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.

REDUCING THE CARBON FOOTPRINTS OF PHILIPPINE GEOTHERMAL OPERATION

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

ABSTRACT

The paper discusses the various initiatives implemented by PNOC Energy Development Corporation in the Philippines in reducing the corporate carbon foot prints of its geothermal operation. These carbon reduction initiatives include: a) trading carbon credits, b) growing carbon sinks, c) measurement of carbon sequestration, d) utilization of biofuels, e) energy conservation, f) paperless operation and g) advocacy of renewable energy.

1. INTRODUCTION

The worldwide energy consumption today is dominated by up to 86.5% fossil fuels (US DOE, 2006). Since the industrial revolution of 1750-1800, the concentrations of Greenhouse Gases (GHGs) from fossil fuel, which cause global warming, are in rising steadily. At the UN Climate Change Convention of 1992, all countries were called upon to reduce their GHGs.

As a major strategy, many countries have shifted to non-fossil fuels as evidenced by investment in renewable and sustainable energy sources. UN Environment Programme (2007) reported that investments climbed to $ 100 billion in 2006. The overall goal is environmental sustainability and that anthropogenic gases be kept at a level that will allow the environment to continue to services man with an ecosystem.

2. STATUS OF GREENHOUSE GASES

Table 1 presents the 6 internationally regulated GHGs and their concentrations in the atmosphere as inventoried by the Intergovernmental Panel on Climate Change or IPCC (Houghton et al., 2001).

TABLE 1: Long-lived Greenhouse Gases

Gas	**Pre-industrial Conc.**	**1998 Ave. Conc.**	**Current Conc. Change**	**Lifetime**
CO2 (carbon dioxide)	280 parts per million	365 parts per million	1.5 part per million per year	5-200 yrs
CH4 (methane)	700 parts per billion	1745 parts per billion	7.0 part per billion per year	12 yrs
N2O (nitrous oxide)	270 parts per billion	314 parts per billion	0.8 part per billion per year	114 yrs
CFC-11 (chlorofluorocarbon)	0 part per trillion	268 parts per trillion	-1.4 part per trillion per year	45 yrs
HFC-23 (hydrofluorocarbon)	0 part per trillion	14 parts per trillion	0.6 part per trillion per year	260 yrs
CF4 (perfluoromethane)	40 part per trillion	80 parts per trillion	1.0 part per trillion per year	>50,000 yrs.

Carbon dioxide or CO_2 is the GHG with the highest atmospheric concentration with almost 200 times that of methane, the GHG with the second highest atmospheric concentration .
At the G8 Conference in 2005 the threshold for global warming was determined at 550 parts per million CO_2 equivalent by volume in the atmosphere based on a temperaturechange of 2°C (3.6°F). It was reported that global temperatures have increased by 0.74°C in the last 100 years (Houghton et al., 2001). Current climate models predict that global temperatures will rise by 1.1°C to 2.9°C for a low emissions scenario and 2.4°C to 6.4°C for a high emissions scenario by the end of the century, compared to the levels of 1990. It was also disclosed that major changes are already happening such as increased threats to human health, decreased agricultural yield, enhanced extinction of species, increased amounts of water shortage, and risks of storms and flooding (IPCC, 2007).

3. PHILIPPINE RESPONSE TO CLIMATE CHANGE AND GEOTHERMAL

In support of the 1992 UN Climate Change Convention, the Philippine Senate ratified the Convention on August 2, 1994 committing the country to the provisions of Non-Annex 1 Party. Furthermore, the Philippines signed the Kyoto Protocol on the Framework of Climate Change on April 15, 1998. The baseline concentrations of GHG conducted by the Philippine Inter-Agency Committee on Climate Change after the ratification of the Convention in 1994 revealed that the GHG contributions from various sectors were as follows: a) energy (49%), b) agriculture (33%), c) industries (11%), and d) wastes (7%), based on the account of Merilo (2003). As the greatest GHG contributor, the Philippine energy sector recognizes its responsibility. The Philippine Department of Energy joined other countries in the energy fuel shift to renewable when formulating the Renewable Energy Framework in 2003, which called for a 100% increase in renewable energy by the year 2012 (Philippine DOE, 2006a).

