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ORIGINAL

The good practices of green it in energy saving and its influence on the cost of electrical service of a higher educational center, in the district of Surco - Lima 2022

Las buenas prácticas del green it en el ahorro de energía y su influencia en el costo del servicio eléctrico de un centro educativo superior, en el distrito de Surco - Lima 2022

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ABSTRACT

This research is based on the study of how the good practices of GREEN IT influences energy savings and the cost of electricity service in a higher education center, which mentions the importance and positive impact of using GREEN IT in organizations, which promotes energy efficiency and sustainability of various technological devices, and to this is added the benefit of preserving both natural and energy resources. These good practices of green economy, the correct use of technologies and processes is proven in this research that directly impacts the costs that can be incurred by the organization for the execution of its activities, as well as the contribution to the care of the environment with the decrease of Co_2 produced by each action and resources used habitually. The objective of this research is to determine how the good practices of GREEN IT in energy saving influence the cost of a higher education center in the district of Surco - Lima 2022. For the above mentioned and to measure the good practices employed in the institution, a questionnaire and the evaluation of fixed and variable costs were used to analyze how much it has impacted economically, as well as the care of technological assets for their longer life. Finally, the results obtained confirm the hypothesis raised, that applying the good practices of GREEN IT has a direct impact on energy reduction, as well as on the costs of the institution; verified in the survey instrument to 132 samples where the evaluation result yields a Cronbach's Alpha for the 22 items of 0,968, which allows affirming that the instrument applied has an excellent level of reliability and a reliability test for each question obtained an alpha greater than 0,965.

Keywords: Energy Savings; Environment; Sustainability; CO2; Green Economy.

RESUMEN

Esta investigación se basa en el estudio de cómo influyen las buenas prácticas de TI VERDE en el ahorro de energía y en el costo del servicio eléctrico en un centro de educación superior, en la cual se menciona la importancia y el impacto positivo del uso de TI VERDE en las organizaciones, el cual promueve la eficiencia energética y la sustentabilidad de los diversos dispositivos tecnológicos, y a esto se suma el beneficio de preservar los recursos tanto naturales como energéticos. Estas buenas prácticas de economía verde, el uso correcto de tecnologías y procesos se comprueba en esta investigación que impacta directamente en los costos en que puede incurrir la organización para la ejecución de sus actividades, así como la contribución al cuidado del medio ambiente con la disminución de Co_2 producido por cada acción y recursos utilizados habitualmente. El objetivo de esta investigación es determinar cómo influyen las buenas prácticas de GREEN IT en el ahorro de energía en el costo de un centro de educación superior en el distrito de Surco - Lima 2022. Para lo anterior y para medir las buenas prácticas empleadas en la institución, se utilizó un cuestionario y la evaluación de costos fijos y variables para analizar cuánto ha impactado económicamente, así como el cuidado de los activos tecnológicos para su mayor vida útil. Finalmente, los resultados obtenidos confirman la hipótesis planteada, de que aplicar las buenas prácticas de TI VERDE tiene un impacto directo en la reducción de energía, así como en los costos de la institución; verificado en el instrumento de encuesta a 132 muestras donde el resultado de la evaluación arroja un Alfa de Cronbach para los 22 ítems de 0,968, lo que permite afirmar que el instrumento aplicado tiene un excelente nivel de confiabilidad y una prueba de confiabilidad para cada pregunta obtuvo un alfa mayor a 0,965.

Palabras clave: Ahorro Energético; Medio Ambiente; Sostenibilidad; CO2; Economía Verde.

INTRODUCTION

The use of digital technologies, where the institutions positioned in the national market must adapt to new technologies, since these have a high cost of electricity and as a result of the constant use impacts on the environment contributing to the emission of Co2.[1] Currently, sustainable companies apply green technology or better known as Green IT, although this initially requires a high investment cost, so institutions must adequately direct the funds allocated to electricity consumption.[2]

Villafuerte defines Green IT, as the "efficient and sustainable use of IT resources with minimal environmental impact during their life cycle".[3] Considering how important environmental sustainability is in the implementation of IT processes, the use of resources, services and business processes is considered to ensure sustainability with the help of an affordable and easy to implement strategic plan in its operations and stakeholders from a green perspective.[4]

