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PNOC GEOTHERMAL PROJECTS: A HOLISTIC APPROACH TO ENVIRONMENTAL MANAGEMENT

Chona Bustamante
Philippine National Oil Company-Energy Development Corporation (PNOC-EDC)
Merritt Road, Fort Bonifacio, Makati City, Philippines

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ABSTRACT

Through more than twenty years of energy development, the Philippine National Oil Company (PNOC) has continually improved on its environmental management system to cope with the demand of its increasing number of energy projects. In the process, the system has become holistic and comprehensive, thus better capable of serving the needs of PNOC's project stakeholders.

Generally, PNOC looks after the project's land, water, air and people. Because these modules are interrelated, the approach to them is integrated. The holistic system consist of rigorous environmental planning and preparations, practical and comprehensive environmental measures, and proactive enhancement methods and approaches. It answers the company's need to enhance the longevity of the geothermal resource and support the continuous harmonious and productive co-existence among PNOC, the environment and the communities around its geothermal projects.

The challenge now lies in more stringent legislations, and greater environmental awareness and demands from various sectors. Proactive and dynamic, the holistic environmental management system can become more relevant and responsive to the needs of the changing times. Flexible and resilient, PNOC can rely on its environmental experience to surge through challenging times.

1. INTRODUCTION

As stated in its corporate policy manual, the Philippine National Oil Company (PNOC) is *"committed to protect and maintain a sound environment and to safeguard the health of its employees, as well as the communities in all of its energy projects through the implementation of a comprehensive, proactive and continuing environmental management program in the pursuit of its corporate and national energy objectives."*

This sums up the driving force behind PNOC's desire to excel in the environmental management field. To achieve this, the Environmental Management Department (EMD) was formed in 1978, a year after Presidential Decree (PD) 1586, the Environmental Impact Statement (EIS) System Law, was enacted. Today, the multi-disciplinary team is composed of nearly 200 professional staff, mainly engineers and scientists, working on the varied environmental needs of the company's energy programs.

PNOC's environmental management system has continually improved towards becoming comprehensive, proactive and holistic. PNOC's commitment and excellence in the environment field have been recognized by professional organizations, business sector, and the government.

2. THE HOLISTIC APPROACH

PNOC's combined production from its geothermal fields now totals 1,137.15 MW (Table 1). As the number of its geothermal projects increases, the need to apply and improve on the environmental management system is emphasized because each project is unique in terms of problems to solve, measures to adopt and conflicts to resolve. Each project is a learning experience whose lessons are applied to succeeding ones.

Generally, the environmental management system is concerned with the preservation and enhancement of the project's land, water, air, and people. Because these modules are interrelated, the approach to them is integrated. On its own, each module as a fundamental component of the system serves its purpose already, but all of them taken as a whole, fulfills a greater purpose. This led to a holistic system that aims to enhance the longevity of the geothermal resource and support the continuous harmonious and productive co-existence among PNOC, the environment and the communities around its geothermal projects.

The challenge lies in getting the right mix of economic development and environmental preservation that would maximize the potential of the geothermal reservation and the people who depend on it for their survival. This has been done by adopting the macro point-of-view using the holistic approach. Even with this, however, the details of each module remains attended to through constant monitoring, auditing, and technology review.

Before a geothermal project could start, extensive environmental planning and preparations start way ahead. These include social preparation activities like information drives, dialogues, and consultations; conduct of EIS studies; and applications for necessary permits like road right-of-way and tree-cutting permits.

There are standard environmental management measures committed in the EIS document that need to be followed from the time the project is started till it is abandoned. The existing status of the land, air, water, people, and watershed are preserved and improved on during geothermal development. These measures have proven to be practical and comprehensive through time.

Because environmental management has to keep pace with dynamic changes and peculiarities of every project site, proactive enhancement methods and approaches such as technology review and networking are done. Through these, the holistic system becomes updated, more relevant, and more responsive to the needs of the changing times.

3. ENVIRONMENTAL MANAGEMENT MEASURES

Environmental management measures are implemented in the three major stages of geothermal development, namely, Civil Works Phase, Well Drilling and Testing, and Power Plant Operations. During the Civil Works Phase, structures such as access roads and well pads are constructed to facilitate transportation and drilling-related activities. After this phase, wells are drilled then discharged to determine their power potential during the Well Drilling and Testing Phase. Finally, the necessary structures are interconnected and operated during the Power Plant Operations Phase. The preventive, mitigative and remedial environmental measures that are implemented during these geothermal development phases are discussed below and summarized in Table 2:

3.1 Land

3.1.1 Civil Works Phase

This stage may entail removal of vegetation, increase in erosion potential, and relocation of people if the area is occupied. To minimize changes and prevent damage in the natural environment, the following measures are adopted: formation of a Civil Works Committee, limited clearing area, reforestation, construction of ripraps and gabions, compensation for crop damage, and relocation.

