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# Assessing DICT carbon footprint contribution through employees' practices in operating its ICT devices and equipment

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## ABSTRACT
Alongside with the increasing demand for technology comes along the increase in the total carbon emissions in the world. And due to the advent of technology and major changes in the Information and Communications Technology (ICT), it has been found out from recent studies that this industry is contributing 2 to 2.5% of the overall greenhouse gas emissions. Equipment under the ICT industry already plays a major role as an enabling technology in aiding to decrease other industry sector's footprint, however raising its own emission. In this paper, the researchers aim to assess the carbon footprint contributed by the Department of Information and Communications Technology Luzon Cluster 3's data center including other office equipment situated in Kumintang Ibaba, Batangas City, Philippines. The data on DICT staff's common practices on utilizing ICT equipment were gathered through a survey whereas each of the equipment's power usage when in use, on standby and switched off were based on the equipment technical specifications. Duration of data collection for the actual operation of the ICT devices and equipment in the office started from July 11, 2017 until July 11, 2018. To analyze the total contribution of DICT in the carbon footprint computation, the following data were gathered: the equipment's 'usage hours', 'on stand-by hours' and 'switched off hours. Power rating of the equipment was also gathered with reference to their respective specification sheets. All equipment under study is operated by electrical power and is also affected by outages therefore data on electrical outages within Kumintang Ibaba were gathered using Meralco as reference. As a result, ICT infrastructure has a total contribution of 20,201.84 kg of CO2 or 89.90% while office equipment has a total of 2,270.18 kg of CO2 or 10.10% carbon emission.

***Keywords:*** carbon footprint, ICT, information and communications technology, data center, electronic device

## 1. Introduction

In the recent days, climate change has been observed to be inducing greater risks to different aspects of life: food security, public health, way of living, and etc [1] in every person's life. One main reason for such is the increasing level of carbon emission in the world also called the *carbon footprint*. This describes the measurement of the amount of greenhouse gas emission from different sectors of the world that releases carbon as a by-product [2]. Though at a wider scale, the ICT sector plays critical roles in enhancing the global economic growth and aids in fighting the adverse effects of climate change [3], it has been charged to be generating an amount of 2% to 2.5% of total greenhouse gas (GHG) [4-5, 17].

Seeing how our reliance on the ICT devices and its services starting to increase at a rapid pace, the energy needed to manufacture them and so is the electricity to power these devices increases along with it. This, however, is one of the significant sources of the fast accumulation of the amount of carbon dioxide stored in the atmosphere, a leading greenhouse gas, as well as other global warming pollutants. [6]

There is a rough estimate that by the year 2020, the ICT Industry's contribution to climate change would increase and worsen. But rather than looking at its negative side, there is still an overriding positive effect from ICT industry since it can create innovations which aids in restructuring the economy and society, thus, is expected to reduce the overall global carbon emission. ICT applications, according to Global e-Sustainability Initiative (GeSI), by the year 2030 could possible help reduce the global carbon emissions by 20% which is considerably higher than its own contribution to carbon output [7].

To create greener and more energy-efficient plants, the use of renewable energies in such areas like generation of electricity and production of equipment should be undergoing voluntary compliance and formal regulation that is amenable to the existing industry standards. ICT firms, on the other hand, must be directed towards taking measures that can recalibrate the production plants and manufacturing systems to make them more energy efficient and environmentally friendly. [4]

This research focused on the computation of the carbon footprint contribution of the Department of Information and Communications Technology Luzon Cluster 3 and aims to accomplish the following objectives:

1. Calculate the average carbon dioxide emission of DICT Luzon Cluster 3 for one year.
2. Identify common practices of employees in using ICT equipment.
3. Suggest measures to lessen carbon dioxide emission from DICT Luzon Cluster 3's daily operation.

