ENVIRONMENTAL ASPECTS OF GEOTHERMAL UTILIZATION: A GLOBAL PERSPECTIVE

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ABSTRACT

Concern for the protection of our common environment have led countries to sign various international agreements. These conventions provide the global fora for governments to discuss and draw up common strategies for international action. Cooperation is manifested by the adoption of the international covenants by multilateral organizations in their protocols and in the sovereign laws of several countries. Due to the global threat on the environment, there is an emerging consensus for an energy shift to sustainable and renewable energy sources, including geothermal energy, due to their benign and sustainable nature. This paper discusses the adherence of geothermal practices to the internationally accepted environmental and social safeguards which make geothermal a preferred energy option whenever it is available.

1. INTRODUCTION

The growing interest in renewable energy development today is linked to concerns about fossil fuel depletion and the related environmental, social, and political risks of the continuous use of fossil fuels. This paper will focus on the practices of the geothermal industry that address the global concern about environmental deterioration.

2. GLOBAL CALL TO ACTION

The imperceptible effects of development due to the vastness of the earth have led to an accelerated infrastructure growth since the industrial revolution that has resulted in the release of resistant toxic gases to the atmosphere, the dumping of wastes into waterways and the contamination of thousands of sites, signifying that the assimilative capacity of the earth has been surpassed.

The first concern about the impacts of man’s activities on the environment was manifested as early as 1980 by the World Commission on Environment and Development when it defined sustainable
development. But the first global call for action came during the UN Conference on Environment and Development (UNCED), also called the Earth Summit, in June 1992 in Rio de Janeiro, Brazil. About 178 countries signed the Rio Declaration which now serves as the Earth Charter. The charter is the statement of broad principles to guide the conduct of all nations on environmental protection and development. The level of implementation by countries of the agreements in the Earth Summit is a test of the willingness of nations to change their lifestyles to preserve the environment. In 2002, ten years after the Earth Summit, the urgent concerns that surfaced were the human situations. Thus, the focus of the Millennium Development Goals (MDG) was on poverty, education, health, gender equality, development partnership and environmental sustainability. It is important to note that the environment has continued to be a part of the goals, ten years hence.

3. GLOBAL ENVIRONMENTAL ISSUES AND GEOTHERMAL ENERGY

The global recognition of the effects of man’s commercial activities spawned numerous international agreements to protect man’s common environment. Table 1 shows the list of treaties signed by a number of countries over the past decade. In support of these treaties, the guidelines for international support through Official Development Assistance (ODA) and the financing of projects through multilateral banks were reconciled with these various agreements.

### TABLE 1: International Agreements on Environment and Development

<table>
<thead>
<tr>
<th>Sector</th>
<th>International Treaty</th>
<th>Signed</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>1. Rio Declaration (Earth Summit)</td>
<td>1992</td>
</tr>
<tr>
<td></td>
<td>2. World Summit on Sustainable Development (Rio Summit + 10)</td>
<td>2002</td>
</tr>
<tr>
<td></td>
<td>5. Climate Change Convention 6. UNFCCC to the UN Framework on Climate Change</td>
<td>1999</td>
</tr>
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<td></td>
<td>10. Forests Convention</td>
<td>1992</td>
</tr>
<tr>
<td></td>
<td>11. Mountain Summit</td>
<td>2002</td>
</tr>
<tr>
<td>Chemicals</td>
<td>12. Montreal Protocol on Substances that Deplete the Ozone Layer</td>
<td>1987</td>
</tr>
<tr>
<td></td>
<td>17. UN Convention to Combat Desertification</td>
<td>1994</td>
</tr>
<tr>
<td>Culture</td>
<td>18. Convention Concerning the Protection of the World Cultural and Natural Heritage</td>
<td>1972</td>
</tr>
<tr>
<td></td>
<td>19. UN Declaration of Rights of Indigenous Peoples</td>
<td>2007</td>
</tr>
</tbody>
</table>

Based on its sovereign development plans, each country formulates its own set of environmental and social laws that adhere to the international covenants. In the Philippines, geothermal projects are subject to at least thirty (30) regulations in compliance with the international covenants of the country. Licenses secured by the PNOC Energy Development Corporation for its five (5) geothermal projects in compliance with these rules were recorded at 1,452 as of August 2007 (PNOC EDC, 2007).
The international agreements also influence the environmental requirements of the donors of the Organization for Economic Cooperation and Development which disburses Official Development Assistance (ODA) to countries amounting to $103.9 Billion as of 2006 (Masaki, 2007). International organizations embrace the global environmental objectives. For example, the United Nations Environmental Programme has five (5) environmental considerations in their projects: a) effluent emissions, b) on-site contamination and hazardous materials, c) biodiversity protection and d) worker health and safety and e) environmental issues sensitive to public perception (UNEP, 2002).