Geothermal is an important sustainable energy source in the Philippines. Its development has been accelerating since 1976 and it now supplies 12% of the country's power. PNOC Energy Development Corporation's (PNOCEDC) projects make up 60% of the total geothermal capacity of the Philippines. Being an indigenous resource, geothermal energy has substantially reduced the country's dependence on imported oil. Since it began operating commercially in 1983, PNOC EDC has generated over 80,000 GWh-hours of steam and electricity—displacing more than 130 million barrels of oil, which translates to foreign exchange savings of almost US$4 billion, and it also helped diversify Philippine power with indigenous and renewable energy. Reduction in the importation of oil is geothermal energy's major contribution to the reduction of GHG in the country. By operating its 1198 MW geothermal fields, PNOC EDC avoids a total of 5,210,000 carbon tons equivalent per year (PNOC EDC, 2007a).

4. PNOC EDC PRACTICES AND PROGRAMS TO REDUCE CARBON FOOTPRINTS

As the energy representative of the Philippine Government in the Earth Summit of 1992, PNOC EDC led the way in modelling the requirements of the Rio Declaration on the Protection of the Atmosphere.

a) Green advocacy

Championing the cause of the renewables, PNOC EDC is the geothermal representative of the Renewable Energy (RE) Coalition composed of energy companies, NGOs, academic institutions and 385,000 individual supporters all over the country that is arguing for the passage of the Renewable Energy Bill.

Table 2 shows the results of the cost benefit analysis of the proposed renewable energy program for the country up to year 2012 (UNDP, 2005). The total cost of the planned RE projects at present value was computed at $ 529.1 million versus the estimated benefits of $ 621.3 million for a net benefit of $ 92.2 million. The expected benefits are in the form of avoided oil imports and avoided social impacts in terms of health and environmental protection.

TABLE 2: Estimated Cost and Benefits from the Philippine RE Program (Years 2003-2012)

	Present Value (US $ Million)
Summary of Costs	
Incentives for indicative RE projects	78.5
Incentives for committed RE projects	41.2
Increase in capital expenditures	202.0
Increase in O & M expenses	44.6
Foregone taxes from conventional projects	162.9
Total costs	529.1
Summary of Benefits	
Avoided oil imports (million barrels)	22.7
Value of imports, forex savings	562.3
Avoided social impacts	59.0
Total benefits	621.3
Net Benefits	92.2

From : UNDP (2005)

b) Carbon credit trading

The participants in the Global Carbon Conference in Cologne, Germany in 2006 confirmed that the doubts about the Kyoto Protocol on Climate Change vanished despite the political issues due to the right stimuli, namely the: i) political ownership at highest level by the governments, ii) private business participation as the main driver, iii) strict regulation despite a free market scheme, iv) signal from players which negotiated beyond the period of the Kyoto Protocol for good of environment, and v) participation of non-obligated private parties in the US and Australia. Carbon markets evolved since January 2005 with recorded carbon trading increasing as follows: i) World Bank Pilot at $6/ton carbon, ,ii) government funds at $12/ton carbon, iii) private funds at $ 18/ton carbon, iv) fund investment groups at $ 22/ton carbon and v) hedge funds at $28-30/ton carbon. Carbon trading is attractive to the Philippines as it contributes to the sustainable development objectives though the transfer of technology on sustainable energy production and the transfer of financial resources by hosting clean energy facilities which in turn generates employment and local environmental benefits. The Philippines have the distinct advantage of having indigenous and renewable energy sources which allow the lowering of GHG as well as the build-up of GHG absorbing capacities.

In December 2005, PNOC EDC formalized its entry into the emission-offsetting markets by enlisting its Nasulo and Northern Negros geothermal projects with the UN Clean Development Mechanism (CDM) of the Kyoto Protocol. Through an Emission Reductions Purchase Agreement, the World Bank as the fund manager of CDM will purchase the certified emission reductions generated by these new geothermal projects on behalf of the Dutch Government. The Nasulo Geothermal Project is expected to avoid 440,000 tons of Carbon equivalent starting year 2010 (IBRD-Netherlands Agreement, 2005). The discussions on the Northern Negros Geothermal Project is on-going for an additional 1.2 million tons of Carbon equivalent. The following geothermal growth projects of PNOC EDC for the next 5 years are candidates for Carbon finance under the CDM: i) Mindanao 3 (50 MW), ii) Nasulo (20MW), iii) Dauin (40MW), iv) Tanawon-Rangas (40-80MW), and v) Manito-Kayabon (40MW).

