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Data Centers As an Emerging Environmental Threat: Case of Malaysia

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ABSTRACT

In the past decade, global attention towards environmental stewardship has increased. Concerns about air pollution, after pollution and hazardous substances have made governments and businesses to move towards greener policies and application. In between, ICT sector as a fast raising industry. Data centers despite the rapid worldwide growth, have not been under consideration until recently. This paper takes a look at this emerging thread and the negative impacts of data centers' activities on the environment. Moreover, the global attempts towards this issue were reviewed and were compared to that of Malaysia.

Indexing terms/Keywords

Green Data Centers, Environmental Protection, Malaysia

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Magement studies, environmental studies

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1. INTRODUCTION

According to a study done by Pickavet, et al (2008) the predicted annual growth rate of data centers is about 12%, which is the highest growth rate among ICT subsectors. Thus the quick increase of power consumption of network equipment is not surprising, as in 6 years from 1999-2005 it rose by 39%. Overall, ICT power consumption was reported to be 168 GW in 2008, which has been estimated to reach over 430 GW by 2020. In addition, total direct electricity consumption (which excludes the manufacturing process consumption) was 8% in 2008 and has been estimated to reach 14% by the year 2020 (Pickavet, et al. 2008).

Data centers in particular are a raising concern. On average data centers consume 15-40 times more power than a similar sized office space (Greenberg, Mills and Tschudi 2006). In U.S in 2006, data centers were responsible for 1.5% of the whole United States national power consumption (EPA, 2007) (Salim and Tozer 2010).

As of 2011 data centers have become a well-known word in the different industries. Despite their expensive construction procedure, the number of data centers is growing rapidly.

Reasons of data centers' fast Growth:

1) Increasing dependence of Industries on IT:

   In the world today, managing huge amount of data has become one of the most important aspects in any industry. From online banking E-businesses to government procurement, businesses are looking for outsourcing their data.

2) Rapid growth of the Internet:

   The Internet is spreading faster than ever. In North America solely 68.6% of the population were reported using Internet in the year 2006, which indicates a growth of 110.4% in less than only 6 years (Yi and Thomas 2007). As a result, the need for 24/7 nonstop Internet and data connection is a vital criterion in the E-world. E-businesses and E-commerce players like online banking need access to massive amount of data daily.

3) Cloud Computing:

   The emergence of the could concept in the 1960s and its subsequent popularity in the 2000s, is another reason behind the vast growth of data centers in the recent years. Cloud computing is a new way of accessing to your data from anywhere at any time, which uses Internet Data Centers to reserve and manipulate the data. Cloud as a metaphor for Internet, is a rather new definition in the IT industry, however like many other innovation in technology, it already has opened its place into normal people's lives. As an instance apple Inc. introduced iCloud for its PC and other apple gadgets to have access to their data such as music, videos (Apple 2011).

Another example is Microsoft Live Mesh, which similarly to iCloud helps users to gain access to their own stored data and apps from anywhere at anytime, by connecting to a web-based online storage data center (Liang Liu 2009).

Cloud computing saves costs and energy consumption, but at the same time leads to a new issue: need for data centers to work as a cloud for outsourcing other enterprises data.

Currently data centers are consuming more than ever, at this point US and Europe have the largest data center power usage, whereas Asia Pacific is rapidly catching up (Daim, et al. 2009).

However, what are the disadvantages of this boom of technology?

2. NEGATIVE ENVIRONMENTAL IMPACTS OF DATA CENTERS

In this part, the clear and undercover negative impacts of data centers on the planet and people all around the world will be viewed.

2.1 Energy Scarcity

One of the important issues of the new world is the insufficiency of energy. The energy resources are not as abundant as they were assumed to be decades ago. It's estimated that by 2008, half of the earth's oil have been extracted by human (Benner 2005). Consequently, new sources of energy like solar and wind power are the possible substitutes, which are not an easy change (Salim and Tozer 2010).