## 3. Materials and methods

Carbon footprint is conceptualized using the ideas of ecological footprint. This is used to measure the amount of demand of humans in the ecosystem. According to Wiedmann et al., carbon footprint is an assessment of the overall carbon dioxide emissions made directly and indirectly and are caused by any activity or accumulated over the product's lifetime. [8] It is therefore known that carbon footprint is a measure of the carbon emissions. [9]

One of the contributors in the increase of greenhouse gas in the atmosphere is due to the ICT industry. Though it may not be sharing that much compared to the other sectors (refer to Figure 1) [16], it still has its own part to the global warming issue. It was estimated that less than 25% of emissions from the ICT industry is generated during its manufacture while the rest resulted from its use and disposal. Owing to its natural reliance on electricity, ICT emissions need grid factors and therefore by

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geographical location. One great sample for this is the Sweden grid electricity which is dominated by hydroelectric and nuclear power. These energy sources have low carbon intensity, and so ICT there would tend have a relatively small carbon footprint. In contrast to that, UK grid electricity has high carbon intensity due to its predominance of coal and gas. This, in turn, means that ICT will have a larger footprint. [3]

The responsibility of the ICT industry makes it efficient when facilitating the greening of other sectors. Even though there are other sectors which have higher carbon emissions, ICT industries must take note of their own emissions, as well. It is true that the ICT industry is not as disruptive as the other industries, but still it has to attend to its own greening ways to redress the increasing carbon footprints caused from high-energy call centers, data centers that run on 'cloud computing', high-speed servers, communication and telecommunication platforms and networks, cooling devices and equipment such as air conditioning units, multiple PCs, modems and phones. [10]

Below is the distribution of carbon emissions by sectors. [11] ICT industry belongs to the group of 'Other Energy' which has a total of 10% emission factor, as combined with aviation, broadcasting and others, to name a few.

Information and Communications Technology industry can be sub-divided into two categories of equipment such as: (a) electronic devices and (b) info-structural or infrastructural facilities. ICT in the form of electronic devices includes desktop computers, laptops, hand-held devices such as smart phones and tablets. Examples of info-structural or infrastructural facilities includes data centers including servers, switches and routers, power and cooling equipment, communication network, and back-up power sources. Printers and other necessary office equipment are also included in this research.

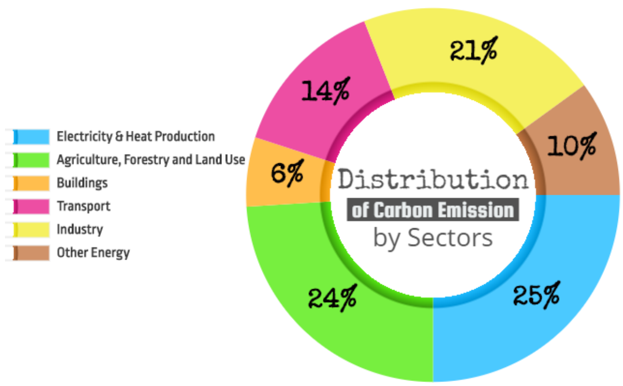


**Figure 1.** Global carbon dioxide emission by sector

Data centers are dedicated facilities that are used to accommodate ICT equipment such as servers (computers that offer services over a network) and data storage. [12] When talking about data centers, they are typically run continuously on a 24/7 basis and except for servers, the useful life of their equipment is over 10 years. So the contribution of the production energy of the equipment tends to be negligible compared to the annual energy consumption, and therefore its contribution to the annual lifecycle footprint can be safely ignored. Even for servers which tend to have a shorter useful life of 3-5 years, the production energy footprint of a typical data center server is estimated at about 328 kg. [13] But for the purpose of this study, the lifecycle, useful life and production energy are not taken into consideration as the data gathered occurred in a sampled date when the researcher took office in the department. Furthermore, the equipment used during the time of sampled date was already several years old and it would be hard to try to gather relevant data for those past years.

## 2. Materials and methods

To accomplish this report, the researcher needs to estimate the following quantities for each component: (a) the time in use, (b) time when on standby, (c) time when switched off. The power rating of the equipment used in this study 'when turned on' was based on equipment's specification sheet, while their power rating when on standby and when switched off is rough estimates. The table below indicates the estimates for each ICT asset. Items number 1 through 19 are grouped as ICT infrastructure and items 20 through 31 are grouped as Electronic devices which as used inside the DICT Luzon Cluster 3's office. During this study, the 'time in use' refers to the duration of equipment being turned on and utilized by the data center and DICT personnel. 'Stand by' returns the values of each equipment when not doing a certain process but is powered on (situation include each equipment being turned on after power loss, rebooting) while the 'switched off' refers to the situation where each equipment is not turned on but is still plugged in to the AC outlet, thus consuming small amount of power (Table 1*)*.

The formula below was used to come up with the computation of the actual carbon dioxide emission of the office:

$$CO2\ Emission = \frac{(\sum(t * P)) * units * 0.5246}{1000}$$

Where $t$ is the time when the equipment is in use, on standby or when switched off, $P$ is the power usage of the equipment when in use, on standby or when switched off and *0.5246* is a constant value for carbon footprint computation. The whole equation is divided by 1000 to convert the total power into kiloWatt (kW).

