The Impact of GPON Technology on Power Consumption and Carbon Footprint in Malaysia

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ABSTRACT

Telecom networks constitute a significant part of Internet & Communication Technology (ICT). With the growth of traffic volume in telecom networks, the energy consumption and carbon footprint increase rapidly. Therefore, as the awareness of sustainable environment increases, all industries including Telco have started their green initiatives to reduce the energy consumption that will lead to the reduction of carbon emission. In general, typical telecom networks can be divided into several sections which are core, metro and access network. In this explanatory research, it aims to focus on the access network so called the “last mile”, to analyse the impact of Gigabit Passive Optical Network (GPON) as fixed access network technology to power consumption and carbon footprint in Malaysia. In Malaysia, GPON is being deployed to provide broadband service; among other access technology such as Digital Subscriber Loop (DSL). GPON technology utilizes fiber optic to connect the central office equipment (Optical Line Terminal-OLT) to the customer device (Optical Network Unit –ONU). By using deductive approach, secondary data from Telekom Malaysia’s (TM) network inventory list is used to determine the number of access network equipment deployed in the entire network. The maximum power consumption for all access network equipment is identified based on the hardware specification and converted to carbon emission. This conversion is based on GHG protocol Scope 2 (Indirect Emission) where the carbon emission is estimated based on the purchased electricity. Based on the
analysis, it is found out that the impact of GPON technology on power consumption per subscriber and annual carbon footprint are less than other fixed access technologies deployed in Malaysia.

Keywords: Power consumption, carbon footprint, GPON, GHG Protocol.

1. Introduction

As the awareness of sustainable environment increases, most corporations have started the initiatives to reduce power consumption and carbon footprint. Taken as part of Corporate Social Responsibility (CSR), Telekom Malaysia (TM) has also aggressively put effort to reduce power consumption and subsequently its carbon footprint. Based on Telekom Malaysia Annual Report (2011), the company has launched a Carbon Management Plan and carried out a company-wide audit of carbon emissions to serve as a baseline for future planning and activities.

Bolla et al., (2011) and Roy (2008) and in their study mentioned that, another reason why corporations work hard to reduce their power consumption is because of the increase in energy prices. This increase in energy price has result a substantial energy cost for large service provider.

According to The Climate Group (2008), the carbon footprint for all ICT is estimated to be 1-2% of worldwide total footprint and the network elements contribution is about 33% of the total ICT carbon footprint. As the customer population growth and the spreading or broadband access, more and more network elements need to be deployed to provide the service. Therefore, it is important for Telco to start considering green telecommunication network and energy optimization in their current and future network deployment.

In TM, GPON technology has been deployed among other fixed access network technology to provide broadband service in Malaysia. GPON technology is utilizing fiber optic for the last mile which connects the central office equipment to the customer premises equipment (Horiuchi and Suzuki, 2007).

1.1 Research Objectives

The objectives of this research are to find out the impact of GPON technology on the power consumption of access network equipment in TM and to find out the impact of GPON technology on the carbon footprint of access network equipment in TM.

1.2 Research Question

RQ1: How does GPON technology impacting the power consumption of access network equipment in TM?

RQ2: How does GPON technology impacting the carbon footprint of access network equipment in TM?
1.3 Problem Statement

As there are many fixed access network technology available for Telco to choose from, the aspect of power consumption and carbon emission need to be considered as well. In a study carried out by Ennser et al. (2010), they point out that the performance and deployment aspect of all these different technologies; for example GPON and DSL have their own trade off. This is because these technologies use different network elements and architecture. These differences will lead to different performance level as well as differences in power consumption and carbon emission. Therefore, this study will be able to provide some information on these two aspects (power consumption and carbon footprint). The findings will enable Telco to better manage and optimize their network deployment and utilization to reduce the power consumption and carbon footprint.

2. Literature Review

Recently, the awareness about sustainable environment has increases rapidly. Many studies has been carried out which relates the industries to its carbon footprint. Carbon footprint is a term used to describe calculation of total carbon emissions of a system that relates the energy consumption in terms of the amount of greenhouse gas (GHG) produced to support an activity (or piece of equipment); it is typically expressed in equivalent tons of carbon dioxide (CO\(_2\)) that is, CO\(_2\)e (Minoli, 2010). Based on this definition, power or energy consumption is the main parameter use to measure carbon emission. Therefore, in order to reduce carbon emission, power consumption should be reduced.

