Ocean Energy

A new development in Philippine renewable energy sources

Prepared by: Fatima S. Rodriguez, MSAE Student
Prepared for: Dr. Melissa E. Agulto, Seminar Mentor
2011
Introduction

The Philippines has been traditionally reliant on imported fuels such as oil and coal for its energy needs. As of 2007, for instance, more than a third of the energy demand of the country came from oil.

The Department of Energy is continuously enhancing the development of untapped indigenous resources. It is expected that by 2012, the energy self-sufficiency will reach 60% given the availability of natural gas and the institutional reforms instituted to advance the use of local energy resources. In particular, the passage of Renewable Energy Act in 2008 and the corresponding incentives such as Renewable Portfolio Standard (RPS) and Feed-in Tariff (FIT) further boosted the demand to promote renewable energy.

Renewable energy, which includes solar, wind, geothermal, hydropower and just recently, ocean, holds enormous potential for the country. For the latter form of energy, which comprised tidal, wave and ocean thermal, the DOE estimated that the Philippines has untapped potential of more than 170 GW. This is more than enough of the current energy needs of the country, which stands at 15,803 MW (DOE, 2006).

Last May 17, 2011, the National Renewable Energy Board, the policy making body created by the Renewable Energy Act of 2008 approved the Feed-in Tariff rates for various sources of renewable energy. The cost for ocean energy was set at PHP 17.65/kWh.

Philippine Energy Situation

The signing into law of Republic Act (RA) 9513, otherwise known as the Renewable Energy Act of 2008 on December 16, 2008 by President Gloria Macapagal Arroyo and the effectivity of the Implementing Rules and Regulations (IRR) on June 12, 2009, paved the way for the promotion of renewable energy sources in the country. These sources of energy include solar, wind, hydropower, biomass and ocean energy.

The law encourages proponents of renewable energy projects by giving incentives such as seven-year income tax holiday, deduction of 10% corporate income tax instead of the 30% usually applied to other companies, exemption from value-added taxes, 1.5% realty tax cap on the original equipment and facilities and duty free exemption for 10 years for equipment used to produce energy.

The Department of Energy under the new Aquino government has outlined three major pillars that will guide the office’s power sector agenda:

1. Ensure energy security;
2. Achieve optimal energy pricing; and
3. Develop a sustainable energy development plan.

Under the first pillar, the long-term goal of the department is to optimize the utilization of local energy resources, ocean energy included. Under the second pillar, the department aims to develop a framework for the pricing of indigenous energy prices. On the third pillar, DOE aims to optimize the use of renewable energy sources, through the establishment of affiliated renewable energy centers, continuing research and development on emerging energy technologies, development of non-food feedstock for
biofuels, and the development of vulnerability assessment to climate change of all energy resources and facilities (Department of Energy, 2010).

On June 25, 2010, the Asian Development Bank announced that it is ready to release $1 billion for energy efficiency and renewable energy projects for the next 5 years for the Philippines. The amount is equivalent to 1000 MW of electricity output and savings from these types of projects.

Last May 17, 2011, the National Renewable Energy Board, the policy making body created by the Renewable Energy Act of 2008 approved the Feed-in Tariff rates for various sources of renewable energy. The cost for ocean energy was set at PHP 17.65/kWh.

Industry Background:

The Philippine national government encourages the use of renewable energy (RE) as a source of electricity as stated on R.A. 9513 (Renewable energy act of 2008). With the initialization of the Department of Energy (DOE), this was implemented on June 12, 2009. It includes resources such as Biomass, Solar, Wind, and Geothermal, Ocean and Hydro energies.

“Renewable energy act of 2008 (R.A. 9513) provides that it is the policy of the State to increase the utilization of renewable energy resources such as, but not limited to, biomass, solar, wind, hydropower, geothermal and ocean energy sources, and including hybrid system by institutionalizing with the development of national and local capabilities in the use of renewable energy system, and promoting its efficient and cost-effective commercial application by providing fiscal incentives;”
As of 2010, the major contributor of electricity is coal with 28.63% (see Table 1). This was noted as polluting and therefore must be replaced. The secondary source (Hydro Power) of electricity primarily effected by the climate that the country has. During 2009-2010, there was El Niño resulting to decrease on nation’s dependence on Hydro Power. This conceptualizes the electricity independence on renewable energy that is affected (minimal) by the climate change. The rise of the ideal on using ocean energy as a renewable energy is not new. For the past decades, United Kingdom has been developing efficient ocean energy converters that are already out for market based on Ocean Energy: Global Technology Development Status from March 2009 report prepared by the Powertech Labs Inc. Here in the Philippines, ocean energy is still on the infancy stage. They are still under laboratory observation according the DOE.