Regarding energy consumption in our country, Osinergmin reports for the year 2020, shows through a questionnaire, the consumption and uses of energy, shows real data of the increase of electricity consumption in Metropolitan Lima mostly due to the use of household appliances, having as a result 172 kWh per month as the highest result, compared to the urban area that resulted almost six times the estimated consumption of the rural area with a 20 kWh per month; result given by the analysis of data collected from the year 2019 to 2020.[5]

This progressive growth in electricity consumption causes environmental problems with the generation of greenhouse gases (GHG).[6] On the other hand, in our country the total production of electric energy shows for September 2022 an amount of 4 979 GWh being an increase of 5,2 % over the previous year. As shown in figure 2, the generation of power plants emits energy according to its source of origin; hydroelectric units produced 0,1 %; thermal power plants generated 6,5 % more than the previous year; non-conventional renewable energy generation had 57 % more than the previous year and solar units had a value of 2 %, a very low result compared to September 2021.[7,8,9,10]

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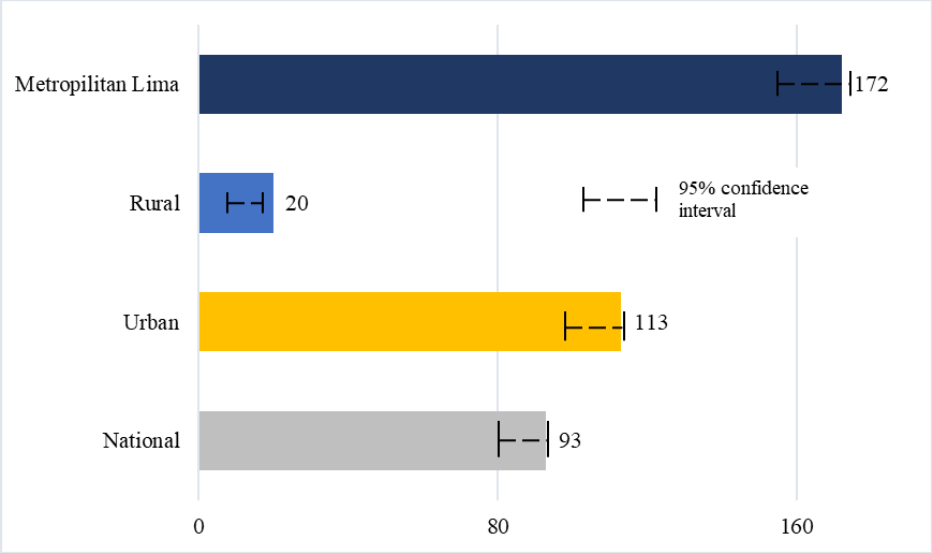

Figure 1. Median electricity consumption by geographical area

Destinity	September		Δ	January - September		Δ
	2021	2022		2021	2022	
Electrical market	4589	4834	**5.3%**	41318	42762	**3.5%**
Hydraulic	1912	1912	0%	23549	23230	-1%
Thermal	2477	2644	7%	15855	17476	10%
Wind	129	203	57%	1344	1475	10%
Solar	71	75	6%	571	581	2%
Own use	144	145	**0.9%**	1378	1409	**2.2%**
Hydraulic	45	46	4%	480	468	-3%
Thermal	99	98	-1%	898	941	5%
National total	4732	4979	**5.2%**	42696	44171	**3.5%**

Main indicators of the electricity sector at the national level - September 2022/MINEM-DGE