Furthermore, the data on power outage during the duration of the study are based on Meralco's electrical outages as posted and reported on their online social networking sites and webpage (Figure 2). The data gathered are then plotted on a table using the ICT Carbon Footprint Measuring Tool [14], each co-relating data being multiplied and added. Some constants used are based on the existing standard conversion factors available [15].

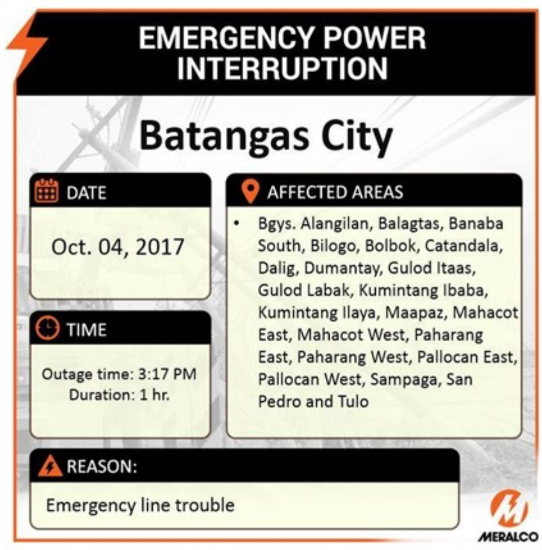


**Figure 2.** Electrical power outage in Batangas City**.**

The formula below was used to come up with the computation of the actual carbon dioxide emission of the office:

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Where $t$ is the time when the equipment is in use, on standby or when switched off, $P$ is the power usage of the