2.2 Greenhouse Gases

In 2007, the entire ICT sector was estimated to be responsible for roughly 2% of global carbon emissions with data centers accounting for 14% of the ICT footprint. The forecasts show that by 2020 data centers' share of ICT carbon footprint (total amount of greenhouse emissions during a specific period of time) will reach 18% ((GeSI) 2008). Some of

the environmental outcomes of increasing greenhouse gases are: the changes in the weather pattern all around the globe and surprising floods, droughts and storms are some examples.

One of the most talked about issues is global warming, which at the beginning wasn't taken seriously. However, recent findings show that the global temperature has risen by about 0.8 °C (1.4 °F) in the last 100 years. Not surprisingly, two thirds of this increase has occurred during the last 30 years. One of the main causes of global warming is the high concentration of CO2 in the atmosphere, which now is at the highest level in at least the last 800,000 years (America's Climate Choices 2011). In Between, ICT sector is highly responsible for this matter. (Caldow 2008) Each PC generates almost a ton of CO2 every year, while being used. (Murugesan 2008). In 2010, U.S. data centers' CO2 emission alone was higher than the emission of countries such as Argentina, Netherland, and Malaysia (Lucente 2010).

2.3 Raw Materials Scarcity

The essential raw materials are another concern. This scarcity can even change the whole pace of development of an industry as it did between the years 1999-2001.

Tantalum is one of the key raw materials in manufacturing ICT devices such as mobile phones and gaming consoles. This precious material only can be found in two places in the world: Congo & Australia. It's imaginable that how the shortage of such key ingredient of ICT manufacturing can be costly for the industry (Elsevier 2005).

2.4 Enormous E-Waste

High levels of energy consumption and CO2 emissions are not the only affects of ICT on the environment. IT equipment not only while being used, but also in manufacturing, post-use stages such as disposal and recycling, can harm the environment. Unstandardized recycling methods and processes are also another concern. Recycling as a new approach into waste management can do more harm than good if done improperly (Murugesan 2008). A PC contains both valuable and dangerous materials. It may contain up to 4g gold as well as hazardous materials such as such as, lead, mercury, arsenic, cadmium, selenium and hexavalent chromium, which have been used in computers, are highly toxic (Elsevier 2005). There is no surprise that some workers in chip manufacturing have started reporting cancer clusters and people who are involved in recycling IT equipment have shown high levels of dangerous chemicals in their blood (Yi and Thomas 2007).

WEEE, Waste Electrical and Electronic Equipment or e-waste for short nowadays has become an environmental hazard. If computer (IT equipment) were buried, toxic materials can leak into underground waterways and soil. If burned the release toxic gases unto the atmosphere. Until some years ago only PCs and special electronic equipment was our target, today the new generation of e-waste is under concern. Everyday a new generation of old equipment changes are being used: smart objects. For instance new house appliances and toys use microprocessors.

In fact in 2005, more than 98% of the microprocessors manufactured were designed for commodities other than computers. These statistics ensure the rapid expansion of both classic and new generation of ICT equipment like cellphones, PCs, refrigerators, etc. into our everyday lives. Consequently, the toxic materials used in such commodities will also continue polluting our planet. However, some scientists argue that according to Moore's Law these equipment will be miniaturized gradually, the fact is as smaller have become the size of these commodities, which is a result of higher technology available, easier have become the production thus the cheaper has become the final price. This will mean the number of units produced will increase dramatically. A good example is the cellphones case. First introduced in 1973, their bulky bodies were weighted as much as 1000 g. Later through the years this massive size decreased and the new generation in now as light as 80g , meanwhile the number of subscribers have raised by a factor of 8.0 (1990-2005). Therefore, mobile phones, which were once a luxurious product, now have become the toys of the new generation of children.

The estimation of number of the "smart objects" in the near future is catastrophic. In a particular forecast, IBM in the year 2005 estimated that in only 5-10 years approximately 1 billion people will be using over a trillion smart objects worldwide, which means an average of 1000 objects per person. Thus, it's not surprising that the amount of WEEE will increase superfast. As an instance, European Commission (2000) estimated the WEEE to be increased by 2.7 in the best scenario and by 4.0 in the worst by 2020. It also has been estimated that under current conditions, the WEEE will increase by a factor of 3.1-7, based on the varying factors (Elsevier 2005).