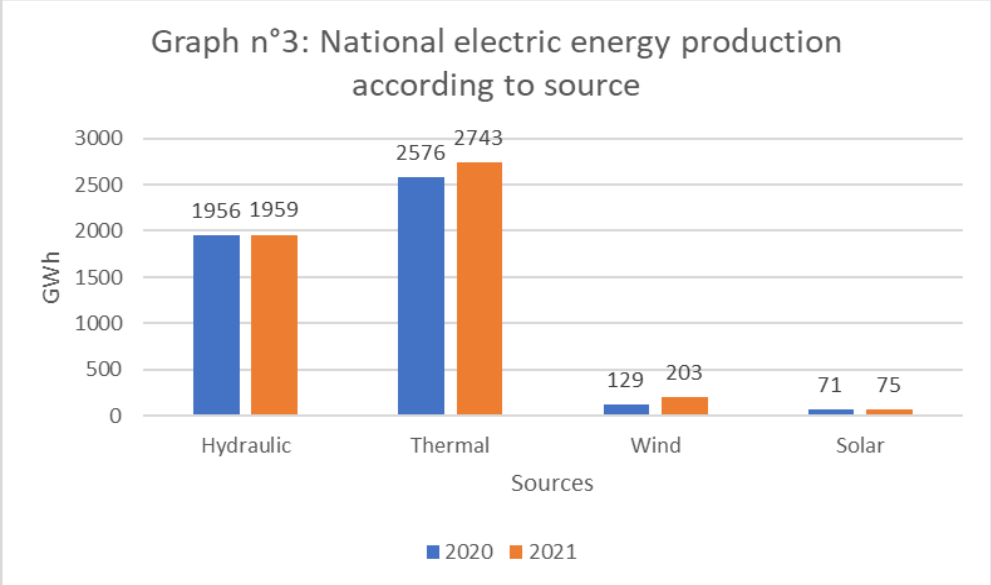

Figure 2. National electrical energy production - (GWh)

As mentioned Briseño Garcia (2012), in his research entitled "Energy optimization in datacenters: Method and application Monterrey - Mexico 2012",[11] identified applicable strategies to reduce the high

costs of electricity in IT infrastructures, in another scenario a methodology that combines a unified and comprehensive method with different strategies to reduce energy consumption in datacenters was demonstrated.

In this research the methodology used were the following:

- Conducted literature reviews on the "green IT" concept, green building certifications and standards, commercial technologies that support energy conservation, data center energy savings studies and case studies, and case studies.
- Developed a general method that identifies common metrics for energy reduction for each strategy reviewed.
- Identified a special case for the data center.
- The request was made to the data center manager for both data collection and video recording.
- Performed data collection such as electrical loads and thermographic analysis of their facilities.
- Calculated the efficiency of the datacenter using the collected data.
- The general method strategies were applied to a specific case, each of which had a return on investment (ROI) and a payback time.

On the other hand, Mazzella (2017)[12] developed research entitled "Competitive advantage in the adoption of information technology practices "conducted in the city of Buenos Aires - Argentina 2017 and its objective was to establish whether the adoption of sustainable practices in information technologies generates economic and social benefits to the organization.[13] In addition to identifying the advantages that a company obtains by adopting sustainable practices in the field of technologies. The methodology used was the collection of primary and secondary information, as well as the implementation of surveys to collect first source data. Regarding the sample of this study, it was formed by a population of 56 IT professionals, to whom a survey was applied. Finally, as a conclusion it was obtained that the research refers to the adoption of green practices in the field of technologies, have generated energy savings and economic benefits, and the social commitment to the environment has been recognized in society.[14,15,16]

To the aforementioned, the following question arises: How the good practices of GREEN IT in energy saving influence the cost of electricity service of a higher education center in the district of Surco - Lima 2022? Therefore, the present research used the following theoretical foundations for each of the variables studied, which were classified in the respective dimensions:

Independent variable: Green it best practices

D1: Green Economy: The author Mazella, mentions that in the GREEN IT the economy is a fundamental dimension for decision making within any organization to execute the regulations and eco-friendly systems that allow a sustainability of the company.

Currently, in order to be sustainable by applying the green economy model, organizations must comply with certain characteristics such as:

- Considerable energy reduction.
- Reduction of Co2 emissions.
- Correct use of resources or raw materials.
- Implementation of furniture and equipment with sustainable characteristics.

D2: Technology: Regarding the technology used in organizations, Unhelkar (2012) mentions that this involves the network infrastructure, hardware, software, and applications used by each company, some of these short-term actions to consider are the following:

- Screen shutdown.
- Hibernate computers.

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- Virtualizing servers.
- Avoid physical printouts.

Long-term actions include feasible physical construction with energy savers and server fixing systems.

D3: Process: Mazella referring to research by Unhelkar mentions that the process dimension of an organization is responsible for monitoring and measuring business processes that achieves improvement in critical performance measures such as os costs, quality, service and speed.

Independent variable: Electric Service Costs

D4: Variable Costs: Balanda defines variable costs as having a progressive behavior, either constantly increasing or decreasing, in relation to the change in the level of activity, as in the case of the production of raw materials when prices remain constant at different levels of activity. To obtain the analysis of the total variable costs, the following formula is used for each activity.