Table 2 shows the performance standards of financing institutions like the International Finance Corporation (IFC) of the World Bank to manage the social and environmental risks of projects to enhance development opportunities. These provide the relevant international environmental criteria against which geothermal development and utilization are evaluated.

**TABLE 2: Performance Standards on Social and Environmental Sustainability**

<table>
<thead>
<tr>
<th>Guidelines</th>
<th>Specific Requirements</th>
</tr>
</thead>
</table>
| Performance Standard 1 | Social and environmental assessment and management system:  
- Social and environmental assessment considering potential risks and impacts  
- Identification of affected and vulnerable groups  
- Management program consisting of operational policies, procedures and practices  
- Community engagement consisting of disclosure, consultation and and grievance mechanisms  
- Monitoring and reporting |
| Performance Standard 2 | Labour and working conditions:  
- Human resources policy accessible to employees  
- Communication of working conditions, terms of employment, wages and benefits  
- Safe and healthy work environment  
- Grievance mechanism |
| Performance Standard 3 | Pollution prevention and abatement:  
- Pollution avoidance  
- Minimization and control of hazardous wastes  
- Emergency preparedness to operational risks  
- Consideration for assimilative capacity of environment  
- Reduction of greenhouse gas emissions |
| Performance Standard 4 | Community health, safety and security:  
- Infrastructure and equipment safety  
- Minimization of community exposure to hazardous materials  
- Minimization of natural hazards due to land use changes  
- Emergency preparedness in culturally appropriate manner  
- Assessment of risks posed by security arrangements |
| Performance Standard 5 | Land acquisition and involuntary resettlement:  
- Alternative designs to avoid physical/economic dislocation  
- Compensation of full cost and restoring and improving standard of living  
- Consultation for informed participation  
- Grievance mechanism  
- Resettlement planning and implementation |
| Performance Standard 6 | Biodiversity conservation and sustainable natural resource management:  
- Minimization of conversion or degradation of habitat  
- Compliance with protected area laws  
- Non introduction of exotic/invasive species |
| Performance Standard 7 | Indigenous peoples:  
- Avoidance of ancestral lands or mitigation of use in culturally appropriate manner |
Chapter 9 of the Rio Declaration of 1992 declared that geothermal is an environmentally advantageous energy option basically due to its benign emissions. But beyond this factor, it is the thesis of this paper that geothermal can be considered a green energy resource because it addresses the major global environmental concerns below.

a) Concern for toxic wastes

The concern for toxic wastes and transboundary movements led to the signing of the Basel Convention (1989). Under this treaty everyone is encouraged to manage the wastes as close as possible to the source of its generation. Geothermal operation can be compliant with this international prescription as geothermal effluents in liquid dominated fields may be reinjected back into its reservoir, ensuring in situ waste management. Reinjection has been adopted for brine disposal in more than 44 fields (Stefansson, V. 1997). It is a standard practice in the Philippines, Japan and some US projects and other countries like El Salvador, Kenya and New Zealand have started adopting the technology to prevent contamination of the environment.

The mineral extraction of silica, zinc, lithium, manganese, caesium, rubidium and rare metals has been studied in Salton Sea and Mammoth Springs in California, U.S.A. with some results (Bloomquist, 2006). Sorption membranes using resins to remove boron have been reported (Yilmaz, I. et al., 2005). Hypersaline brines and supersaturated steam may contain high levels of chemicals that can generate solid wastes. These wastes may be reduced to soluble forms for reinjection. Thiobacilli is used as a biothechnological method to dissolve, separate or immobilize hazardous geothermal sludge (Premuzik et al., 1989). Countries utilizing geothermal energy also adopt best practices in the management of its solid wastes and no utilizing country has been reported to export wastes to other countries.

b) Dislocation of households

Another international concern about infrastructure projects is dislocation and its related social costs. To address the socio-economic and physical dislocation in cases when these are unavoidable, appropriate involuntary resettlement packages must be negotiated with the affected households, to include replacement of structures, amenities and livelihoods. The objectives of resettlement are to: i) relocate houses to areas where residents are not exposed to physical, health, and security hazards; ii) ensure that affected households are fully and justly compensated for any crop and property damages; and iii) help the relocated households regain and improve their standard of living on the settlement sites. In negotiating with the affected population, the community is assisted in gathering facts and perceptions, understanding their situation, developing common solutions and agreeing on a mode of collaboration with the geothermal developer. For three (3) out of five (5) geothermal projects in the Philippines, namely, the Leyte, Mindanao and Northern Negros geothermal projects these procedures have been undertaken in compliance with the operational directives of World Bank and JBIC that provided funds for these projects (PNOC EDC, 2007).