2.5 Water Scarcity

Data centers use massive amounts of water directly for cooling purposes and indirectly for generation of their power. For instance a 15 MW data center consume up to 360,000 gallons of water daily (Sharma, et al. 2009).

Direct use of water: data centers use water for cooling IT equipment. In this process, the water absorbs the heat and needs to cool down by evaporation. Then it will be reused in the cooling system. However, some water then acts as a cleanser to clean the path from sediments. This small amount becomes enormous in large-scale data centers.

Indirect use of water: most of data centers work solely based on electricity. In many countries water is still one of the premier choices for power generation. In U.S. almost half of the water withdrawals are for power generation.

Water consumption of data centers hasn't been under the spotlight as energy and power consumption was. Only recently, experts have turned the public attention towards this new issue. According to James Hamilton, a data center designer and researcher at Amazon.com, water consumption in data centers is tomorrow's big problem. As the number and size of the data centers increases, does their water consumption. Therefore, gurus like Google and Microsoft have started using solutions to cut the water consumption by manipulating revised cooling system designs (Miller 2009).

Considering all these affects, what have been done about data centers' environmental sustainability?

3. GREEN DATA CENTERS MOVEMENT

The fact is that only recently data centers have gain global attention and some efforts have been made to make them more efficient and effective. In this section we will take a look at two of the key influential corresponding on data centers' environmental sustainability; researchers and corresponding organizations.

3.1 Role of Researchers

One of the first attempts toward environmental sustainability was in 1998 by Jokinen and a group of researchers. This paper was mainly focused on the conceptual aspects than the application. At the same year Cohen proposed another view on the same topic, this time by focusing more on e-commerce and its impacts on the sustainability process. Later in 1999, Arnfalk published his PhD thesis entitled "IT in Pollution Prevention"; in his work, Arnfalk was tried to evaluate the possibilities of using teleconferencing and teleworking to prevent or lessen environmental and economic impacts of organizations. Another example is another PhD thesis published in 2001. In this dissertation, Hurst investigates around the environmental impacts of B2C e-commerce through case study of 7 British companies and advantages and disadvantages of E-commerce (Yi and Thomas 2007).

One of the most significant team of researchers, whom made massive efforts in order to enhance data centers environmental sustainability, is the Lawrence Berkeley National Laboratory team. Since 2006, this team has produced interesting materials about data centers greenness and efficiency.

Two of their most influential publications are:

1) Best Practices for Data Centers: Lessons Learned from Benchmarking 22 Data Centers in 2006: This journal provides a comprehensive collection of data center benchmarking efforts done by LBNL team. The participant data centers were assessed through various aspects, such as energy consumption, cooling system design and efficiency as well as power supplies efficiency.

Since then, the results of this benchmarking study have been used by many researchers and associated organizations worldwide.

2) Self-benchmarking Guide for Data Center Infrastructure: Metrics, Benchmarks, and Actions: This simple yet detailed step-by-step guide is a great reference for data centers to start monitoring their performance. It provides benchmarking principles based on the findings of the previous work. Overall, help data center managers to better monitor and assess their energy and power performance as well as cooling system efficiency.

3.2 Influential Organizations on Green Metrics Development

Four of the most influential groups, which are working on data centers green metrics at this point, are:

1) The European Commission:

EC is one of the main executive bodies of European Union (EU), which is responsible for drafting new legislations as well as managing and implementation of the EU laws. EC consists of 27 commissioners selected every 5 years from their representative member country in the EU. EC environmental activities include:

1. New legislations and their implementation
2. Development of a voluntary Data Center Code of Conduct, by signing it organizations become responsible to reduce their energy consumption
   - UPS system efficiency
   - Overall efficiency of data center

- Data center design
- Using eco-friendly products

Some of the participants in this voluntary code are: Microsoft, Vodafone, Intel, and Hewlett-Packard (Alger 2009) (Commission, European 2012).

