MEASURING CARBON FOOTPRINT OF COMPUTING TECHNOLOGY – A CASE STUDY AT ICIMOD

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ABSTRACT

Being an organization working and advocating on environment issues, and having been using extensive IT to carry out its operations, projects and programmes, the International Centre for Integrated Mountain development, ICIMOD, www.icimod.org, was keen to measure the carbon footprint of its computing technology out of IT use mainly. There was equally the motivation to go green with IT as the organization looked into reducing operating expenses, be socially responsible by reducing environmental impact and to support the broader scientific consensus on climate change, which is another priority working area of ICIMOD. Thus, in this study focus has been given to calculate total power consumption by users computers, individually and collectively, and the same for the server systems hosted. To calculate carbon footprint, the power consumed figure have been fed into an widely accepted algorithm from AMEE, www.amee.com to take stock of carbon emissions in terms kg of CO2 equivalents. Various other analogies has been drawn from the results obtained ranging from server to distributed PCs ratio of CO2 emission, individual CO2 emission from computer use raising awareness for staff, consideration of other phases of product, besides use, and pretest on response to effect of applying a common power management strategy. The outcome was also compared with the results from similar measurements by a computer product manufacturer, using another approach, thereby corroborating the results. Further, in this phase of the work, key figures and thereby trend has come out to take actions and influence IT asset procurement. This paper therefore highlights the importance of calculating and knowing IT carbon footprint, following which how organizations can reap benefit in reducing costs and environmental impact through green computing, and features experience of a leading-edge, mid-sized organization.

KEYWORDS

carbon footprint, energy consumption, green computing, green ICT, environmental impact

INTRODUCTION

Increased attention to green IT has resulted from a number of factors, including: rising energy costs, increased publicity regarding global warming and climate change. IT industry accounted for about 2% of global emissions of carbon dioxide (CO2) or 830 MtCO2 eq, according to estimates by Gartner Group in their study during 2007 [1]. The figure is said to have been equivalent to that for the aviation sector. This figure sent an alert to the IT industry. The rapid uptake of computers, mobile phones and the Internet and mushrooming of data centres is set to double the emissions and could soon overtake the aviation sector. In fact as per another report by The Climate Group [2], this figure looks set to grow at 6% each year until 2020.

The International Centre for Integrated Mountain Development (ICIMOD) is a regional intergovernmental learning and knowledge sharing centre serving the eight regional member countries of the Hindu Kush Himalayas – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan – and based in Kathmandu, Nepal. Globalization and climate change have an increasing influence on the stability of fragile mountain ecosystems and the livelihoods of mountain people. ICIMOD aims to assist mountain people to understand these changes, adapt to them, and make the most of new opportunities, while addressing upstream-downstream issues.

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At ICIMOD, IT unit is taking measures such as virtualization of servers in its server farm, launching workflow enabled electronic forms thereby reducing paper use, when appropriate encouraging video-conferencing to substitute travel, use of thin-clients as training computers, storage consolidation, printer consolidation, responsible use of paper. These are activities on carbon management from IT perspectives and can be replicated or initiated by any organization, all of which provide immediate cost reduction benefits along with reduced environmental footprint. Being an organization working in the domain of environment, these contribute to enhancing ICIMOD's 'green' credentials also. Along the same line, it was important to exactly measure IT energy consumption and IT carbon footprint and have evidence for management to take measures further, which is the focus of this paper. Energy prices have been going up while other aspects of the operational costs such as Internet bandwidth have been falling. With carbon footprint measured data, it was easier to evaluate the assumptions and identify opportunities both to improve operational efficiency and to lower costs.

The 'carbon footprint' concept has become popular over the past few years – since, more or less, 2005 – and is currently widely accepted and used by the public and media despite its lack of universally adopted guidelines [3]. It describes greenhouse gas emission measurement from the narrowest to the widest sense. Several calculation methods and approaches for carbon footprint accounting have been proposed and are being used like the one followed in this study. The carbon footprint is increasingly used as the stick by which to measure the volume of GHG emissions, expressed in terms of emitted CO_2-equivalents, related to specific activities or products.