In Copenhagen 2009, Prime Minister of Malaysia made a voluntary commitment to reduce CO\(_2\) intensity by 40% by 2020 relative to 2005 levels which can be achieved by having renewable energy contribution at 11% by 2020 (Gee, 2012). However, as a developing countries, it is a big challenge to all sectors in Malaysia since development still need to go on. For example, in the case of ICT sectors, the increase of broadband service demand in Malaysia is so great and this require more equipment to be deployed to provide and extend the service coverage. According to Muniandy and Muniandy (2012), Malaysia shows a rapidly growing number of Internet users, where in 1995 it was only 0.1% and within 10 years (2005) it grew up to 37.9%. Currently, based on Malaysian Communication and Multimedia Commission (MCMC) Pocket Book of Statistic (2012), Malaysian broadband subscription was about 5.9 million in quarter 3 2012.

Such increase in broadband and internet penetration happens almost everywhere in the world. Therefore, all Telco are deploying more network elements to extend the broadband services coverage to more users with more bandwidth and these network elements consume huge amount of energy. This increasing trend has been confirmed in recent reports published by Telco and Internet Service provider in other countries as well. Based on Nippon Telegraph and Telephone Corporation (NTT) CSR report (2010), the electricity consumption for telecommunication in 2009 is 763.95 million kWh and in 2010 it has increased by 98.61 million kWh (approximately 0.8 TWh). As for Telecom Italia, based on a study carried out by Bianco et al. (2007), it requires more than 2TWh of electrical energy in 2007. These numbers shows that the energy usage of Telcos are relatively very high and it keeps on increasing.
More network elements means more power utilization which result to the increase in carbon footprint. Based on The Climate Group (2008), carbon footprint for ICT is estimated to be 1-2% of worldwide carbon footprint and the network elements contribution is about 33% of the total ICT carbon footprint, while the rest is composed of data centers, personal computers, printers and peripherals. This finding is align with another study in Europe carried out by ETSI (2012) where ICT industry is responsible for less than 2% of global carbon emission and consumes 7% of electricity generated in Europe. However, if the business of ICT operates in business as usual scenario, this fraction will be double by 2020 as reported by Vereecken, Heddeghem, Colle, Pickavet and Demeester (2010).

The telecommunication network can be divided into three network domains which are core, metro, and access network. Based on study carried out by Lange and Gladisch (2009), access network comprises the larger part of the telecom network. It is also a major consumer of energy due to the presence of a huge number of active elements. In GPON technology, fiber optic cable is use to connect the network equipment to the customer; whereas other technology may use other transmission medium such as DSL technology which uses copper cable or combination of fiber optic and copper. Because of this, GPON technology falls under the Fiber-to-the-home family. Typical deployment of fixed line access network technologies including wireless technology is highlighted in a study carried out by Horiuchi and Suzuki (2007) and illustrated in Fig. 1.

![Fig. 1. Various Access Network Technologies (Horiuchi and Suzuki, 2007)](image-url)
Vereecken et al., (2011) has carried out a study on power consumption in Telecommunication Network on most of the access network technology including fixed line access network technology such as GPON and DSL. Depending on countries, different technology is being used to provide broadband service. According to Cota and Pavicic (2011), the global deployment percentage for DSL, Cable Modem, FTTx (including GPON) and other technologies are 63.41%, 20.40%, 13.23%, and 2.96% respectively, with a strong growth in fiber based technology is being projected.

Based on a study by Xiyang and Chuanqing (2009), PON subscribers are expected to grow dramatically at a compound annual growth of 150% through 2010 in North America and Asia Pacific, with GPON gaining traction in China and North America, and EPON dominating Japan while European broadband subscribers will largely continue to use DSL, although each region has its own variations within it.

PON technology is using the point-to-multipoint (PtM) FTTH network architectures as appose to point-to-point (PtP) configuration. The differences of these two configurations (PtP and PtM) are illustrated in Fig. 2. Optical fiber technologies allow for higher bit rates and longer ranges. The bit rate can go up to 10 Gb/s for a single optical fiber with amaximum range between 10 and 20 km (Coomonte et al., 2011).