<table>
<thead>
<tr>
<th>Plant type</th>
<th>Philippines</th>
<th>Capacity (MW)</th>
<th>Percent Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Installed</td>
<td>Dependable</td>
</tr>
<tr>
<td>Coal</td>
<td>4,277</td>
<td>3,813</td>
<td>27.40</td>
</tr>
<tr>
<td>Oil Based</td>
<td>3,193</td>
<td>2,528</td>
<td>20.46</td>
</tr>
<tr>
<td><strong>Diesel</strong></td>
<td>1,768</td>
<td>1,204</td>
<td>11.33</td>
</tr>
<tr>
<td>Oil Thermal</td>
<td>650</td>
<td>646</td>
<td>4.16</td>
</tr>
<tr>
<td><strong>Gas Turbine</strong></td>
<td>775</td>
<td>678</td>
<td>4.96</td>
</tr>
<tr>
<td>Nature Gas</td>
<td>2,831</td>
<td>2,700</td>
<td>18.14</td>
</tr>
<tr>
<td>Geothermal</td>
<td>1,953</td>
<td>1,321</td>
<td>12.51</td>
</tr>
<tr>
<td>Hydro</td>
<td>3,291</td>
<td>2,914</td>
<td>21.09</td>
</tr>
<tr>
<td>Wind</td>
<td>33</td>
<td>33</td>
<td>0.21</td>
</tr>
<tr>
<td>Solar</td>
<td>1</td>
<td>1</td>
<td>0.01</td>
</tr>
<tr>
<td>Biomass</td>
<td>30</td>
<td>10</td>
<td>0.19</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>15,610</td>
<td>13,319</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. 2010 Installed and Dependable Capacity, Philippines *from Power Statistics - DOE

Figure 1 below shows the participation of several countries who are engaged in ocean energy conversion system.
Why Ocean Energy?

As of today, the Philippine stands as the South East Asia's first and largest potential wind energy producer. By taking note that wind energy conversion system has a very similar mechanics with the ocean energy conversion system, this can also be an opportunity for our local energy providers. The geographic location of the Philippines establishes the corporation’s ideal of the usage of its 7,100 islands' coast* as a source of ocean energy for power generation. As estimated by the Mindanao State University, potential theoretical capacity that our coast can yield is 170,000 MW.

Another is that among all renewable energy sources, ocean energy is the least affected by the any factors due to climate (change) such as El Niño and La Niña.

1. **Ocean Thermal Energy Conversion (OTEC)**

OTEC system has a minimum depth requirement of 1km from its mean sea level for its set-up. The temperature difference between the two stations 1km apart (vertical distance) allows substance within it travel depending on its relative temperature difference between the two station (deep water has higher temperature than the mean sea level water). The presence turbine between the stations converts the mechanical energy of the revolution of the turbine into electrical energy.
According to the DOE there are 15 sites (Figure 2) that qualified for this system that may generate an estimate of 265 million megawatts. These potential sites are San Vicente at Ilocos Sur, Agno at Pangasinan, Palauig at Zambales, Agusuhin at Bataan, Mananao at Mindoro, San Jose at Antique, Manukan at Misamis Occidental, Omosmarata at Basilan, Palau Island at Cagayan, Dijohan Pt. at Bulacan, Mascasco at Masbate, Batag Island at Samar, San Francisco at Surigao del Norte, Lamon Pt. at Surigao del Sur and Lacaron at Davao del Sur.

Figure 2. DOE assessed possible allocations for ocean thermal energy conversion system

2. **Tidal and Wave Energy Conversion**

These conversion systems uses bouys and wave sensors to record water motion at single dimension (vertical). As a lever's motion follow the wave, a linked rotating turbine converts a single dimension motion into a rotation giving the turbine a mechanical energy subject for energy conversion.
Ideally, these systems should be located between island to accumulate constructive interface of the waves, maximizing the location's potential ocean energy. As assessed by the DOE 8 potential tidal energy source site (Bohol/Talibon Strait, Basiao Channel, Surigao Strait, Gaboc Channel, Hinatuan Passage, San Bernardino Strait, Basilan Strait and San Juanico Strait; Figure 3) and 4 potential sites for wave energy (Batanes Island, Cagayan, Polilio Island and Bolinao; Figure 4)

**Ocean energy from other countries (technology-based)**

**OTEC: Ocean Thermal Energy Conversion**

Keahole Point on the Kona coast of Hawai'i, since 1993

*Principle:* Warm water (26°C) from the surface is evaporated at low pressure, then rapidly condensed by exposure with cold water (6°C) from depth (2700 ft). At a rate of 6500 gpm, the power output is 50 kW.