ICIMOD uses a fleet of servers to deliver IT services ranging from enabling communication to managing information. There are 10 servers in use in the Server Farm – HP Proliant ML 150 (1), Dell PowerEdge T610 (1), Dell PowerEdge 2900 (4), Dell PowerEdge 1430 SC(1), Dell PowerEdge R810 (2). There are external storage devices of 20 Tb from Lacie, network switches, a single monitor attached to the servers via KVM switch. There is also a one tonne air-conditioner used for cooling the room and the devices within. All these are powered through five set of heavy duty UPS, 24 x7, 365 days. Power consumed by the server room is measured by measuring the supply into it. As per the users computers, there are 158 distributed computers in use, which include staff laptops, training room thin clients PCs, and several workstations used for image processing. Each staff has a single, branded office laptop – either a Dell or HP. Computers were monitored in as is condition of daily work activities. This was basically the environment when the measurement was done.

METHODOLOGY

To start with, the team did an energy measurement exercise of all the desktops, laptops, servers, being currently used in the organization. To measure energy consumed by a computer, a digital energy meter, as shown in Fig. 1, was used that measured energy consumed by a device in KWh over a representative period of time.

Fig. 1 Digital energy meter

Then to calculate the CO_2 emission, the energy consumption after normalization to a common base was calculated as per the algorithm used by AMEE platform which is, CO_2 = Energy consumed per year x carbon emission factor x no. of computers

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AMEE, www.amee.com, is a web-based tool that allows users to store and retrieve many forms of consumption data over long periods, while simultaneously applying recognized carbon calculation models to determine the environmental consequences of that consumption. It has been used by developers to deliver myriad energy-tracking and energy-management solutions [4].

The carbon emission factor is a constant unit and is different for each country. According to a voluntary reporting of greenhouse gases published by U.S. Department of Energy, Energy Information Administration, the emission factor for Nepal is 0.013 Metric tons/ MWh, where ICIMOD is located and which is the emission factor used. Likewise, at the time of writing, the US emission factor was 0.676 Metric tons/ MWh.

For energy consumption measurement, following assumptions were made:

a. The user computers operate 8 hours a day, so 1 day is equivalent to 8 hrs. Servers, however, operate 24 hours a day so energy consumption for servers has been calculated based on 24 hours. For comparison, 24 hours has been taken as a base
b. Computers were monitored in 'as is condition of daily work activities'
c. Energy consumption for laptops were measured while being connected to docking station and an external monitor
d. The carbon footprint has been calculated based on *use* phase, i.e. actual energy consumed.
e. Lifetime of the laptops was estimated at 4 years.

It is equally important to be clear of the scope of study. The study does not take into account the carbon footprint impacts through other phases of the computer product life cycle, which are beyond our control — such as from designing and sourcing through manufacturing, order fulfillment, transportation, and product recovery or recycling. However, to have an idea of overall footprint and to be able to make comparison with other independent researches, other factors namely manufacturing, transport and recycling have been taken from figures reported, for the same brand being used here. The table below provides an overview on the methodology.

Table 1 - Overview of methodology

	Carbon Footprint
What is measured	The anthropogenic emission of greenhouse gases (GHG)
Unit of Measurement	Mass of CO2 equivalents per product per unit of time, in per year or per product life
Geographical Dimension	Place of use and emission matters as their emission factor differs
Entities for which the carbon footprint has been calculated	Measurement of indirect emission of power consumed on use by computer products. To draw comparison with other research, carbon footprints for manufacturing, transport and recycling figures referenced
Calculation Method	Based on AMEE tool that takes consumption data for representative period of time

FINDINGS AND ANALYSIS

The total greenhouse gas emissions from users computers and the servers for the whole of the organization came to close to 775 Kg of CO2 equivalents per year. While the greenhouse gas emission due to computers might be very small, it still has some impact on our environment. Additionally, it does indicate the power consumption pattern by computing equipment. It was of interest for everybody and an opportunity to raise awareness through evidence the CO2 emission by their own computer. Organizationally, considering 158 PCs and 10 servers in use, the average CO2 emitted per computer per year came out to be 4.9 Kg. The table 2 below gives the summary of results obtained for all brands measured and being used currently. Likewise, Table 3 gives the overall figures of carbon footprint for the organization.