2) The Green Grid:

A non-profit trade organization of IT professionals founded on 2007 provides recommendations on best practices, metrics, and technology to improve data centers efficiency. Some of the most common metrics, such as and DCiE, which nowadays are being used for measuring data centers efficiency, are introduced for the first time by this organization. One of their latest efforts introduced on 2009 is Data Center 2.0 program, a new guide towards running data centers more efficient as "end-to-end guide, from the IT equipment all way through the facility infrastructure" (Green Grid 2007) (Daim, et al. 2009). Green Grid has gain strong position in the "Green IT" concept, as most of the ICT guru firms, such as IBM, HP, Intel and Sun Microsystems have direct participation in the organization's activities. The acceptance of Green Grid was that high that EPA changed its plans of introducing a replacement for PUE metric caused by high negative feedback from the industry experts (Tomory 2010).

3) Uptime institute:

Established in 1993, the Uptime Institute is an educational and consulting institute, serving Facilities and IT organizations interested in maximizing their data centers green level. This institute has been a pioneer in greening data centers, and is best known for introducing Tier classification for data centers' availability (Stanley, Brill and Koomey 2007) (Alger, 2009).
Launched in 1993, organization's website offers a collection of white papers and provides fast communication between its 100 members. In the recent years, Uptime Institute has changed its path from working on data centers' availability to their energy efficiency by publishing white papers and organizing seminars.
Their latest work is proposing Green Enterprise IT Awards program in 2008, which is focused on data centers energy efficiency (Alger 2009).

4) The U.S. Environmental Protection Agency (EPA)

From decades ago EPA has been working on environmental sustainability issue, but it's only from 2007 that they have focused on data centers as one of the key ICT subsectors on environmental protection (Alger 2009). One of the well-known efforts of EPA towards environmental stewardship is ENERGY STAR program. A joint program started by the US Environmental Protection Agency (EPA) and the US Department of Energy (DOE) started on 2009 (Daim, et al. 2009). Started in 1992, this program was the first movement towards a "greener" IT (Tomory 2010). The aim of this program is offering international standards for consumer products' energy efficiency. First started on U.S., the standards of this program are now widely acceptable in. The products with Energy Star label in average consume 20-30% less electricity than similar products (Energy Star 2011). Newest standard of this program, No. 4.0 is specially revised for a number of different devices such as PCs and gaming consoles. This new version includes all of the operating modes of the device, from idle time to standby and sleep mode, which wasn't considered in the previous standards (Murugesan 2008).
One of the most recent activities of ENERGY STAR was launching online portfolio manager in which more than 62,000 building were monitoring in 2008.
Since 2010 ENERGY STAR has dedicated a specific part for data centers in its online portfolio manager. We will take a look at this online tool in part 2.6 Data center tools

4. GREEN ICT IN MALAYSIA

Malaysia's environmental sustainability efforts goes back to the Clean Air Act in 1978, which was proposed to control the impacts of industries on various aspects such as waste management, air pollution and industrial facilities standardization such as controlling greenhouse gas emissions and polluting water (Department of Energy, 1978).

Ministry of energy, water, and communication established on 27 March 2004 was responsible for environmental protection regulations and agenda, which later in 2009 changed its name to Ministry of energy, green tech, and water in order to emphasize the important role of Green IT on enhancing economic and protecting environment.

In 2009, the Prime Minister established Malaysia Green technology and Climate Change Council with the goal of encouraging best practices to reduce power consumption and equipment use. On 24 July 2009, the Ministry launched The National Green technology Policy with four specified pillars:

1) Energy: Promote efficient use of energy and make the country independent of importing energy sources
2) Social: Improving Malaysia's people's lives
3) Environment: Conserve and minimize the environmental impacts from industries
4) Economy: Developing Malaysia's economy by manipulating new technologies

Therefore, the Ministry started designing their path by 2011, to provide a plan to improving energy use, buildings' design and construction, water and solid waste management, manufacturing processes and has tried to move industries towards IT enhanced procedures (Green Tech Malaysia 2010).