![Fig. 2. PtP and PON Network Configuration (Coomonte et al., 2011)](image-url)
There are two popular variants of PON; EPON (Ethernet PON), which uses Ethernet as the underlying transport mechanism, and GPON (Gigabit PON), an evolution of Broadband PON (BPON) standard (Zhang et al., 2010). Vereecken et al., (2011) found that GPON technology power consumption is of about 0.2-0.8 W/subscriber. This finding is confirmed by another study carried out by Ennser et al., (2010), where the maximum power consumption of the OLT (GPON) is 200W for 256 subscriber which is approximately 0.8W per subscriber. In contrast with another finding, Valenti ET AL., (2012) found out that GPON OLT has a global power consumption of about 77W, and it does not depend on the number of active GPON ports or subscribers.

Several international accounting tools have been introduced for government and business leaders to understand, quantify, and manage greenhouse gas emissions. The most widely used international accounting tool is the Greenhouse Gas Protocol (GHG Protocol) where it is use by government, business leaders to understand, quantify and manage GHG emissions (World Business Council for Sustainable Development and World Resources Institute, 2012). As explained in the GHG protocol (2004), the protocol differentiates between three different categories of emissions, known as Scope 1, Scope 2 and Scope 3 as depicted in Fig. 3. Scope 1 covers the GHG emissions generated by facilities within the boundaries of an organization; Scope 2 covers the indirect emissions from the generation of purchased electricity, heat or steam consumed by the organization; Scope 3 covers a company’s entire value chain emissions impact, and enables a company to track the full impact of its upstream and downstream impact such as corporate business travel or commuting. Often, the majority of total corporate emissions comes from scope 3 sources and the standard to assess this scope is explained in detail in the GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard (World Business Council for Sustainable Development and World Resources Institute, 2011). Department of Energy and Climate Change (DECC) and Department for Environment, Food and Rural Affairs (DEFRA) in United Kingdom (2012) has established carbon emission conversion factors that can be used for most countries.

There were various methods and framework uses in GHG assessment and management. Life-Cycle Approach accounting can also be used to evaluate GHG emission for a specific material or product (EPA, 2010). It deals with all stages of a product’s life from raw material extraction through material processing, transportation in all the phases; production; use; repair and maintenance, and disposal or recycling (Kim et al., 2012). A new guideline for for ICT sector has been produced under GHG protocol implementing Life-Cycle Approach in March 2012 (World Business Council for Sustainable Development and World Resources Institute, 2011).
International standard has also been established for environmental management for example the ISO 14000 standards. It provides practical tools for companies and organizations looking to identify and control their environmental impact and constantly improve their environmental performance (ISO, 2012). Malaysia has also adopted this environmental management standard under the MS ISO 14000 Family which addresses Environmental Management (Department of Standards Malaysia, 2012). All the related international standards and methods for GHG assessment framework are explained in detail by Kim et al., (2011), Sandhu et al., (2012) and Rhee et al., (2009).

3. Methodology

3.1 Scope of the study

Since power utilization and carbon footprint differ for every country because of different sources of energy being used, TM network in Malaysia is used as a case study for this research. The study focuses on one of the fixed line access network technology uses in TM which is GPON. It will cover the access network which is the “last mile” of the telecommunication network that connects the Central Office to the residential and business customers.

In this study, the impact on energy consumption per subscriber and carbon emission are only focusing on the access network elements which are OLT for GPON, while the customer equipment (ONU) is not covered.

3.2 Data Collection and Analysis

The research is an explanatory study where the impact of GPON technology to power consumption and carbon footprint is being studied. It uses the deductive approach where
secondary data from TM’s network inventory list (last update in March 2012) and power utilization are used to analyse the impact of the dependent variable to the independent variable.

The data is analysed based on Scope 2 (purchased electricity) of GHG protocol. Scope 1 and Scope 3 are not included in this research paper. There are two parts of analysing the data. The first part is to determine the power consumption of each network element based on the hardware specification provided by the product manufacturers.

Based on total power consume in a year, the carbon emission is calculated using the Scope 2 GHG protocol tools as in Eq. 1.

\[
\text{Carbon Emission} = \text{Annual Electricity Consumption} \times \text{Emission Factor}_{\text{Malaysia}} \quad (I)
\]

The carbon emission (tCO₂/year) is calculated by multiplying the annual electricity consumption (kWh/year) with the emission factors for that particular country, in this case for Malaysia (tCO₂/kWh). Emission factor for Malaysia as provided by DECC and DEFRA(2012) is listed in Table 1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Emission Factor [tCO₂/kWh]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-2010</td>
<td>0.67552</td>
</tr>
</tbody>
</table>

3.3 Hypothesis

The hypothesis for each research questions are as follows:

**RQ1:** How does GPON technology impacting the power consumption in TM?

- \( H_0 \): GPON power consumption per subscriber is more or equal than other fixed access network technology uses in TM.
- \( H_1 \): GPON power consumption per subscriber is less than other fixed access network technology uses in TM.

