Estimating the Cost of CO$_2$ Mitigation by Feed in Tariff Approach in the Philippines

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ABSTRACT
The Philippines is located in Southeast Asia characterized by a tropical weather and high level of rain which makes this country as a high potential in generating electricity by hydro-power and wind. Solar potential at this country is one of the highest in the world. All these opportunities help the country to replace clean and green renewable energies instead of fossil sources which will reduce the amount of produced carbon dioxide significantly. This study illustrates the Philippines attempts for encouraging investors for investing in renewable energies. Meanwhile the cost of avoiding carbon by generating electricity by solar panels estimated and compared with the other parts of the world. The conclusion shows despite of all opportunities in the country still cost of avoiding CO$_2$ by using solar panels in the Philippines is higher than average world price.

Key words: Renewable energy, energy policy, economic growth, feed in tariff

INTRODUCTION
The Philippines as a sovereign island country in Southeast Asia is created from 7,107 islands in a 300,000 square kilometers land. The country is surrounded by the Philippine Sea in East, The Sulu Sea to the southwest and South China Sea in the west (NAMRIA., 2012). Hong Kong, Taiwan, Vietnam, Malaysia and Indonesia lie in the waters around the country (Fig. 1).

The geography area is created from youngest earth layers which is the center of different volcanoes. Also different tycoons damage many parts of the country annually.

Almost 100 million populations in 2013 make the country a huge market for electricity consumption. The country economy with US $250 billion is transferring from an agricultural economy to a service base and industrial (IMF., 2012).

The 32% of the Philippines labor force is working in agriculture sector but the share of this sector in the country economy is less than 15%. The service sector is biggest part of the Philippines economy with 56% of total GDP (WBG., 2013). Almost 19 million Filipinos are working in service sector. GDP per capita in 2012 was in highest point of the country with US $2614 and the government is hopeful to pass US $2000 in 2013 (IMF., 2012). Since 1999 the gross rate is positive but is not stable yet. The Philippines experienced Asian financial crisis in 1997-98 and global financial crisis in 2008. Although in Asian crisis the Philippines GDP reached negative growth, in recent crisis it was still growing around 1.2% (IMF., 2013).

As is visible in Fig. 2, the Philippines GDP is increasing through last decade. Just in 2008 in effect of global financial crisis the countries production shows a small decrease which improved again in 2009.

In the recent years government had been successful in making a stable situation for inflation rate and controls the rate under 4%. Also, it is expected to be around 3% in next 5 years.

Economists are optimistic to the Philippines economy and estimate a higher GDP for 2013 and 2014 and more stability. Neighbor countries such as Malaysia, Thailand and Indonesia are looking for new policies for encouraging investors for replacing renewable energies instead of fossil sources. Most Malaysia attention has been focused on solar when Thailand has more focuses on hydro power (Bakhtyar et al., 2012a). The Philippines and Indonesia are among top three countries in generating geothermal electricity in the world.
PHILIPPINES ENERGY INDEXES

The Philippines have three main power generations by grid namely: Mindanao, Visayas and Luzon. Luzon is providing 52,312 GWh electricity, Visayas generating 11,483 GWh and Mindanao 9,127 GWh in 2012, totally, 72,922 GWh (Bakhtyar et al., 2013a). The share of each sector in the Philippines electricity consumption is indicated in Fig. 3.

Residential sector in the Philippines consumes 19,695 GWh, commercial sector is using 17,777 GWh, industrials are consuming 20,071 GWh and the other sectors are using 1,668 GWh (Bakhtyar et al., 2013b).

Public access to electricity in the Philippines is more than 97% in urban area but for rural area this rate is not more than 65%. The annual electricity consumption for each Filipino was 729 kWh in 2012 (Bakhtyar et al., 2013a).

Since 1999, electricity consumption and generation in the Philippines is increasing, frequently. Figure 4 shows the trend of electricity generation in the country. As is visible in this figure total electricity generation in 1999 from 40,000 GWh increased to 50,000 GWh in 2003. This trend continued and reached to 60,000 GWh in 2007 and finally in 2011 the Philippines was able to generate more than 70,000 GWh electricity.

The fuel price in the Philippines is almost expensive. Petrol price in this country is US $0.91 per liter. Diesel is a little bit cheaper, US $0.81 per liter (EIA, 2013).
Renewable energies have an effective role in the Philippines energy production while the source of 20% country electricity is renewable. Solar potential for generating electricity at this country is 5.1 kWh m⁻² day⁻¹ which is one of the highest possibilities in the world. The total electricity generated from sun radiation is almost 1 MW (Bakhtyar et al., 2013a). Although sitting astride the typhoon belt is imposing huge damage, it is a good potential for wind energy and theoretically can provide 76,600 MW electricity in the Philippines. Practically this amount is less than 1.2 MW.