Two of the most important initiatives done at the ministry are:

1) Launching Green Practices including:

- Energy and water conservation: using green technology to reduce government and enterprise energy and water consumption
- 3Rs (Reducing, Reusing & Recycling): providing government and enterprise scale standards and labeling; and
- Transportation: reducing transportation costs by promoting telecommunication and teleworking (Green Tech Malaysia 2010) (MAMPU 2010).
- 2) Greening existing data centers in Malaysia: improving, consolidation and increasing the awareness between experts. As a role model, the Ministry is upgrading their data center by

- Revising the layout of servers' room by partitioning the room to improve the cooling systems effectiveness
- Revising the cooling system by using cold aisle design and keeping the room temperature under a certain point 24 ∓ 1℃.
- Reducing lighting system power consumption by using higher efficient equipment as well as sensors to automate rooms' lighting; and
- Improving power supply system's efficiency by monitoring the equipment's power consumption (MAMPU 2010).

Below is the roadmap of Green ICT in Malaysia:

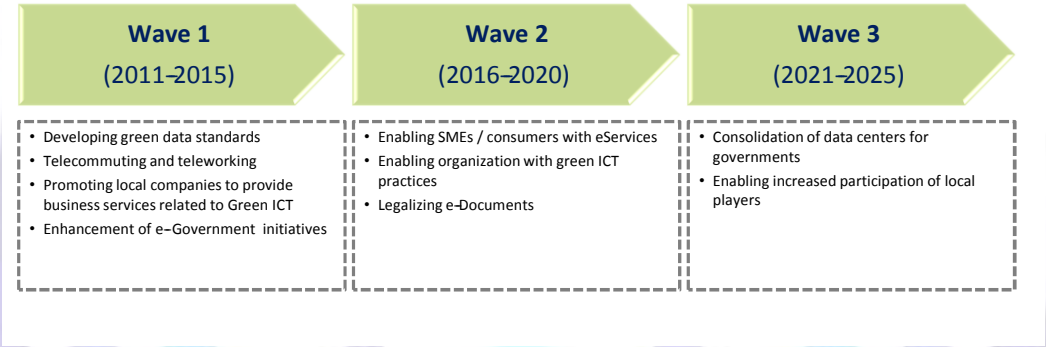

Fig 1: Green ICT Roadmap in Malaysia (Green Tech Malaysia 2010)

The positive outcomes of this Green Agenda are:

- Environmental/ Society: It is forecasted that by implementing this plan by 2025 more than 36000 Green jobs will be active in Malaysia,
- Reducing Costs: One of the main important outcomes of this agenda is saving million of RM annually by implementation of green choices.
- Improving economy of the country: It is forecasted that by 2020 the national GDP will increase by RM 22,557.2 million, and by 2025 Green ICT will contribute to more than RM 50,710.2 million of national GDP (Green Tech Malaysia 2010).

5 CONCLUSION

Consistent and meaningful metrics are crucial in the way of greening data centers. Therefore since 2005, many of researchers have introduced new metrics toward reaching this goal. However, one of the main obstacles toward greening data centers is the willingness of its owners to make the changes, as sometimes these changes can be costly. As a study of key managers of some data centers in America shown that the most important attributes from participants in the study's point of view were performance and cost, while energy efficiency was at the 5th place (Daim, Justice, et al., Data center metrics: An energy efficiency model for information technology managers 2009).

But the fact that greening data centers at the same time leads to higher overall efficiency and lower costs can be a winning card to persuade data centers to manipulate the new ways of doing things (Lopper and Parr 2007).

Compared to developed countries working on green data centers, Malaysia's movement towards green IT is only at the beginning. Despite the new regulations and slight changes, Malaysia still has a long way to go towards gaining international green standards.

While the push for data center sustainability began with a focus on energy consumption, IT leaders must recognize the critical need to address a wider range of environmental issues. By providing clear, easily understood and consistent

metrics, data center leaders can assess whether their data centers are running “greenly” and how to improve towards the goal of reducing waste and energy and increasing recycling and reuse, while save millions of dollars at the same time.

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