**Table 1.** Carbon footprint data of DICT's data center and other peripherals.

| No. | ICT Asset | Time in Use | Stand By | Switched Off | Power Usage (in watts) | | | Annual Unit Consumption | # of Units | Total Power Consumption (kWh) | Cost (Php) | $CO_2$ emissions (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | In-use | Stand by | Switched Off | | | | 10.32 | 0.5246 |
| 1 | Delta Battery Pack | 30.00 | 8,700.00 | 30.00 | 900.00 | 3.60 | 0.50 | 58,335.00 | 3 | 175.01 | 1,806.05 | 91.81 |
| 2 | Switch (Huawei S5320-28P-SI) | 8,700.00 | 30.00 | 30.00 | 21.20 | 4.00 | 0.20 | 184,566.00 | 1 | 184.57 | 1,904.72 | 96.82 |
| 3 | Switch (Huawei S5320-28X-SI) | 8,700.00 | 30.00 | 30.00 | 22.30 | 4.00 | 0.20 | 194,136.00 | 1 | 194.14 | 2,003.48 | 101.84 |
| 4 | Switch (Huawei S6720-54C-EI-485) | 8,700.00 | 30.00 | 30.00 | 209.00 | 6.20 | 0.20 | 1,818,492.00 | 1 | 1,818.49 | 18,766.84 | 953.98 |
| 5 | Router(Microtik CAS125-24G-15-RM) | 8,700.00 | 30.00 | 30.00 | 15.00 | 4.00 | 0.40 | 130,632.00 | 1 | 130.63 | 1,348.12 | 68.53 |
| 6 | Router (CISCO ASR 1002-X) | 8,700.00 | 30.00 | 30.00 | 470.00 | 14.00 | 0.40 | 4,089,432.00 | 1 | 4,089.43 | 42,202.94 | 2,145.32 |
| 7 | Switch (CISCO Catalyst 2960-X) | 8,700.00 | 30.00 | 30.00 | 66.00 | 4.00 | 0.20 | 574,326.00 | 1 | 574.33 | 5,927.04 | 301.29 |
| 8 | BlueCoast (Cacheflow 500) | 8,700.00 | 30.00 | 30.00 | 400.00 | 12.00 | 0.50 | 3,480,375.00 | 1 | 3,480.38 | 35,917.47 | 1,825.80 |
| 9 | Transmission System (Huawei RTN 950A) | 8,700.00 | 30.00 | 30.00 | 125.00 | 3.00 | 0.50 | 1,087,605.00 | 1 | 1,087.61 | 11,224.08 | 570.56 |
| 10 | Power supply (Mean Well SP-240-48) | 8,700.00 | 30.00 | 30.00 | 240.00 | 3.00 | 0.50 | 2,088,105.00 | 1 | 2,088.11 | 21,549.24 | 1,095.42 |
| 11 | Power Module (Huawei PDC-350WA-B) | 8,700.00 | 30.00 | 30.00 | 350.00 | 10.00 | 0.50 | 3,045,315.00 | 1 | 3,045.32 | 31,427.65 | 1,597.57 |
| 12 | UPS (Delta GES103R212035) | 30.00 | 8,700.00 | 30.00 | 900.00 | 27.00 | 0.50 | 261,915.00 | 8 | 2,095.32 | 21,623.70 | 1,099.20 |
| 13 | UPS (LP12-40) | 30.00 | 8,700.00 | 30.00 | 22.40 | 3.60 | 0.50 | 32,007.00 | 4 | 128.03 | 1,321.25 | 67.16 |
| 14 | Router (Huawei ATN910C) | 8,700.00 | 30.00 | 30.00 | 69.00 | 4.00 | 0.50 | 600,435.00 | 1 | 600.44 | 6,196.49 | 314.99 |
| 15 | Router (Ruijie RG-RSR20-X) | 8,700.00 | 30.00 | 30.00 | 48.00 | 4.00 | 0.50 | 417,735.00 | 2 | 835.47 | 8,622.05 | 438.29 |
| 16 | Server (Poweredge R420) | 8,700.00 | 30.00 | 30.00 | 183.00 | 97.00 | 0.50 | 1,595,025.00 | 2 | 3,190.05 | 32,921.32 | 1,673.50 |
| 17 | Switch (Ruijie RG-N18010) | 8,700.00 | 30.00 | 30.00 | 730.00 | 21.90 | 0.50 | 6,351,672.00 | 2 | 12,703.34 | 131,098.51 | 6,664.17 |
| 18 | M18010 CM | 8,700.00 | 30.00 | 30.00 | 40.00 | 4.00 | 0.50 | 348,135.00 | 1 | 348.14 | 3,592.75 | 182.63 |
| 19 | M18000 (24GT20SFP4XS) | 8,700.00 | 30.00 | 30.00 | 100.00 | 4.00 | 0.50 | 870,135.00 | 2 | 1,740.27 | 17,959.59 | 912.95 |
| | Total | 139,290.00 | 26,580.00 | 570.00 | 4,910.90 | 233.30 | 8.10 | 27,228,378.00 | 35 | 38,509.04 | 397,413.30 | 20,201.84 |
| 20 | Laptop | 1,440.00 | 480.00 | 6,840.00 | 65.00 | 12.00 | 1.00 | 106,200.00 | 13 | 1,380.60 | 14,247.79 | 724.26 |
| 21 | Desktop | 1,440.00 | 480.00 | 6,840.00 | 60.00 | 12.00 | 1.00 | 99,000.00 | 17 | 1,683.00 | 17,368.56 | 882.90 |
| 22 | LCD Screens (Samsung) | 1,200.00 | 5,808.00 | 1,752.00 | 57.00 | 1.60 | 0.40 | 78,393.60 | 9 | 705.54 | 7,281.20 | 370.13 |
| 23 | Epson Printer L365 | 960.00 | 960.00 | 6,840.00 | 11.00 | 3.60 | 1.30 | 22,908.00 | 2 | 45.82 | 472.82 | 24.04 |
| 24 | Epson Printer L385 | 960.00 | 960.00 | 6,840.00 | 11.00 | 3.60 | 0.30 | 16,068.00 | 3 | 48.20 | 497.47 | 25.29 |
| 25 | Epson L210 | 960.00 | 960.00 | 6,840.00 | 12.00 | 3.80 | 0.30 | 17,220.00 | 2 | 34.44 | 355.42 | 18.07 |
| 26 | Epson LQ 2190 | 120.00 | 72.00 | 8,568.00 | 46.00 | 3.00 | - | 5,736.00 | 1 | 5.74 | 59.20 | 3.01 |
| 27 | Epson L565 | 960.00 | 960.00 | 6,840.00 | 11.00 | 1.60 | 0.30 | 14,148.00 | 1 | 14.15 | 146.01 | 7.42 |
| 28 | Epson LX-300 | 960.00 | 960.00 | 6,840.00 | 120.00 | 30.00 | - | 144,000.00 | 2 | 288.00 | 2,972.16 | 151.08 |
| 29 | HP 2545 Printer | 960.00 | 960.00 | 6,840.00 | 10.00 | 2.00 | 0.20 | 12,888.00 | 1 | 12.89 | 133.00 | 6.76 |
| 30 | Epson LX-310 | 960.00 | 960.00 | 6,840.00 | 27.00 | 1.10 | 0.30 | 29,028.00 | 1 | 29.03 | 299.57 | 15.23 |
| 31 | TP Link Archer C7 | 8,700.00 | 30.00 | 30.00 | 4.60 | 0.10 | - | 40,023.00 | 2 | 80.05 | 826.07 | 41.99 |
| | Total | 19,620.00 | 13,590.00 | 71,910.00 | 434.60 | 74.40 | 5.10 | 585,612.60 | 54 | 4,327.45 | 44,659.27 | 2,270.18 |
| | Grand Total | 158,910.00 | 40,170.00 | 72,480.00 | 5,345.50 | 307.70 | 13.20 | 27,813,990.60 | 89 | 42,836.49 | 442,072.57 | 22,472.02 |