Table 2 - Carbon footprints of computers by model

Computer Model	Energy consumed in 1 year (KWh) on as is condition	Carbon foot print for each computer model in Kg of CO2 eq. per year
Dell Precision M4400	161.3	2.10
Dell Latitude E6400	88.3	1.15
Dell Precision M4300	161.3	2.10
Dell Latitude E6420	92.0	1.21
Dell Precision M4600	54.9	0.71
Dell Latitude E5420	143.6	1.87
Dell Precision M2400	92.7	1.20
Dell Precision 690	512.9	6.67
Dell Precision T7500	362.1	4.71
HP EliteBook 8560w	116.2	1.51
Dell Latitude E6320	84.5	1.10
Dell Latitude E6520	101.4	1.32
Dell Latitude E4310	84.5	1.10
UPS1 - 2 KVA (24h) – Server room	4708.5	
UPS2 - 2 KVA (24h) – Server room	8084.7	
UPS3 - 2 KVA (24h) - Server room	7259.8	
UPS4 - 3 KVA (24h) – Server room	9526.5	
UPS5 - 10 KVA (24h) – Server room	11212.8	

Table 3 – Overall carbon footprint

	ICIMOD (considering emission factor of 0.013 for Nepal)	United States (considering emission factor of 0.676)
Total Carbon footprint in kg CO2 eq. per year (Actual running conditions)	775.7	40338.1
Average carbon footprint per computer per year, excluding Servers, in Kg CO2	2.05	101.9
Average carbon footprint per computer per year, including Servers, in Kg CO2	4.9	255.3

The manufacturers have also been coming with computers having lower footprints. From the data obtained and shown in the table above, one can observe the newer computer models within their family following lower footprint pattern as that effort seemed to have gone into enhancing the energy efficiency of computers, particularly laptops.

The emission factor used is significant. For Nepal, this is fairly low, 0.013, considering mostly clean and renewable source of power generated, hence low CO2 equivalent. Using US emission factor of 0.676 to make comparison with other reports, the average CO2 emitted shoots to 255 Kg per computer per year. Dell, in one of their own studies has mentioned that total greenhouse gas emissions taking use, manufacturing, transport, recycling for the Latitude E6400 is 350 kg CO2 eq for the whole product life of 4 years when used in US [5]. The figures Dell has come up from that study are respectively approximately 165, 45, 170, 30 Kg of CO2 for manufacturing, transport, use and recycling. The 30 kg CO2 eq for recycling is taken as carbon credit due to the fact that the recycled material can be used directly to replace the primary material in new products. Accordingly, the 350 Kg of CO2 eq (165+45+170-30) is arrived at. As per the report, Dell used the carbon-foot printing expertise of PE International and on its associated database and tool for those calculations.

This figure for E6400 laptop gave an idea to corroborate our own findings. At ICIMOD, there are 50 numbers of Latitude E6400 deployed. One unit of E6400 laptop was measured to be consuming 88.32 KWh per year. If one takes that actual power consumed data during use by a Latitude E6400 and assumed it being placed in US for 4 years having emission factor of 0.676 and apply the identical figures for transport, manufacturing, recycling and estimate the Kg CO2 equivalent emitted, this figure for Latitude E6400 laptop comes out to be 388 Kg C02 equivalent (165+45+238-30) and is fairly comparable to Dell's report of 350 Kg CO2 eq taking into account of the addition of external monitor and the dock prevalent in the said laptop utilized at ICIMOD. The figure 2 below illustrates this point.

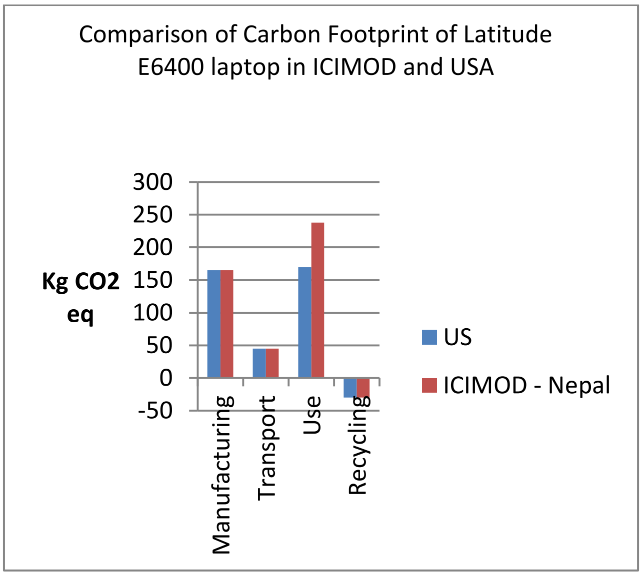

Fig. 2 Comparison of carbon footprint by location of use and by other phases of the product