CV = CVu x Q (1)

CV: Variable cost

CVu: Variable unit cost

Q: Operating volume

D5: Fixed Costs: Horngren et al. (2012), mentions that a fixed cost remains stable as a whole over a certain period of time; being constant despite possible changes that may arise in the level of activity. To obtain an analysis of the total fixed costs, the following formula is used for each activity.

CF = CT x CV (2)

CF: Fixed cost

CTu: Total cost

CV: Variable cost

METHODS

This research was descriptive - causal correlational. Descriptive because it described the data obtained from the questionnaire and other inputs collected. Causal correlational because it allowed measuring the variables and analyzing to what extent the degree of influence between the study variables is determined.[17,18]

Sample

The present research has the probabilistic sampling and therefore the following formula was developed that allowed establishing the study sample for the private educational institution of the Surco headquarters.

Table 1. Data to determine the sample

Parameter	Value
N (population)	200
Z	1,96
p	50 %
q	50 %
e	5 %

Applied formula:

n = (N*Z^2*p*q) / (e^2*(N-1) + Z^2*p*q (3)

n=192,08/1,4579

n=132

Regarding the formula applied, the instrument was applied to a minimum of 132 people of the higher education institution considering the administrative and academic staff and is shown in table 2.

Table 2. Sample of the areas that consume electrical energy

	Area	Number of rooms	Number of people
Administrative staff	Technical support	1	2
	Sales area	1	1
	Student support	1	1
Academic staff	Students using the computer labs (16 computers per classroom)	8	128

Data analysis

For this study, a general observation of the entire building of the educational institution under study was carried out. Regarding energy consumption, it was detected that it is high because of the lack of saving measures, since the main activity of the institution is based on technological use and there is a high energy consumption, even in a week of inactivity. As a result, we began to review all the devices connected to the electrical network, observing that many of them were left on after some time of use, either intentionally or accidentally. It was also determined that there was not an adequate policy for the use of equipment based on GREEN IT to have a lower or zero consumption while not using the equipment and certain activities and regulations were implemented internally with the staff of the areas of the educational institution to demonstrate that good practices, regulations and eco-friendly systems allowed to promote sustainability to the headquarters under study.[19,20]

For this reason, methodologies were used based on the good practices of GREEN IT and how it would impact on savings and cost reduction of the institution; for this purpose, the survey instrument was taken with the new activities proposed in the areas and thus it was verified whether the proposed energy savings were implemented.

In addition, it was classified into two variables, each with different dimensions, which were measured in the instrument implemented and made it possible to evaluate whether these good practices are effectively related to and have an impact on energy savings.

The variables and dimensions mentioned are:

Independent variable: GREEN IT best practices are as follows:

- D1: Green Economy
- D2: Technology
- D3: Processes

Dependent variable: Electric utility costs are as follows:

- D4: Fixed costs
- D5: Variable costs

Finally, the SPSS tool detailed in the results section was used to perform and test the hypothesis of this research if the good practices of GREEN IT in energy saving influence the cost of electricity service of a higher education center in the district of Surco - Lima 2022.

Limitations of the study are as follows:

- Display of confidential information with important specification for the research.
- Lack of technological resources to facilitate the research.
- Scarce budget.

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- Lack of information about GREEN IT applied at the national level in private educational institutions.

RESULTS AND DISCUSSION

Reliability test

Reliability testing was performed in SPSS for the results of a total of 132 respondents.

Table 3. Reliability statistics

Cronbach's Alpha	Cronbach's alpha based on standardized items	Number of items
0,968	0,968	22

The result of Cronbach's alpha for the 22 items was 0,968, which allows us to affirm that the instrument applied has an excellent level of reliability and thus allows us to proceed with the normality and correlation test. Likewise, the reliability test was performed for each question, where in most cases an alpha greater than 0,967 and an alpha of at least 0,965 was obtained for all the questions posed in the reliability instrument. The results for each question are shown in table 4 below.

