Presented at Short Course on Geothermal Development in Central America – Resource Assessment and Environmental Management, organized by UNU-GTP and LaGeo, in San Salvador, El Salvador, 25 November – 1 December, 2007.

UNITED NATIONS UNIVERSITY
GEOTHERMAL TRAINING PROGRAMME

LaGeo S.A. de C.V.

ENVIRONMENTAL ASPECTS OF GEOTHERMAL UTILIZATION: A GLOBAL PERSPECTIVE

Agnes C. de Jesus
PNOC Energy Development Corporation
Merritt Road, Fort Bonifacio
Taguig City
PHILIPPINES
dejesuac@energy.com.ph

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

Sector	International Treaty	Signed
General	1. Rio Declaration (Earth Summit)	1992
	2. World Summit on Sustainable Development (Rio Summit + 10)	2002
Atmosphere	3. Vienna Convention for the Protection of the Ozone Layer	1985
	4. Climate Change Convention 5. Kyoto Protocol to the UN Framework on Climate Change	1992 1999
Biodiversity	6. Convention on International Trade of Endangered Species	1979
	7. Bonn Convention on Migratory Species of Wild Animals	1979
	8. Convention on Biological Diversity	1992
	9. Cartagena Protocol on Biosafety	1992
	10. Forests Convention	1992
	11. Mountain Summit	2002
Chemicals	12. Montreal Protocol on Substances that Deplete the Ozone Layer	1987
	13. Basel Convention on Transboundary Movements of Hazardous Wastes	1989
	14. Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	1998
	15. Stockholm Convention on Persistent Organic Pollutants	2001
Land	16. Ramsar Convention on Wetlands	1971
	17. UN Convention to Combat Desertification	1994
Culture	18. Convention Concerning the Protection of the World Cultural and Natural Heritage	1972
	19. Convention on Prior Informed Consent	1998
	19. UN Declaration of Rights of Indigenous Peoples	2007

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

Guidelines	**Specific Requirements**
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

	-Disclosure, consultation and informed participation of affected indigenous peoples -Provision of culturally appropriate development benefits
Performance Standard 8	Cultural heritage: - Protection and support for cultural heritage - Cost benefit analysis of heritage loss in case of removal of cultural heritage - Compliance with local cultural regulations for the protection of cultural heritage

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 stu 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 iwill 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 (CO_2) 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 CO_2 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 thos of fossil fuels.

The annual anthropogenic CO_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

Country	Ranking Based on Geother-mal Use (MW)[1]	Geothermal Running Capacity (MW)[1]	GHG Ranking	GHG Emission (Annual CO_2e in thousand metric tons) as of 2003	Share of World GHG (%)	GHG per Capita Rank w/ Land Use as of Year 2000 [2]	GHG per Capita Rank on Emission as of Year 2000 [2]
World		8,001.6		27,500,000	100.0		
U.S.A	1	1,914.0	1	5,799,240	21.2	14	7
Philippines	2	1,838.0	40	77,095	0.3	132	152
Mexico	3	953.0	11	416,698	1.5	92	80
Indonesia	4	838.0	21	295,596	1.1	24	123
Italy	5	699.0	10	446,302	1.6	66	47
Japan	6	530.0	5	1,233,640	4.5	50	35
New Zealand	7	403.0	66	34,819	0.1	18	12
Iceland	8	202.0	131	2,191	0.1	57	40
Costa Rica	9	160.0	104	6,340	<0.1	109	112
El Salvador	10	119.0	102	6,553	<0.1	145	148
Kenya	11	127.0	93	8,790	<0.1	158	158
Russia	12	79.0	3	1,495,870	5.4	33	22
Nicaragua	13	38.0	114	3,917	<0.1	34	121
Guatamela	14	29.0	87	10,711	<0.1	78	126
China	15	19.0	2	4,151,410	15.2	121	99
Turkey	16	18.0	23	220,409	0.8	106	82
France	17	15.0	13	374,577	1.4	68	48
Portugal	18	13.0	49	57,659	0.2	84	54
Ethiopia	19	7.0	98	7,347	<0.1	178	178
Papua	20	6.0	122	2,515	<0.1	7	154
Austria	21	1.0	43	70,435	0.3	56	39
Thailand	22	0.3	22	246,372	0.9	112	93
Germany	23	0.2	6	806,577	2.9	40	26
Australia	24	0.1	15	354,731	1.3	9	5

[1] Bertani (2005)
[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_2 makes up more than half the GHGs and research in CO_2 capture in Europe may be applicable to if not compatible with geothermal systems. BRGM, the geosciences organization of France has identified three CO_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

& D Programme (IEA, 2007) are the same It has been shown that CO_2 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 CO_2 from rising to the surface (BRGM, 2004).The applicability of CO_2 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 CO_2 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.