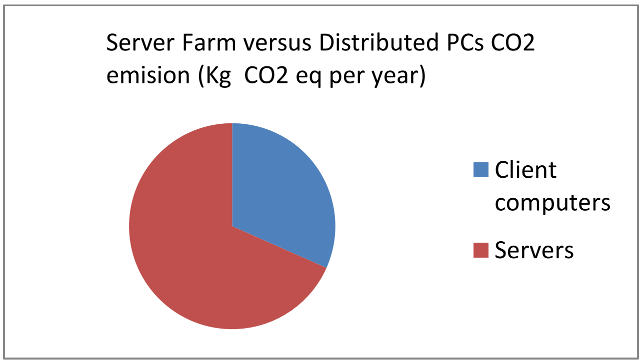

Fig. 3 Comparison of Servers and Users PCs footprint

The data also showed servers footprint against the rest of the distributed users computers in terms of CO2 emissions per year, which in terms of ratio was 70:30 meaning that 70 percent of the total footprint is created by servers. This is certainly an area to tighten and have room for much improvement. When taking into account the high footprint of servers, a fact that the servers run continuously all 24 hours becomes clear why the figure is also so overlooking.

In this phase of the work, key figures and trend has come out to take actions. There is evidence now that has been measured for which management measures can be taken. One action as a follow up planned to this work is applying a centralized power management software controlled strategy to reduce energy consumption. Before doing that in a larger organization-wide level and also to see the response, the team took three models of computers being used and applied a defined power management setting and took the measurement for a representative period of time like before. The three different models used were – HP Elite Book 8560w, Dell Precision M4400, and Dell Precision 690 representing three different range of products. The power setting configuration is as given below in the table 4.

Table 4 – power management setting applied

Settings	Battery	Plugged in
Dim display	2 min	5 min
Turn off display	5 min	10 min
Put into sleep	15 min	15 min

The results obtained for the three models measured is as in Table 5, vis-a-vis to the measurement taken before applying specific power management setting.

Table 5 – response to before and after power management

Computer Model	Carbon foot print for each computer model in Kg of CO2 eq. per year	Carbon foot print for each computer model in Kg of CO2 eq. per year, after applying specific power management setting
Dell Precision M4400	2.10	2.05
Dell Precision 690	6.67	4.8
HP EliteBook 8560w	1.51	1.5

The response from this measurement indicates that for the laptops (HP EliteBook or Dell Precision M4400), there was not significant saving in energy and for that matter no noticeable reduction in carbon footprint. However, as per the desktop model, Dell Precision 690, the same changes were strong enough, a reduction of 1.87 (6.67 – 4.8) Kg of CO2. This implies significant reduction in CO2 eq can be achieved for desktops model with proper power management strategy. For laptops, the energy consumption looks optimized by design and the default factory setting looks working best. Ultimately, it makes the case that use of power management features, needs to be applied by the users more uniformly and contributes to lowering CO2 emission.

CONCLUSION

All these measurements are expected to implement further organization wide energy management strategies and introduce technologies to reduce carbon footprint of computing, thereby demonstrating superior environmental performance, besides making aware of the idea of 'green computing' for each individual user. PC power management is a low hanging fruit to realize value to reduce carbon footprint. Being an organization working in the domain of environment, this exercise is expected also to enhance ICIMOD's 'green' credentials as well and build awareness of green ICT among partners and other organizations in the region. It also has featured experience of a leading-edge, mid-sized organization. Furthermore, the paper is expected to impart a simple methodology to calculate carbon footprint of computing technology at any organization. By calculating total carbon footprints for all sources, organizations also get the opportunity to see if they can become carbon neutral, e.g. by balancing a measured amount with amount offset. Organizations must develop a green IT or green computing strategy, including measurement so as to manage, and to tackle information technology own impact, as well as help the organizations meet its growing environment related challenges. As ICT practitioners, we are also the primary users, beneficiaries and curators of the flourishing ICT industry, and thus must also seek solutions on our own doorsteps.

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