c) Loss of biological diversity
The conservation of the variability of genes, organisms and ecosystems is important for the adaptation and sustainability of man in the future (UNEP, 1995). The wealth of information that can be unlocked from the genes of an organism may introduce new medicines, industrial materials, better crop varieties, cultural values and other ecological services in the future. The current environmental measures for geothermal projects minimize habitat destruction and therefore, the loss of biological diversity. The measures include: i) an environmental impact assessment prior to project implementation that already integrates biodiversity considerations; ii) avoidance of rare, endangered or threatened species in earthworks; iii) minimization of openings; iv) directional drilling that allows compact work areas which are standard practices in geothermal development and minimize impacts on habitats. The recent procedure of redirecting emissions during well testing to avoid brine spray and defoliation proved helpful for projects in forest locations (Tuyor, et al., 2005). In the Philippines, an improvement of this design for zero brine spray and emission is will ber at the stage of pilot testing by PNOC EDC by the end of year 2007.

d) Protection of critical habitats

Geothermal prospects in natural parks and protected areas used to pose difficulties to geothermal developers. Current international opinion however indicates that authorities now recognize that development may be considered in protected areas. The International Union for the Conservation of Nature (IUCN) prescribes the exclusion or the declaration of special zones for areas that are needed to maintain services to human settlements (IUCN, 1986).

In the Philippines, buffer zones for geothermal development (Philippine Congress, 2001) and for geothermal sustenance (Philippine Congress, 2003) have been declared for the Mt. Kanla-on Natural Park and Mt. Apo Natural Park, respectively. These geothermal support areas were established at the edge and outside the boundaries of the park. They are multiple-use zones that serve as protective layers to the parks. The geothermal operation in the buffer zone provides economic opportunities to communities, hence giving them no reason to encroach the park for livelihood. This concept of co-existence was reiterated by IUCN at the Biodiversity Convention in Kuala Lumpur, Malaysia in February 2004, advising that parks must be managed with due consideration of the people and managed with the people. Current geothermal measures also balance energy development and environmental protection.

The declaration of geothermal projects as ecotourism sites in Bacon-Manito, Albay-Sorsogon in the Philippines because of its green and blue waterfalls and bat caves at the heart of the geothermal field (PNOC EDC, 2007) is proof that the utilization of geothermal energy does not contribute to the earth’s deterioration. Other sites include the Hoshino, a resort in Japan using geothermal heating, Hells Gate National Park in Kenya combining safari and geothermal production, the Great Geysir, the Surtshellir lava cave, and the Deildartunguhver hot spring of Iceland and Rotorua of New Zealand, to name a few.

in his study of the Mt. Apo Geothermal Project in the Philippines Dr. P.M. Zamora concluded that the “presence of government and PNOC EDC can be a deterrent against the influx of unsustainable populations as these agencies provide positive influence on the conservation of valuable life forms by subsidizing and implementing conservation measures”(1991). Chevron supports its Darajat and Salak geothermal fields in Indonesia by supporting the biodiversity protection of the Coral Triangle (US Info, 2007).
e) Respect for Indigenous Peoples (IPs)

Apart from critical habitats, there are also critical or vulnerable groups that need special attention based on international consensus. The UN Declaration on the Rights of Indigenous Peoples (IPs) affirms that IPs are equal to all other peoples and that the UN is convinced that the IPs have suffered historic injustices through dispossession of their lands (UN, 2007). Thus, the UN recognizes the urgent need to respect and promote the inherent rights of the IPs to their lands, territories and resources and their need to have control over the developments affecting them. Issues such as encroachment of geothermal projects into the ancestral lands of indigenous communities, desecration of their sacred sites and the destruction of IP traditional ways of life are due to the growing awareness of the IPs as distinct peoples who have the right to self-determination.

The current practices in geothermal development and utilization are compliant with these prescriptions of the UN declaration. Geothermal project developers in the Philippines are required by RA 8371 or the Indigenous Peoples Rights Act (IPRA) to secure Free and Prior Informed Consent (FPIC) before any operation. The FPIC is a consensus of all members of the IPs based on their customary laws obtained after full disclosure of the intent and scope of the project in a language and process understandable to the IPs. They are also remunerated for crop and other damages incurred, provided a healthy and clean environment, given a share of the royalties and socio-economic benefits from the geothermal project and as needed, their tribal traditions are considered in the design of the project and in the protocols of geothermal operation.