c) Growing Carbon sinks

As the administrator of 4 geothermal forest reservations for the Philippine government, PNOC EDC has reforested the denuded public lands around the geothermal project areas since 1984. Water and CO_2 are the requirements for plant growth. Thus, the growth of reforestation stands can capture CO_2 from the atmosphere. For the past 23 years, the company's reforestation efforts have been capturing and storing the CO_2 in the biomass of trees. To date, PNOC EDC has planted an estimated 6.2 million trees in an area of 9,274 hectares. Table 3 shows the reforested areas that serve as carbon sinks in PNOC EDC geothermal areas

TABLE 3: Summary of Area Reforested by PNOC EDC and Equivalent CO2 Sequestered

	BGPF		LGPF		MGPF		NNGP		SNGP	
YEAR	Area (ha)	Equivalent CO2 (tons)	Area (ha)	Equivalent CO2 (tons)	Area (ha)	Equivalent CO2 (tons)	Area (ha)	Equivalent CO2 (tons)	Area (ha)	Equivalent CO2 (tons)
1989	-		25	9,467.68					25	9,467.68
1990	-		100	35,643.04					178	63,444.61
1991	-		140	46,781.49					201	67,164.85
1992	-		100	31,187.66	25	1541.40			278	86,701.69
1993	219	63,422.33	315	91,223.91	100	5725.20			821	237,761.35
1994	191	51,058.65	195	52,127.95	150	7927.20			790	211,185.01
1995	200	49,009.18	182	44,598.35	100	4844.40	186	45,578.54	1,078	264,159.48
1996	69	15,371.06	249	55,469.48	50	2202.00			844	188,017.04
1997	233	46,714.66	232	46,514.17	50	1981.80			1,092	218,937.37
1998	70	12,577.04	162	2,887.09	50	8910.76			297	52,929.91
1999	10	1,559.38	273	42,571.16					500	77,969.15
2000	-	-	262	35,019.29	20	528.48			509	68,033.65
2001	86	9,579.07	100	11,138.45	50	1101.00			556	61,929.78
2002	25	2,227.69	185	16,484.91					390	34,751.96
2003	30	2,004.92	208	13,900.79			47	620.96	621	41,501.86
2004	30	1,336.61	45	2,004.92			87	766.30	438	19,514.56
2005	30	668.31	244	5,435.56	40	176.16	11	48.44	525	11,695.37
TOTAL	**1,193**	**255,528.91**	**3,008**	**542,455.88**	**635**	**34,938.40**	**332**	**47,014.24**	**9,145**	**1,715,165.36**
TOTAL AREA (hectares)										**14,313.00**
TOTAL ESTIMATED EQUIVALENT CO2 (tons)										**2,595,102.80**

Legend: BGPF - Bacon Manito Geothermal Production Field
LGPF - Leyte Geothermal Production Field
MGPF- Mindanao Geothermal Production Field
NNGP- Northern Negros Geothermal Project
SNGPF- Southern Negros Geothermal Production Field

d) Measurement of Carbon sequestration

Even though geothermal has a low GHG emission, it still emits CO_2 which is a dominant GHG component in the atmosphere today. The emissions from the geothermal fields of PNOC EDC is composed of 99.98% steam and 0.8-1.02% Non-condensable Gases (NCGs). About 95% of the NCG is CO_2 (PNOC EDC, 2007b). With the assistance of the World Bank Global Environment Facility (GEF), the company studied the procedures for measuring the CO_2 absorptive capacity of the vegetation surrounding its Leyte Geothermal Production Field (LGPF) vis-à-vis the CO_2 emissions of the geothermal power plants. For the 20,000 hectare watershed of the 8 Leyte power plants, the estimated total carbon stored was measured at 3.84 Mt C (14.10 Mt CO_2) while the carbon sequestration based on biomass change due to tree growth was about 47.35 kilotons of carbon. Under a "business as usual" scenario, the forest reserve will store more than 32 years of CO_2 emission from the power plants (Lasco et al., 1999). Table 4 shows the details of the LGPF carbon budget.