Electricity generated from water source is 1448 MW but the country potential is much higher than this amount. The amount of electricity generated from biomass is around 20 MW whereas, biogas is providing 635 MW (Bakhtyar et al., 2013b).

There are many active volcanos in the Philippines. Mayon, Mount Pinatubo and Taal are three famous and active volcanos in the country which ranks the Philippines second in the world, after the U.S, in producing electricity from geothermal sources almost 1900 MW.

MATERIALS AND METHODS

This study is using secondary data produced by the US Energy Information Administration (EIA) for introducing total primary energy for the Philippines electricity. Surely any amount of generated electricity will generate a certain amount of carbon. Using carbon lifecycle is the reasonable solution for calculating the Philippines total carbon emission generated by electricity power plants. Also in this study, the average abatement cost of carbon emission in the world, Europe and the US extracted and compared with normal carbon abatement costs in the Philippines. In this study, the Feed in Tariff (FIT) in the country is explained and the amount of each kg avoided carbon in this mechanism is estimated.

RESULTS AND DISCUSSION

CO₂ emissions for electricity generation: For first time Gagnon et al. (2002) estimated the emitted carbon of three fuel namely; diesel, oil and natural gas. After Gagnon and his colleagues many other scientists estimated carbon emission of the other energy carriers (Gagnon et al., 2002).

In Pehtn (2006) estimated and listed the amount of carbon emission for 15 energy sources.

Table 1 and Fig. 5 shows the amount of primary energy sources of the Philippines electricity (GWh) at the end of 2012. Also, it determined the estimate (g CO₂ e kWh⁻¹) according Pehtn final list (Pehnt). This table indicates that for the Philippines electricity in 2012 almost 42 million metric ton carbon is emitted.

In the other word, the emitted carbon for electricity of each Filipino in 2012 is almost 430 kg. As it is visible in Table 1, for some fuel such as biomass, coal or renewable sources like wind and hydro, there are variety of carbon emission. At this study the highest amount of emitted carbon has been assumed for the calculations.

Figure 6 shows the trend of carbon emission (million metric ton) for power generation since 1986 and estimated emission for 2030. The figure indicates that despite of all government plans for substituting renewable energies instead of fossil sources, the consumption of coal and consequently carbon emission is increasing, significantly.
Table 1: Estimated amount of emitted carbon for the Philippines electricity

<table>
<thead>
<tr>
<th>Technology</th>
<th>Capacity configuration/fuel</th>
<th>Estimate (g CO₂e/kWh)</th>
<th>Amount (GWh)</th>
<th>Emitted carbon (Metric ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>Diesel-heavy oil: Various generators</td>
<td>778</td>
<td>4,254</td>
<td>3,309,612</td>
</tr>
<tr>
<td>Hydro</td>
<td>3.1 MW, reservoir</td>
<td>11</td>
<td>10,252</td>
<td>133,250</td>
</tr>
<tr>
<td></td>
<td>300 kW, nm-of-river</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geothermal</td>
<td>80 MW, hot dry rock</td>
<td>38</td>
<td>10,250</td>
<td>389,500</td>
</tr>
<tr>
<td>Coal</td>
<td>Various generator types with scrubbing</td>
<td>960</td>
<td>28,265</td>
<td>29,678,250</td>
</tr>
<tr>
<td></td>
<td>Various generator types without scrubbing</td>
<td>1050</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other renewable</td>
<td>Wind: 2.5 MW, offshore</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>energies</td>
<td>Wind: 1.5 MW, onshore</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biogas: Anaerobic digestion</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biomass: Waste wood steam turbine</td>
<td>31</td>
<td>259</td>
<td>10,619</td>
</tr>
<tr>
<td></td>
<td>Biomass: Short rotation forestry steam turbine</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biomass: Short rotation forestry reciprocating engine</td>
<td>41</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Solar PV: Polycrystalline silicone</td>
<td>32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural gas</td>
<td>Various combined cycle turbines</td>
<td>443</td>
<td>19,642</td>
<td>8,701,406</td>
</tr>
<tr>
<td>Total</td>
<td>-</td>
<td>72,922</td>
<td>42,222,637</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 7: Trend of carbon emission in the Philippines per dollar of GDP (ET., 2013)

Fig. 8: Annual CO₂ abatement cost in the Philippines (Merilo, 1992)

Figure 7 indicates that the increasing carbon emission in the Philippines is part of carbon emission trend at this country. This trend not only has increased per capita emission but per dollar of GDP.