Table 4. Reliability statistics for each question of the instrument

Total element statistics				
	Scaling average if the element has been suppressed	Scale variance if the element is suppressed	Total correlation of corrected elements	Cronbach's alpha if the element has been deleted
1. Users apply green economy principles.	81,19	177,269	0,775	0,966
2. The screens used by users comply with eco-efficiency standards.	81,15	173,687	0,816	0,965
3. Users apply good energy saving practices, such as hibernating screens, turning off lights when it is not necessary, impacting on the cost of electric services.	81,20	175,335	0,763	0,966
4. It has been proven that sustainable companies apply energy saving regulations. As mentioned above, your organization is sustainable by using efficient methods to leverage and take advantage of the i...	81,10	174,486	0,814	0,965
5. Digital prints are made in the company.	81,12	178,703	0,653	0,967
6. By putting a computer into hibernation, users contribute to the reduction of CO2 production.	81,11	177,439	0,694	0,967
7. Computer equipment can hibernate after a short period of inactivity, consuming less energy.	80,97	179,083	0,692	0,967
8. Information is lost when using hibernation techniques. in computer equipment.	81,27	177,070	0,684	0,967
9. In the company, the screens stay on when not in use.	81,19	179,208	0,668	0,967
10. Printed sheets are reused and digital documents are sent to avoid the constant use of paper.	81,08	175,994	0,738	0,966
11. The company avoids the use of local server equipment, minimizing CO2 emissions.	81,17	178,384	0,746	0,966

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12. In your organization, physical servers are moved to a virtualized environment in the cloud, thus improving their availability and speed.	81,11	174,361	0,815	0,965
13. In the data center there are other elements such as air conditioning, stabilizers, battery banks, among others, that when transferred to the cloud, these electrical costs are redirected to energy.	81,05	181,708	0,646	0,967
14. Computer equipment is reused up to its maximum use and then processed by a WEEE (Waste Electrical and Electronic Equipment) company.	81,12	177,069	0,707	0,966
15. The company performs periodic physical maintenance of computer equipment, thus extending its durability.	81,06	179,660	0,668	0,967
16. Your company or area turns off lighting equipment after use, which directly impacts energy consumption costs (electricity bill).	80,68	168,096	0,868	0,965
17. Natural lighting is constantly used to reduce the impact of electricity consumption, which is reflected in the electricity bill.	80,70	172,500	0,818	0,965
18. To achieve significant savings, the equipment is turned off after a certain period of inactivity, directly impacting the electricity consumption bill.	80,77	169,185	0,833	0,965
19. In your company or area, the type of Led lighting could reduce the fixed costs in the electric service (light bill).	80,72	168,280	0,858	0,965
20. The reuse of printed sheets of paper in your company directly impacts your organization's tangible costs.	80,82	171,417	0,753	0,966
21. The application of digital printing of documents in your company has a direct impact on the tangible costs of your organization (avoidance of printing).	80,88	175,604	0,723	0,966
22. Reusing office supplies (pens, pencils, notebooks, etc.) directly impacts your organization's tangible costs.	80,84	175,478	0,725	0,966

Exploratory and normality test

The exploratory analysis was applied to the 132 cases and determined the count of respondents according to their area, where they perform various activities with the use of technological devices and how the good practice of Green IT influenced each action they perform on a daily basis.[21,22,23]

These areas were determined by the high consumption of energy consumed daily, since its main activity is through computer equipment, printers, routers and switches; therefore, several questions related to the practices that were implemented to validate whether it has been applied and has impacted the costs of electrical services of the institution were raised. The questionnaire was given to the technical support personnel, sales area, student services, teachers and all the students of the educational institution of the Surco headquarters.[24,25]

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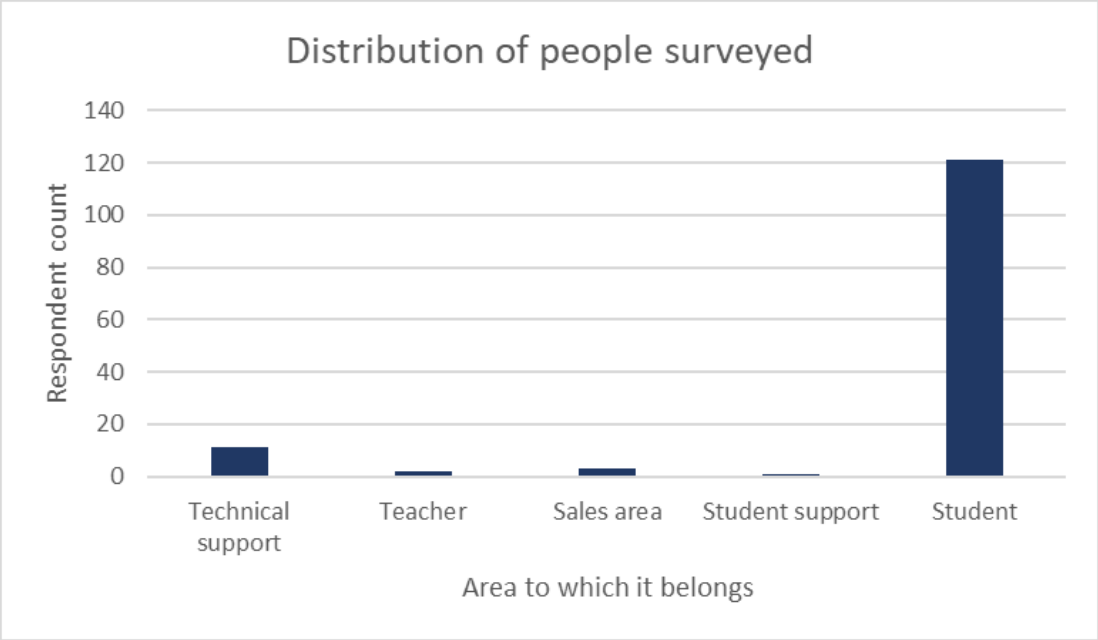