There are other examples of the participation of IPs in the establishment of geothermal projects in their lands. The Calpine Corporation was opposed by the Pit River Tribe in Montana, U.S.A. and was disallowed to develop the area in 2004 in recognition of cultural rights (Calvert, 2004). The Kalinga tribes of the Philippines did not issue a Free and Prior Informed Consent to GMC-Aragorn Power and Energy Corporation last March 2007 (Northern Dispatch, 2007). Geothermal areas are regarded as taonga or treasures by the Maoris of NZ and they manage geothermal development wisely. Under New Zealand laws, developers must secure “resource consents” for projects. On the other hand, the Mokai Geothermal System is a geothermal resource in Waikato New Zealand managed by the Tuaropaki Trust, a unique project of the IPs (Waikato Council, 2007).

f) Combating climate change

Climate change is a global concern that is closely linked to energy utilization and sustainable development. The goal of the UN Climate Change Convention (UNCC) of 1992 is the “stabilization of Greenhouse Gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system… within a time frame sufficient to allow ecosystems to adapt naturally...” (UN, 1992). Carbon dioxide (CO₂) emissions represent the main GHG known to cause global warming.

In 2005, about 200 scientists from thirty (30) countries discussed the latest research on climate change. They confirmed the link between the concentration of GHGs in the atmosphere and the increase in global temperature levels. A change of 2°C (3.6°F) was defined as the threshold to avoid the serious effects of global warming. This translates to a ceiling of 550 parts per million CO₂ equivalent by volume in the atmosphere (G8 Conference, 2005). Among the known geothermal emissions, only carbon dioxide and methane are known to be GHGs. Their levels are however much lower from geothermal production compared to those of fossil fuels.
The annual anthropogenic CO\textsubscript{2} emissions recorded by the United Nations Statistics Division stand at 27.5 trillion for the year 2003 derived from energy, transport and land use change sources (US DOE, 2006a). Table 3 shows the relative contribution of geothermal energy producing countries to global GHG concentrations (Bertani, 2005 and US DOE, 2006a). The per capita emissions with and without land use changes are also provided in the table (WRI, 2000 and Houghton, 2003). It was concluded that the level of GHG is linked to the conversion of forests to industrial/residential uses as well as the economic status of the country.

**TABLE 3: GHG Emissions of Geothermal Utilizing Countries**

<table>
<thead>
<tr>
<th>Country</th>
<th>Ranking Based on Geothermal Use (MW)\textsuperscript{1}</th>
<th>Geothermal Running Capacity (MW)\textsuperscript{1}</th>
<th>GHG Ranking</th>
<th>GHG Emission (Annual CO\textsubscript{2}e in thousand metric tons) as of 2003</th>
<th>Share of World GHG (%)</th>
<th>GHG per Capita Rank w/ Land Use as of Year 2000 \textsuperscript{2}</th>
<th>GHG per Capita Rank on Emission as of Year 2000 \textsuperscript{2}</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>8,001.6</td>
<td>27,500,000</td>
<td>100.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U.S.A</td>
<td>1,914.0</td>
<td>5,799,240</td>
<td>21.2</td>
<td>14</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Philippines</td>
<td>1,838.0</td>
<td>77,095</td>
<td>0.3</td>
<td>132</td>
<td>152</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>953.0</td>
<td>416,698</td>
<td>1.5</td>
<td>92</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>838.0</td>
<td>295,596</td>
<td>1.1</td>
<td>24</td>
<td>123</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>699.0</td>
<td>446,302</td>
<td>1.6</td>
<td>66</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>530.0</td>
<td>1,233,640</td>
<td>4.5</td>
<td>50</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Zealand</td>
<td>403.0</td>
<td>34,819</td>
<td>0.1</td>
<td>18</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iceland</td>
<td>202.0</td>
<td>2,191</td>
<td>0.1</td>
<td>57</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Costa Rica</td>
<td>160.0</td>
<td>6,340</td>
<td>&lt;0.1</td>
<td>109</td>
<td>112</td>
<td></td>
<td></td>
</tr>
<tr>
<td>El Salvador</td>
<td>119.0</td>
<td>6,553</td>
<td>&lt;0.1</td>
<td>145</td>
<td>148</td>
<td></td>
<td></td>
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<tr>
<td>Kenya</td>
<td>127.0</td>
<td>8,790</td>
<td>&lt;0.1</td>
<td>158</td>
<td>158</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>79.0</td>
<td>1,495,870</td>
<td>5.4</td>
<td>33</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nicaragua</td>
<td>38.0</td>
<td>3,917</td>
<td>&lt;0.1</td>
<td>34</td>
<td>121</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guatamela</td>
<td>29.0</td>
<td>10,711</td>
<td>&lt;0.1</td>
<td>78</td>
<td>126</td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>19.0</td>
<td>4,151,410</td>
<td>15.2</td>
<td>121</td>
<td>99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turkey</td>
<td>18.0</td>
<td>220,409</td>
<td>0.8</td>
<td>106</td>
<td>82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>15.0</td>
<td>374,577</td>
<td>1.4</td>
<td>68</td>
<td>48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>13.0</td>
<td>57,659</td>
<td>0.2</td>
<td>84</td>
<td>54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethiopia</td>
<td>7.0</td>
<td>7,347</td>
<td>&lt;0.1</td>
<td>178</td>
<td>178</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Papua</td>
<td>6.0</td>
<td>7,251</td>
<td>&lt;0.1</td>
<td>7</td>
<td>154</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Austria</td>
<td>1.0</td>
<td>56,435</td>
<td>0.3</td>
<td>56</td>
<td>39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td>0.3</td>
<td>246,372</td>
<td>0.9</td>
<td>112</td>
<td>93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>0.2</td>
<td>806,577</td>
<td>2.9</td>
<td>40</td>
<td>26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>0.1</td>
<td>354,731</td>
<td>1.3</td>
<td>9</td>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{1} Bertani (2005)  
\textsuperscript{2} WRI (2000)