- Meager output (much less than 1 MW).
- Works only in the tropics where the temperature difference is large over a relatively small depth.
OTEK closed-cycle technology

The working fluid is ammonia (which at the pressure used condenses between the higher and lower temperatures).

The device is essentially an ocean-sized heat pump used in reverse.

Open-cycle ocean thermal electric generator produces both fresh water and electricity as long as the water temperature differential is at least $29^\circ$C ($50^\circ$F).

(From Cunningham & Saigo, 1997)

OTEK open-cycle technology

Open-cycle ocean thermal electric generator produces both fresh water and electricity as long as the water temperature differential is at least $29^\circ$C ($50^\circ$F).

(From Cunningham & Saigo, 1997)
Artist rendition of how the system may look like

\[ P = \frac{1}{2} C_p \rho A V^3 \]

With \( C_p = 0.2 \), \( \rho = 1000 \text{ kg/m}^3 \) and \( V = 1 \text{ m/s} \)
→ Required \( A = 10,000 \text{ m}^2 \) or diameter = 113 m
to provide 1 MegaWatt!

**3a. Tidal Energy**

System in La Rance, France, operating since 1960:

180 \( \times 10^3 \) m\(^3\) of water behind a 750-m long dam
throughflow of 18,000 m\(^3\)/s
elevation difference of 13.5 m

Array of 24 turbines producing a total of 68.5 MW
(enough to power 250,000 households)

Such system can only work where tidal elevations are considerable, i.e. at only a few spots on the planet.

Blocking estuarine flow also raises serious environmental concerns for the biology.
A much less intrusive approach
(better for ecosystems and sea life)

$12-million tidal power project planned for Bay of Fundy

PREMIER RODNEY MacDonald announced on 8 January 2008 that the province has approved a $12-million tidal power demonstration project in the Bay of Fundy that could make Nova Scotia a "groundbreaking" force in green energy.

Minas Basin Pulp and Power of Hantsport will build a demonstration facility, including underwater transmission lines that will take the power generated by turbines at the bottom of the Minas Channel to a building containing the electrical equipment needed to synchronize with the Nova Scotia power grid.

Types of devices to extract energy from ocean waves

Tapered channel (TAPCHAN)

Oscillating water column (OWC)

Pivoting flap device (Pendulor)

Heaving buoy device (Hosepump)
Tapered overtopping channels

Pilot project near Trondheim, Norway
(www.math.sintef.no/ns/research/waves.html)

Project by OCEANOR in 1996 for the Non-Conventional Energy Division of the Philippines Department of Energy with funding from UNDP
(www.oceanor.no/projects/wave_energy/)

The Wave Dragon

The Wave Dragon overtopping device elevates ocean waves to a reservoir above sea level where water is let out through a number of turbines and in this way transformed into electricity, i.e., a three-step energy conversion:
Overtopping (absorption) → Storage (reservoir) → power-take-off (low-head hydro turbines).

The first prototype connected to the grid is currently deployed in Nissum Bredning, Denmark. Long term testing is being carried out to determine system performance.
The Salter duck and wave swing are energy devices that generate electricity through the oscillatory motion of a buoyant part of the device, as opposed to fixed systems which use a fixed turbine which is powered by the motion of the wave.

In these systems, the devices rise and fall according to the motion of the wave, and electricity is generated from the rotary motion of the supporting shaft.

Oscillating Water Column (OWC) in Pico, Azores

How the system works

How big the waves can get

Front cover

Air intake/exhaust in back

500 kW system
60 kW OWC system in Sakata, Japan

75 kW OWC system near Madras, India

Pelamis System, few kilometers offshore from the coast of Portugal (since 2006)

Articulated structure composed of cylindrical sections linked by hinged joints, 120 m long, 3.5 m diameter, delivering 2.25 MW (about 1,500 households)

System being manufactured on dry land

First system being towed

First system in place

Artist rendition of a future array
References

Department of Energy. 2011

National Renewable Energy Board. 2011

Deep Ocean Power Philippine Incorporated. 2010

http://www.energy from the sea.pdf.com/.2010