CO₂ abatement cost in the philippines: The marginal cost as carbon avoided in the European countries is almost 40 Euros per ton which is decreasing in recent years. The anticipation estimates that the carbon abatement cost in the Europe will be less than 30 Euros in 2030 (Meeting Carbon Budgets-the need for a step change. Progress report to Parliament Committee on Climate Change, presented to Parliament pursuant to section 36(1) of the Climate Change Act 2008 (Committee on Climate Change, 2009)). This amount in the United States has a wide range between US $26 to $250 (Bakhtyar et al., 2012b). However, a paper published by Nature Climate Change shows that the approximate amount of the global CO₂ abatement cost is almost US $35 per ton (Landis and Bernauer, 2012).

In the Philippines also there are different ranges as carbon abatement cost. Figure 8 shows abatement cost as annual CO₂ reduction potential.

Figure 8 has been described by the Table 2. Table 2 shows highest abatement potential in the Philippines is belong to “Heat rate improvement” and on the other side highest abatement cost according US $ is belong to “Combined cycle natural gas”.

One of the government rules that is implementing in the country with the CO₂ abatement target is Feed In Tariff (FIT). FIT is a new incentives mechanism for replacing renewable clean energies instead of fossil energy (Bakhtyar et al., 2012a). At this new mechanism government guarantees buying generated electricity from renewable and clean sources.

Feed in tariff in the philippines: The primary target of the Philippines' FIT is to attract investment. Also the government aim to encourage private sector to involve in renewable energies and join to anti carbon emission program. The
Table 3: Rate of tariff for renewable sources

<table>
<thead>
<tr>
<th>Sources</th>
<th>Year</th>
<th>Php/kWh</th>
<th>USD/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro</td>
<td>20</td>
<td>5.900</td>
<td>0.141</td>
</tr>
<tr>
<td>Biomass</td>
<td>20</td>
<td>6.630</td>
<td>0.158</td>
</tr>
<tr>
<td>Wind</td>
<td>20</td>
<td>8.530</td>
<td>0.203</td>
</tr>
<tr>
<td>Solar</td>
<td>20</td>
<td>9.680</td>
<td>0.231</td>
</tr>
<tr>
<td>Ocean (delayed)</td>
<td>Not yet</td>
<td>Not yet</td>
<td>-</td>
</tr>
</tbody>
</table>

Philippines tariff is defined for 20 years (Bakhtyar et al., 2013a). It means an investor can be sure for selling generated electricity for at least 20 years. The rate of the Philippines tariff is an adjusted rate based on inflation and currency changes.

Hydro, biomass, wind and solar are included in the FIT policy until end of 2012. Table 3 shows the selected sources by government and their fixed tariff.

For instance the government is paying US $0.141 per kWh for electricity generated from hydro and US $0.231 for electricity produced by solar panels.

This study assumes as an average each family can generate 300 kWh solar electricity per month. This is clear that the amount of generated electricity and calculating FIT rate for the other renewable energy sources is possible too (Bakhtyar et al., 2012b). Accordingly, each family is generating 3600 kWh energy per year which is equal with Php 34848 or US$831 solar FIT. This amount is the rebate for an average 3,600 kWh per year and is equal with 1727 kg annual reduction equivalent of CO2 from fired plants. It means the Philippines is not producing this amount of carbon dioxide because of replacing solar panels instead of the other fuel sources but solar panels are producing CO2, too. The amount of carbon emission based on Sovacool calculation confirms that 3600 kWh energy from solar panel produces 115 kg CO2. Consequence, the final amount of avoiding emitted carbon in the Philippines for 3600 kWh electricity per year is 1612 kg. In the other word, generating each kWh electricity by solar reduces 0.447 kg CO2 in the country. Also, it is possible to calculate the cost of avoiding 1 ton carbon dioxide by using FIT mechanism in the Philippines is US $110.187. This amount is two times higher than Europe carbon abatement cost but it is in the range of US $26-250 which is US carbon emission cost for avoiding 1 ton carbon dioxide.

CONCLUSION

The Philippines as a South-east Asian country is taking advantage of rich renewable energy resources which forces policy makers to replace fuel resources with clean and renewable energies. At this regard the country is introducing new incentives for investors with target of reducing in carbon emission rate. This research shows the Philippines government is paying US $110.187 for avoiding each ton CO2 by its payment through FIT policy. Although this rate in compare with the average world CO2 abatement cost is high, is lower than many other solutions in the United States or some other parts of the world. In this research the Philippines carbon abatement cost is calculated based on government tariff for energy generated by solar. Obviously, the calculated rate for the other renewable energy sources will be different with the mentioned price of CO2.

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