TABLE 4: Total CO_2 Storage of Leyte Geothermal Development Block

Year	CO_2/Yr (Tons)	Storage by Existing Vegetation (Ton/Yr)	Storage by Reforested Vegetation (Ton/Yr)	Total Sequestration (Ton/Yr)	% CO2 Sequestered (Ton/Yr)
1999	437,674	173,768	42,571	216,339	49.43
2000	394,291	173,768	35,019	208,787	52.95
2001	417,553	173,768	11,138	184,906	44.28
2002	399,377	173,768	16,485	190,253	47.64
2003	392,421	173,768	13,901	187,669	47.82
2004	385,913	173,768	2,004	175,772	45.53
2005	386,811	173,768	5,436	179,204	46.33

The Leyte geothermal reservation covers 107,625 hectares and about 50% are built-up or occupied areas. Thus, based on the 20,000-hectare study plot and the homogenous distribution of land uses, the carbon sequestration capacity of the total reservation may be doubled. It is projected that as of year 2007, the forest reserve still has 26 years of Carbon sequestration capacity. The remaining life of the power plant is 24 years under the Geothermal Service Contract with the government. The sequestration capacity in the area will offset the CO_2 emission from the Leyte power plants. Thus, the geothermal operation will not exacerbate the problem of global warming. A similar computation of the carbon budgets of the other geothermal projects of PNOC EDC has been carried out.

e) Biofuel utilization

To further reduce the release of CO_2, the company is fuelling its vehicle fleet with coconut-based fuel. After the trans-esterification process of coconut oil, the product matches the physico-chemical properties of commercial diesel fuel. In 2004, its Energy Research and Development Department successfully developed a small-scale Coco Methyl Ester or CME production plant. This plant is capable of producing about 640 litres of CME every month. The price per litre of CME is higher than that of diesel but the savings in fuel economy arise from the increased mileage estimated at 32.7%. The CME also provides better power and acceleration, a cleaner engine and lower maintenance cost. The company has been using 1% CME blend in all its diesel-fed vehicles at the head office. Meanwhile, the vehicles of other project sites use commercial CME sources.

In 2007, the company will pilot a CME plant in its Southern Negros Geothermal Production Field to supply the requirements of its site vehicle fleet. As a livelihood option for the settlers in the areas around the geothermal project, the company is discussing with the Provincial Government of Negros Oriental the possibility of scaling up this biofuel project to benefit Dumaguete City and nearby urban centres. If feasible, this project will be replicated in other project sites.

Another biodiesel being studied for use in the geothermal projects is Jatropha oil where the raw oil is planned to replace the diesel fuel in stationary machines, such as the hundreds of generator sets used in the various sites. Jatropha oil was projected as competitive at a crude oil price greater than $ 44/barrel. The company established a 33 hectare experimental plot in its Southern Negros Geothermal Production Field in May 2006 to determine the superior Jatropha variety and the optimum local agricultural conditions for productionof maximum oil content. The experiment will be completed by the year 2008. Based on initial results of the experiment, open areas in the geothermal reservations of up to 112,407

hectares may be developed as Jatropha plantations for the commercialization of the project. Similar to CME, the Jatropha project shall supplement the livelihood of the settlers in the reservation while serving the biodiesel requirements of the company.

f) Energy conservation

To save on energy and to reduce the operation of power plants run by fossil fuel, energy conservation is a regular program in PNOC EDC. Energy Audit Teams from the company's Energy Research Development Department periodically conduct audits of company facilities to identify potential savings in energy utilization. Office audits have so far saved the company $ 42.5 thousand per year. In the field, regular energy audits of the steam lines and compressors have resulted in the identification of areas of recoverable energy that translates to additional revenues. The latest site audit reported a calculated total steam loss equivalent to 3.5 MW in the Malitbog project in Leyte Geothermal Production Field. In the offices, energy conservation activities include the scheduling elevator use, air conditioning use based on recorded ambient temperature, switching off lights during lunch breaks, car pooling and other initiatives.

Another energy saving activity of PNOC EDC is the dissemination of the Light Emitting Diode (LED) technology. It is one of the efficient energy technologies known today which uses only one seventh of the energy consumed by an ordinary incandescent lamp. LED technology has been adopted by the company in various applications such as flashlights, torches, radios and streetlights. LED is also often used for off-grid rural electrification projects of PNOC EDC. As a result of these initiatives, the Department of Energy - through the Philippine Lighting Market Transformation Project or PELMATP presented PNOC EDC with an Enercon Award last December 2006 for its efforts in addressing barriers to the widespread use of energy-efficient lighting systems in the country.

g) Paperless operation

As trees are important in carbon sequestration, the company has encouraged a paperless operation to minimize the utilization of trees. A ton of paper uses 19 trees which should store water and carbon dioxide instead. Paperless operation is done by maximizing computer-based transactions and applications.