Figure 2. Count of respondents according to their area

Table 5. Descriptive statistical table of the variables and dimensions

Descriptive statistics of dimensions and indicators	μ	L. Lower	L. Upper	Me	s^2	S
Variable: good practices in Green IT	56,19	54,69	57,68	60,00	75,407	8,684
Green economy dimension	18,60	18,04	19,16	20,00	10,700	3,271
Technology dimension	18,74	18,23	19,26	20,00	8,956	2,993
Process dimension	18,85	18,35	19,35	20,00	8,343	2,888
Variable: electrical service costs	28,68	27,67	29,70	30,50	34,783	5,898
Fixed Costs Dimension	16,61	15,97	17,24	17,50	13,767	3,710
Variable Costs Dimension	12,08	11,65	12,50	12,00	6,116	2,473

On the other hand, the Kolgomorov-Smirnov normality test was performed for the sum of the indicators of each dimension, and it has a normal distribution in all cases with a confidence level of 95 %.

Table 6. Kolmogorov-Smirnova

Kolmogorov-Smirnova	Statistician	gl	Sig.
Green economy indicator	,333	132	,000
Technology indicator	,337	132	,000
Process indicator	,352	132	,000
Dimension: GREEN IT best practices	,329	132	,000
Fixed cost indicator	,259	132	,000
Variable cost indicator	,200	132	,000
Electrical services costs dimension	,153	132	,000

Due to the value obtained in the normality test, it was decided to perform a Pearson correlation test, in which a correlation percentage of 80,1 % was obtained for the variables of good green IT practices and electric service costs.[26] Therefore, it is affirmed that Green IT practices have a very high degree of direct relationship with electric service costs; however, further research and analysis of the intervening dimensions is required to determine if there is a cause-effect relationship.[27] Correlation tables for each variable and dimension are shown below.

Table 7. Correlation for the study variables.

Pearson's correlation test for study variables		Variable: Electric utility costs
Variable: GREEN IT best practices	Pearson correlation	,801**
	Sig. (bilateral)	,000
	N	132

Table 8. Correlation for the study dimensions.

Pearson's correlation test for the study dimensions		Variable: Fixed costs	Variable: Variable Costs
Green economy dimension	Pearson's correlation	,784**	,689**
	Sig. (bilateral)	,000	,000
	N	132	132
Technology dimension	Pearson's correlation	,742**	,631**
	Sig. (bilateral)	,000	,000
	N	132	132
Process dimension	Pearson's correlation	,792**	,636**
	Sig. (bilateral)	,000	,000
	N	132	132

In the correlation table by dimensions, the lowest correlation value is the technology dimension with the variable cost's variable with a level of 63,1 % and the green economy dimension with the same variable of costs has a level of 68,9 %, which is considered the highest. On the other hand, the highest degree of correlation occurs between the process dimension and the fixed cost variable with a level of 79,2 %, which is a high value.[28,29,30,31,32]