The most immediate solutions to global warming are change in lifestyle in the form of energy conservation/efficiency and the replacement of fossil fired fuels by renewable energy resources. As of 2005, renewable energy only contributes 0.72% of the total world energy supply (US DOE, 2006b). From the above table, it is important to note that countries with high GHG indices but with geothermal and renewable energy capacities have the opportunity to maximize the development of their geothermal resources.

CO\textsubscript{2} makes up more than half the GHGs and research in CO\textsubscript{2} capture in Europe may be applicable to if not compatible with geothermal systems. BRGM, the geosciences organization of France has identified three CO\textsubscript{2} storage options, namely: i) depleted oil reservoir, ii) non minable coal seams and iii) deep aquifers and low enthalpy geothermal reservoirs. The findings of the IEA Greenhouse Gas R
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& D Programme (IEA, 2007) are the same. It has been shown that CO₂ can be injected into deep geological layers of porous and permeable rocks commonly saturated with saline waters. The presence of impermeable formations above the storage sites prevents CO₂ from rising to the surface (BRGM, 2004). The applicability of CO₂ capture for renewables like geothermal, wind and hydropower is projected by D. Gielen (2004).

Another action taken by the international community to address global warming was the signing of the Kyoto Protocol in 1997 by 156 countries. The convention requires developed countries and those in transition economies to reduce their GHG emissions by 5% of their 1990 level (UN, 1997). The agreement allows the joint cooperation of developed countries to abate GHGs and for industries to trade their emissions based on their permit ceiling. A third instrument is the Clean Development Mechanism (CDM) by which developed countries can buy carbon credits or GHG capacities of developing countries in the form of areas that can be planted to forests or carbon credits from renewable energy programs. As reported in the Carbon Expo of 2006, about $ 247 billion have been invested in CDM in 2005 with 78 countries participating, 614 Emission Reduction Agreements signed and 4,634,963 million tons of CO₂ equivalents certified by the UN (Carbon Expo, 2006). The Nasulo Geothermal Project in the Philippines is a recipient of a CDM facility in December 2005 from the Dutch Government which will purchase 440,000 tons of carbon credits from the project (IBRD-Netherlands Agreement, 2005). Chevron’s Darajat III geothermal plant has also been registered under CDM (US Info, 2007).

4. CONCLUSION

Economic, social and environmental developments are the interdependent principles of true sustainable development. The international consensus on the need to halt the deterioration of our common environment through sustainable activities and the resulting peer pressure on countries to abide by the international commitments has led to the enhanced regulation of the energy industry. Geothermal is a benign energy resource and geothermal practices are protective of the environment. Thus, investments in renewable energy including geothermal, wherever they are found must be given government support as a major step in heeding the call to global action for the protection of the environment.

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