equipment when in use, on standby or when switched off and *0.5246* is a constant value for carbon footprint computation. The whole equation is divided by 1000 to convert the total power into kiloWatt (kW).

Furthermore, the data on power outage during the duration of the study are based on Meralco's electrical outages as posted and reported on their online social networking sites and webpage. The data gathered are then plotted on a table using the ICT Carbon Footprint Measuring Tool [14], each co-relating data being multiplied and added. Some constants used are based on the existing standard conversion factors available [15].

This power interruption during October 4, 2017 is vital for the operation of the uninterruptible power supply. Based on specifications, each of the UPS stored in the data center of the department can operate in 30 minutes maximum.

Other than these details, a survey questionnaire has been provided to determine the common practices of each employee when handling their ICT equipment inside the office. And the result of the survey is reflected on the table below with 30 total number of respondents:

**Table 2.** Common practices of DICT employees in the office.

| Activities/Practices of Employees | Frequency | Percentage (%) |
|---|---|---|
| 1. Computers/laptops are not turned off during break time and lunch break | 21 | 70.00 |
| 2. "Hibernate" and "Sleep" option for computers/laptops are not utilized. | 19 | 63.33 |
| 3. Unplugs laptop devices after shutting down (for laptop users, out of 13 units). | 9 | 69.23 |
| 4. Unplugs desktop computers after shutting down (for PC users, out of 17 units). | 5 | 29.41 |
| 5. Does not unplug laptop devices even when the unit is fully charged (for laptop users, out of 13 units). | 10 | 76.92 |
| 6. Turns on printers before work schedule and turns off after work schedule | 22 | 73.33 |
| 7. Unplugs printers from outlets after shutting down (after end of work schedule) | 22 | 73.33 |

Furthermore, the following are also observed on the actual operations of the office in terms of its utilization of ICT office equipment:

1. UPS is not being used in most employees using desktop computers.
2. Flat screen monitors are used instead of cathode ray tube displays.
3. Printers used in the office are all multi-functional that can scan, copy, and print.

## 3. Results and discussion

The data collected were analyzed to calculate the data center and department's office's carbon emission. Basically, the study was carried out to analyze the emission made by ICT equipment and other office equipment carbon emission distribution. There are different factors that accounts to the ICT carbon emission but in this study, the factors include time of usage, time on standby and time during equipment is switched off. The electrical outages and its duration were also taken into consideration knowing that the department is using uninterruptible power supply as backup source during power outages. Aside from that, common practices of employees in using ICT equipment were also considered which primarily affects the usage of equipment inside the office.

Among these practices, not shutting down or putting computers in sleep mode, not unplugging the chargers from outlets, not using UPS for desktop computers (no UPS is seen inside DICT Luzon Cluster 3's office), and not turning off printers after every use still produce carbon footprint. All of these practices' respective amount of carbon emissions were incorporated in the calculation made on table 1 however, the time used for each device during its 'time in use', 'on standby' and 'switched off' were approximates.

On the other hand, using flat screen monitors and multi-functional printers and the idea of unplugging printers and laptops after every working hour helps in reducing the carbon emission. Flat screen monitors have lesser power rating compared to cathode ray tube monitors; same with the recent printing products present as compared to old-fashioned type of printer (dot matrix).