5. CLIMATE CHANGE ADAPTATION

Notwithstanding the carbon reduction activities in geothermal operation, PNOC EDC implemented the climate change adaptation strategies on early hazard detection and emergency preparedness on company premises and in its environs.

Indications of climate change have been recorded in the country in the past 20 years chiefly in the form of increased frequency of dry spells or El Niño and unusual flooding events called La Niña (PAG-ASA, 2007). The National Disaster Coordinating Council of the Philippines has recorded an average of 37 disasters annually. The natural climate disturbances, mostly in the form of typhoons and landslides have resulted in a number of damages to the company amounting to $ 12.2 million from years 1994 -2006 (PNOC EDC, 2007c).

As a reaction to the natural climate disturbances, which are common in the topography and climate regime of the company's geothermal project sites, PNOC EDC formed a landslide risk assessment team in the year 2000 comprising geologists, hydrologists, civil engineers and foresters to assess and implement erosion control prevention measures to protect its facilities and the communities living below the

geothermal areas. Each project site of the company has an Emergency Response Team to address the natural and industrial disasters.

Since 2006, the company's Community Partnerships Department started organizing able-bodied men and women in the host communities into Village Emergency Response Teams to strengthen the communities' capability of responding to natural calamities that are expected due to climate change. The program is called "Komunidad Kontra Kalamidad" (Communities Addressing Calamities). The objectives of the program are to harness local manpower and mobilize as "first responders" in time of disasters and for the community to protect themselves from the harm and damage of anticipated disasters. The program was envisioned to support the risk management program of the local government units hosting the PNOC EDC projects. Communities that are empowered to manage disasters somehow reduce the pressure on emergency service providers and on government's limited resources. There are now 7 of these teams operating in the host villages of geothermal sites and the company continues to organize more teams on the sites.

Recently, the company tied up with a local institution, the Manila Observatory of Ateneo University, to assess the environmental hazards and natural calamities that might be encountered in the geothermal project sites due to climate change. Early warning measures are to be developed to lessen their impacts on geothermal operations.

6. CONCLUDING REMARKS

The experiences of PNOC EDC in its geothermal operation for the past 31 years have made it realize that the environment is a mainstream and not just a regulatory issue. It can create enormous business opportunities for man if man is able to balance its utilization with proper management. Businesses which depend on natural resources like geothermal energy must reduce its carbon footprints knowing that the environment has no boundaries. This path will give our children an earth that will continue to give life.

REFERENCES

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

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

Houghton J.T., Ding Y., Griggs, D.J., Noguer M., van der Linden P.J., Dai X., Maskell K., and Johnson C.A., (2001). Climate Change 2001 - The scientific basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

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

Intergovernmental Panel on Climate Change Working Group II Fourth Assessment Report (AR4) "Impacts, Adaptation and Vulnerability". February 2, 2007.

Lasco R.D., Lales J.S., Arnuevo M.T., Guillermo I.Q., de Jesus A.C., Medrano R.S., Bajar O.F. and Mendoza C.V. 1999. Carbon dioxide (CO2) storage and sequestration of land cover in the Leyte Geothermal Reservation, World Bank GEF Study, 6 pp.

Merilo, G.A., 2003: Addressing climate change and the CDM, NEDO Japan Mission on Technology Needs for Technology Transfer, December 12, 2003, Quezon City, Philippines.

Philippine Athmospheric and Geophysical Sciences Administration (PAG-ASA), 2007. Meteorological reports from 1970-2007.

Philippine Department of Energy, 2006a. National Energy Plan Update, 6pp.

PNOC Energy Development Corporation, 2007a. Personal communication with the Environmental Management Department.

PNOC Energy Development Corporation, 2007b. Personal communication with the Geoscientific Department.

PNOC Energy Development Corporation, 2007c. Personal communication with the Property Management Department.

UNDP, 2005: Comparative analysis of renewable energy (RE) vis-à-vis conventional energy sources for power application (both grid and off-grid), CBRED Technical Studies, 23pp.

United Nations Environment Programme, 2007: New Energy Finance Ltd., p.3.

US DOE, 2006. World Consumption of Primary Energy by Energy Type and Selected Country Groups, 1980-2004.Energy Information Administration (July 31, 2006).