high processing power. This would increase the time of use of these machines, since they would stop becoming obsolete quickly, not to mention the gain in processing.

When it comes to paper consumption, control of impressions and consumption of toners and printer cartridges, a good practice is the implementation of Outsourcing of printing (robust printers, placed in strategic points of the organization, that meet the need of collaborators).

By using this practice, the IT manager has control over what is printed, inhibiting undue impressions, eliminating the diversity of printer models and brands in the organization, and considerably reducing the acquisition and consumption of large quantities and models of cartridges and tonners One hundred percent of the universities do not have Print Outsourcing, but one of them is starting a deployment project.

According to IT managers, there is usually a lot of resistance from most employees regarding convenience and culture, especially the high-level staff. Employees do not agree, for example, to have to get up from their armchair, get out of the front of their computer, to get their printout that was sent to a printer located in a hall ten meters from your living room. (Strategic point).

Another very important practice is the use of the Thin Client or VDI system, in which the company has only one large server (usually clustered) and in the stations only the monitor, the mouse and the keyboard are included, thus eliminating a large amount of CPU's on workstations. For managers, it would be very good to be able to use this system, but this technology has a very high deployment value, especially in relation to infrastructure.

Of these companies, fifty percent have some kind of cloud storage that makes a notable gain in information security and reduces the use of physical equipment in the organization and consequently reduces the amount of disposal in the environment.

On the last of the indicators, the Electronic Document Manager (GED), which is a computer system in which it has a set of five basic functionalities, which are: capture, manage, store, distribute and preserve information [11]. In this sense, only 25% of universities said they managed documents by image and use documents with controlled copies.

4.1 Suggested Model

For each indicator analyzed with the IT manager of each institution is verified the scenario in which it is found and added the appropriate score according to the legend:

Evaluation: Absent (0); Initiated (1); Partially (3); Total (5)

Table 6 shows the green IT level calculation model, according to the valuation ratio found in each existing or non-institution indicator.

Table.2: Fictional Institution

Weight	Indicator	Utilização				Accum.	w/weight
		Absent	Initiated	Partial	Total		
1	Program of education for sustainability	X				0	0
1	Use the hibernate function				X	5	5
3	Use of some kind of alternative energy (solar, etc)		X			1	3
3	Energy consumption management policy	X					0
1	In the	X					0

Weight/difficulty	Indicator					Valuation	Weighted
	purchase, sale, production of IT products is controlled emission of CO2						
3	Execution of adequate donation and disposal of equipment				X	5	15
1	Option for products with green seal in the acquisition of new equipment			X		3	3
3	Work home office			X		3	9
3	Reconsider redundancy	X					0
3	Outsourcing of printing	X					0
5	VDI or Thin client project (mouse, monitor, keyboard)	X					0
5	Virtualization of servers and storages			X		3	15
5	Clustering	X					0
5	Computing in the cloud		X			1	5
5	GED (Electronic Document Management)		X			1	5
	TOTAL	7x0=0	3x1=3	3x3=9	2x5=10	32/75=**42,7%**	60/280=21,42%
	ATTRIBUTED CONCEPT					C	D

If we did not include a weight (degree of difficulty), the fictitious company would reach the green level category "C", since the maximum score would be 75 points.

Already with the weight, the calculation is done upon the multiplication of the valuation with the weight and at the end would be divided no more by 75, but by 280, which is the maximum attainable value. Then, 280 points are equal to 100% and the concepts would be subdivided into the following scale:

Concept (A): 80% above; **Concept (B)**: between 60 and 79%; **Concept (C)**: 40% and 59%; **Concept (D)**: between 20 and 39%; **Concept (E)**: up to 19%.

According to the concepts adopted above, we mapped institutions using the relationship between the indicators method and the valuations obtained in the current scenario.

Table 3 shows that none of the institutions studied have an ideal level of green IT deployment. We have a big gap that can be seen as opportunities for improvement that can be healed with awareness and motivation.

Table.3: Institutions Mapping

Weight/difficulty	Indicator	Institution			
		Inst. U	Inst. F	Inst. N	Inst. P
1	Program of education for sustainability	5	1	1	1
1	Use the hibernate function	3	3	5	0
3	Use of some kind of alternative energy (solar, etc)	1	0	0	1
3	Energy consumption management policy	3	0	0	3
1	In the purchase, sale, production of IT products is controlled emission of CO2	3	0	0	0
3	Execution of adequate donation and disposal of equipment	5	3	3	1
1	Option for products with green seal in the acquisition of new equipment	5	0	0	0
3	Work home office	0	3	3	3
3	Reconsider redundancy	0	3	3	0
3	Outsourcing of printing	1	0	0	0
5	VDI or Thin client project (mouse, monitor, keyboard)	0	0	0	0

5	Virtualization of servers and storages	5	3	3	0
5	Clustering	5	0	0	0
5	Computing in the cloud	5	3	0	0
5	GED (Electronic Document Management)	5	0	3	0
	TOTAL	52,14%	21,42%	22,5%	8,92%
	ATTRIBUTED CONCEPT	**C**	**D**	**D**	**E**

V. FINAL CONSIDERATIONS

In the perception of most of the interviewees, the organizations in which they work do not know or do not care about Green IT practices, although some use an environmental management system, usually led by the respective ISO 14001-related Headquarters, standardization, and environmental regulation. Some simple practices, such as the use of control of energy expenses, paper consumption and equipment discards, show that organizations, even without knowing the practices, already apply some initiatives, yet it is still irrelevant to what is proposed in green IT.

We also noticed that even with the lack of knowledge in Green IT practices, the majority of interviewees do not think about implementing practices in their organizations, even though they are concerned about sustainability.

In view of the above, it is necessary to pass on the knowledge of Green IT practices in order to articulate them effectively to a strategic policy of implementing a culture of sustainability in companies. It is understood that these policies and practices should be part of not only the strategy, but the culture and business of organizations in all their environments, so that not only IT professionals know, but everyone who is part of the organization.

Green IT still shares opinions. Some practices, which have a considerable environmental impact and return, are not easy to implement but should be part of a new IT culture. With that, IT professionals, organizations, and the environment as a whole win.

It is hoped that this work will sharpen the sense of greenness and social, educational, cultural and environmental responsibility of managers in the general scope and that green IT will be a part of a massive form in the institutions, not only those of higher education, of this study, but in general. That the synchronism of the processes of the companies and the environment are treated like differential and attractive model for new clients.

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