**RQ2:** How does GPON technology impacting the carbon footprint in TM?

- \( H_0 \): GPON carbon footprint in a year is more or equal than other fixed access network technology uses in TM.
- \( H_1 \): GPON carbon footprint in a year is less than other fixed access network technology uses in TM.
4. Result and Discussion

Technology used by TM to provide broadband access services is based on fixed line access technology; which are Gigabit Passive Optical Network (GPON) and Digital Subscriber Line (DSL; ADSL2+ and VDSL2). GPON technology was installed at new deployment area and VDSL2 has been deployed at high-rise buildings to provide High Speed Broadband service for bandwidth more than 5Mbps. ADSL2+ is deployed to provide broadband services for bandwidth below 4 Mbps.

The total power utilization per subscriber and carbon emission per year will be based on the number of network element deployed and number of active subscribers attached to the equipment. Based on the analysis, the number of active subscriber for GPON technology in TM networks is only 9% of the total broadband subscribers as compared to ADSL and VDSL technology; which are 81% and 10% respectively. The total number of equipment deployed for GPON is 2% where the rest are ADSL and VDSL equipment.

Based on the network inventory list in 2012, the total power consumption of the CO equipments for GPON and DSL (which are ONU and DSLAM/RDSLAM) are estimated at 58 million kWh in a year. GPON contribute to only 12% of the total power while ADSL and VDSL are 72% and 16% respectively. In terms of power consumption per subscriber, for GPON technology, the normalized value is relatively high as compared to ADSL which is about 1.43 higher. This is due to the number of active user for GPON technology in Malaysia is still low as compared to ADSL. This finding is also not aligned with Vereecken et al., (2011) and Ennser et al., (2010), where the maximum power consumption of the OLT (GPON) is is approximately 0.8W/subscriber. The reason might due to the current active subscribers in this analysis is much smaller than the previous research. As for carbon emission, the normalized value for GPON technology to ADSL is 0.16 and for VDSL technology to ADSL is 0.22. The findings are illustrated in Fig. 4.
Fig. 4. Normalization of GPON and DSL Technology – Power consumption per subscriber, Power Consumption and Carbon Emission in a year

Since the number of equipment deployed and number of active subscribers are not comparable for every technologies; another useful parameter is the normalization of power consumption to total bandwidth; where GPON has the lowest value which is 0.66 W/Mbps with 6.16 Mbps of the average bandwidth per user. This shows that, without taken into consideration the cost of deployment, GPON can provide higher bandwidth to users with lower power consumption.
Based on the analysis and result, the accepted hypothesis is that GPON technology power consumption per subscriber is higher than ADSL technology. This is because the number of active user for GPON is much lower as compared to ADSL. As for carbon emission in a year, the accepted hypothesis is that, GPON carbon emission in a year is much lower than ADSL. Even if the number of GPON OLT deployed are low and the number of subscribers are relatively very small as compared to DSL technology, GPON power to bandwidth normalization is significantly small as compared to DSL since GPON can provide much higher average bandwidth to users. Therefore, the power consumption and carbon emission can be further reduced by increasing the equipments utilization.

5. Conclusion

This research paper has achieved its objective to find out the impact of GPON technology on power consumption and carbon footprint in Malaysia by using TM as a case study. In the context of TM, GPON technology power consumption per subscriber is higher than ADSL. As for carbon footprint in a year, GPON is significantly lower than the ADSL and VDSL. This is because the number of active user for GPON in this analysis is much lower as compared to ADSL and the number of equipment deployed for ADSL is much higher than GPON. Therefore, in order to reduce power consumption and carbon emission, equipment utilization should be increased.
6. Policy Implication and Future Research

These findings can be used as a baseline for Telco to craft their policy and guideline in access network planning and deployment. Power consumption and carbon emission should be one of the criteria in selecting the access technology besides performance and deployment cost. This study opens up future research on maximizing the equipment utilization to further reduce the power consumption and carbon footprint. Besides that, renewable energy should be considered as another wise option for a sustainable future.

References