Based on Table 3, summarizing the contribution of ICT infrastructure and electronic devices, the values measured for its total power consumption, cost, and carbon emission (in kg and percentage) have a huge difference. ICT infrastructures consume a considerable amount of power. Since all the equipment installed in the ICT infrastructure or data center must be turned 24/7 basis, it has been computed to be giving off 89.90% of the overall carbon emission for the whole department while the electronic devices contribute a total of 10.10% of the carbon emission.

Though ICT infrastructure equipment used in the data center is lesser than the office equipment, it still has a high gap of percentage of carbon emission. Based on table 1, the emission of the equipment rises as the time of usage increase. The fact that data centers must be open and accessible 24/7, one factor affecting this gap is highly dependent on power supply and back up sources.

Based on the study conducted by Malmodin and Lunden [18], the largest portion of the carbon footprint emitted from the ICT sector in the year 2015 is related to user devices and the actual utilization stage. Furthermore, the calculations made on the study emphasized that the energy consumption related to offices for the ICT which operates the data centers were also included in the footprints.

With the rise of technology in the world, the increase in the number of devices and thereby in subscriptions remains the main reason in the rise of the share of the ICT in the carbon emission count which is also reflected on another

**Table 3**. Power consumption, cost, and total emission breakdown per item.

| Item | Consumption kWh | Total Cost (PhP) | Total Emission (kg) | Annual Average |
|---|---|---|---|---|
| ICT Infrastructure | 38,509.04 | 397,413.30 | 20,201.84 | 1,683.49 |
| Electronic Devices | 4,327.45 | 44,659.27 | 2,270.18 | 189.18 |

study conducted by J. Malmodin, et.al. [19]. It further suggested that improvements in the energy efficiency of network equipment that are being run 24/7 must be considered. There must also have a better power management and lower stand-by power consumption of user equipment. Data centers, being one of the highest contributors of emissions within the ICT sector may be virtualized coupled more efficient servers and supporting infrastructures.

On this study, the researcher has made several estimations especially in computing the power rating of equipment, both from ICT infrastructure and electronics devices during stand-by and switched off. For the accuracy of measurement, the researcher recommends the use of a specialized tool that can measure such details.

Consider also computing the production footprint of each equipment including their total carbon emission during its whole life cycle. In this way, it will be accurate to say whether the equipment is producing too high or just enough carbon footprints.

When it comes to the equipment used inside the data center, contractors and the DICT itself has to come up with an agreement with the use of more energy efficient routers, switches and UPS since some of these items consume really high power. The researcher also recommends inspecting the status of the cooling equipment installed in the data center. Layout of the building and locations of the cooling equipment must help avoid the mixing of hot and cold air to avoid moisture thus affecting the functions of items.

Meanwhile, the researcher also recommends the following solutions to combat the emission coming from electronic devices:

1. Create environmental standards in operating electronic devices in the office which can help reduce the irresponsible emission of carbon.
2. Replace old-fashion printers (like the dot matrix) to the recent models of printers as they are more energy efficient
3. Set a certain power management rule for computers and laptops that can automatically put the units in low power mode after a period of inactivity
4. If possible, replace the desktop computers and cathode ray tube monitors into laptop computers and flat screen monitors, respectively, as they are more energy efficient
5. Use multi-functional devices like printers which are more efficient than using different devices

## 4. Conclusions

The analysis of the data gathered shows that ICT technologies, equipment, facilities, and devices do contribute to the increasing amount of carbon dioxide in the world. Usage length and power consumption are the main contributing factors that made computing the total carbon emission easier. DICT Luzon Cluster 3 has an ICT carbon dioxide emission of 22,472.02 kg of CO2e emitted for the whole duration of the study, which is 1,872.67kg of CO2e on the average for a year.

Arising from the survey conducted to employees is the problem about having no environmental policy within the office. One proof is the continual use of the old versions of printers such as the dot matrix, which also comes in different models (see table 1). The issues of leaving their laptops/ desktop computers turned on even during break time and lunch time also emits certain levels of carbon. Looking at the ratings of old-fashioned printers, most models consume the most power and therefore, higher carbon emission. To reduce such high amounts of carbon emissions, consolidating the devices in the data center and office area can optimize the department's operations.

Other than that, it is also beneficial to know that ICT footprint is increasing at an alarming rate especially the emissions coming from the data centers which are operating at a 24/7 rate. Also, the increase in temperature in the world's environment has already caused severe effects to humans. Having such alarming increase in the emission of the ICT sector would further furnish detrimental consequence.

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