REFERENCES

Avoiding Dangerous Climate Change: A Scientific Symposium on Stabilization of Greenhouse Gases, G8 Conference, UK, Feb. 1-3, 2005.

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, March 22, 1989.

Bertani, R., 2005: World geothermal power generation in the period 2001-2005. Geothermics, 34, 651-690.

Bloomquist, R.G. 2006: Economic benefits of mineral extraction from geothermal brines. Washington State University Extension Program, 1-6.

BRGM. 2004: Annual Report on Geothermal Energy and Geological Storage of CO_2, 4pp.

Calvert Asset Management Company Resolution to Calpine Company, Sept 1, 2004.

Avoiding Dangerous Climate Change: A Scientific Symposium on Stabilization of Greenhouse Gases, UK, Feb. 1-3, 2005.

Gielen, D., 2004: The future role of CO_2 capture in the electricity sector. International Energy Agency, France, 9 pp.

Global Carbon Conference in Cologne, Germany, May 10-12, 2006.

IBRD-Netherlands Clean Development Mechanism Facility, Emission Reductions Purchase Agreement , December 9, 2005.

International Energy Association, 2007: Assessing European potential for geological storage of CO_2 from fossil fuel combustion. Greenhouse Gas R & D Programme.

International Union on Conservation of Nature, 1986. Management of Protected Areas in Tropics".

Masaki, H. 2007. "Ever shrinking ODA budget". Ohmy News, July 19, 2007.

Philippine Congress, 1997. Republic Act 8371 (Indigenous Peoples Rights Act).

Philippine Congress, 2001. Republic Act 9154 (Mt. Kanla-on Natural Park Act).

Philippine Congress, 2003. Republic Act 9237 (Mt. Apo Natural Park Act).

PNOC Energy Development Corporation (PNOC EDC), 2007. Personal Communication with Environmental Management Department.

Premuzik, E. et al., 1989: Advanced Biochemical Processes for Geothermal Brines, Annual Report FY 1989, 30pp.

Stefansson, V. 1997: Geothermal re-injection experience. Geothermics, 26, 99-139.

The Northern Dispatch Weekly. Kalinga Folk reject geothermal project, March 31, 2007.

Tuyor, J.B. et al., 2004: Impacts of geothermal well testing on exposed vegetation in the Northern Negros Geothermal Project, Philippines. Geothermics, 34, 252-265.

United Nations, 1992 a. UN Framework Convention on Climate Change.

United Nations, 1992 b. UN Conference on Environment and Development.

United Nations, 1997. Kyoto Protocol on UN Framework on Climate Change.

United Nations, 2007. UN Declaration of the Rights of Indigenous Peoples.

United Nations Environment Programme, 1995. Global Biodiversity Assessment.

United Nations Environment Programme, 2002. Environmental Due Diligence of Renewable Energy Projects: Guidelines for Geothermal Energy Systems, Release, p. 1-14.

US Department of Energy, 2006a. World Consumption of Primary Energy by Energy Type and Selected Country Groups, 1980-2004.

US Department of Energy, 2006 b. World Energy Intensity: Total Primary Energy Consumption per Dollar of Gross Domestic Product using Purchasing Power Parities, 1980-2004.

US International Information Program, 2007. Chevron dives into Indonesia's Coral Triangle, September 12, 2007.

Waikato Regional Council, 2007.Mokai geothermal system.

World Resources Institute, 2000. WRI Climate Analysis Indicators Tool.

Yilmaz, I. et al. 2005. A submerged membrane-ion exchange hybrid process for boron removal. 2nd Membrane Science and technology Conference of Visegrad Countries, Poland, Sept 18-22, 2005.

Zamora, P.M., 1991. "Understanding Biodiversity", University of the Philippines.