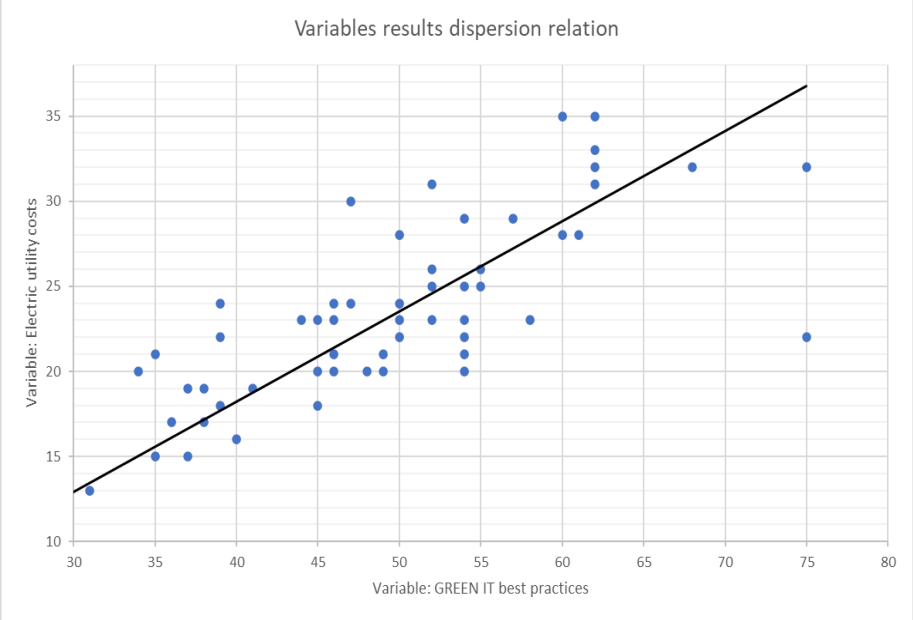

Figure 3. Variable dispersion relation - SPSS

Figure 3 shows the distribution of points where Green IT best practices and electric utility costs have a positive relationship with a high degree of fit.

The results obtained through the reliability test analysis have a value of 0.968 and show that the instrument applied has a high level of reliability, for which reason the normality and correlation test was performed.[32,33,34,35] In addition, it was verified that the results of the correlation test between the

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variables and dimensions proposed are related and demonstrate the feasibility of adopting the good practices proposed in the research.[36]

It should be noted that the results obtained do not differ from the experiences prior to the research carried out, such as Briseño Garcia (2012)[37] in his research on energy optimization in data centers: Method and application that managed to identify applicable strategies to reduce the high costs of electrical energy in IT infrastructures and demonstrated a methodology that combines a unified and comprehensive method with different strategies to reduce energy consumption in data centers.[38,39,40,41] Likewise, Mazzella (2017) research titled, "Competitive advantage in the adoption of information technology practices", he managed to establish the adoption of sustainable practices in information technologies that generated economic and social benefits for the organization.[42,43,44,45,46,47,48,49,50,51,52]

Therefore, it is stated that the good practices of GREEN IT in energy saving influence the cost of electrical service, in this case proven in a higher educational center in the district of Surco.

CONCLUSION

This study demonstrates that the good practices of Green IT based on the results obtained are directly correlated between the dimensions studied based on the green economy, technology, processes and good action for energy savings and cost reduction.

This research for its execution and analysis was applied to 132 respondents, both administrative staff and students and teachers, who are the people who, due to their main activity, require the use of technologies that consume electrical energy constantly, which is why it was decided to adapt good practices of Green IT that allows influencing cost reduction.

The use of the instrument showed the result of good practices, concluding that the variables and dimensions proposed were the main axis for cost savings in electrical consumption, since the money should be reused in the purchase of elements that generate clean energy such as solar panels, wind systems, batteries, inverters, allowing savings in electricity consumption to become a more sustainable institution.

On the other hand, it is concluded that the objective of this research to determine how good Green IT practices in energy saving influence the cost of a higher educational center in this research is viable for the educational institution, based on the results obtained. through reliability test analysis of 0,968. This affirms that the instrument applied has a high level of reliability, allowing the normality and correlation test to be carried out. In addition, the correlation test with the proposed variables and dimensions are interconnected, allowing the adoption of good practices proposed in the research through main dimensions in a Green IT of any sustainable institution such as the green economy, technology, processes, fixed costs, and variable costs.

Finally, it is affirmed that the hypothesis that effectively the good practices of Green IT in energy saving influence the cost of electricity service of a higher education center in the district of Surco and keep sustainable any organization contribute to the care of the environment of our surroundings.

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