A multi-disciplinary Civil Works Committee is tasked to select the road route and the well pad locations based on slope, soil type, erosion potential, vegetation and occupancy. Relatively gentle slopes, open areas like existing community roads, and degraded sites are prioritized. Road alignment on the ground must avoid existing large trees to provide slope stability, and prevent erosion and siltation.

Furthermore, the clearing area is limited only to what is truly necessary. For instance, only 80 hectares of the 107,625-hectare reservation area of Tongonan, Leyte was used for geothermal facilities. Tree-cutting is non-contiguous thus resulting in patches of opened areas with natural forest in between to serve as buffers. If directly cutting through vegetation can't be prevented, compensation is offered for the affected crops. The crops will be priced according to prevailing market rates or as prescribed by the Assessor's Office. Moreover, if truly necessary, relocation is done for affected residents.

Reforestation or biological stabilization is done on the opened area. The land is compacted then immediately planted with fast-growing species as an initial phase, then finally, with forest tree species. Endemic, rare and endangered species present in cleared areas may be transplanted if practical, to similar nearby habitats. However, if the above measure is not feasible, engineering structures such as ripraps or stonewalls and gabions or check dams are built to prevent soil erosion.

3.1.2 Well Drilling and Testing Phase

The measures that are used to minimize the effects to the land are directional drilling and construction of multi-well pads. Geothermal wells are drilled at an angle, with a maximum horizontal distance of 1.5 kms. away from the vertical, to meet target permeable zones and depths with minimal environmental effects. Though 20% costlier, directional drilling can avoid populated or environmentally-critical areas. If it is not feasible, and vertical drilling should be done, crop damage compensation and relocation of residents are the possible options for the affected parties.

In a multi-well pad, several wells are drilled from a single site to achieve compact development. An average of 1.5 ha at 3 wells/pad is opened during drilling. This scheme was initially developed for Palinpinon I of the Southern Negros Geothermal Project (SNGP) in 1983, and was subsequently applied to other geothermal projects.

3.1.3 Power Plant Operations Phase

The magnitude of the continuous reforestation activities to be done by PNOC depends on the resulting degree of denudation due to developing the area. Rehabilitation may be done through the standard reforestation procedures if the area is unoccupied; otherwise, PNOC implements social forestry. This scheme involves the community residing in the area in forestry activities.

3.2 Water

3.2.1 Civil Works Phase

Excessive surface run-off during rainy days may be expected because of the removal of existing vegetation. Run-off water can transport soil particles that could result to siltation of river systems. Ultimately, water quality will be affected. To help minimize siltation, the exposed cleared areas undergo stabilizaton/rehabilitation and earthworks maintenance. Proper grading, surfacing, compacting and maintenance of the soil surface are done. Excess excavated soil, or spoils, are hauled to carefully selected disposal sites and compacted. The filled-up site is then replanted.

Furthermore, to minimize the sedimentation of any residual silt from stabilized areas or disposal sites, silt barriers/traps or filtration systems are built along slopes and rivers. River drainage systems consisting of drainage ditches/canals, diversion channels, culverts and spillways are installed as necessary.

3.2.2 Well Drilling and Testing Phase

To prevent water pollution, measures such as well casing, sump system, limited testing period, regulated discharge and closure of acidic well are used.

During drilling, wells are enclosed with steel casing that is cemented down to 1.7 kms deep to avoid contact with the water table that is usually found 50-300 meters underground. Similarly, cold water from the groundwater aquifers could not permeate the well and thus, could not quench the high temperature-geothermal resource.

The resulting drilling mud, additives, drill cuttings, cement, oil and grease are not disposed directly to the nearest waterway. The drilling fluids are passed through a sump system with adequate volume where the drill cuttings and mud particles can settle, while the still-viscous drilling fluid can be recycled back to the system.

Well testing is limited to 30-60 days. Vertical discharge, which is done to clear the wells of blockage and impurities prior to the horizontal discharge that would gauge the well's potential capacity, is limited only to 30 minutes. On the other hand, to minimize the effects to the environment of the horizontal discharge, it is directed parallel to the prevailing wind direction or towards a less critical land use area such as cogon and other secondary areas.

As much as possible, geothermal fluids are contained in thermal ponds. If, however, the well needs to be discharged beyond the capacity of the pond, regulated discharge is done so that ambient standards are met. Regulated discharge can be done only when there is prior approval from the Department of Environment and Natural Resources (DENR) or if the effluent standards are met; otherwise, reinjection or discharge to ponds is resorted to. If the discharge is acidic, the well is closed and not utilized anymore because it will just corrode pipelines and produce adverse pH effects on the surrounding environment.

3.2.3 Power Plant Operations Phase

Together with the power plant, a closed fluid collection and disposal system (FCDS) is likewise installed. This insulated network of pipelines is used to ensure that the brine is fully contained and no spillage can occur. As added measure, drains to collect condensed steam, and pressure control and safety valves are added to the system.

The collected brine is reinjected to the geothermal reservoir for environmental reasons and as recharge to the geothermal reservoir. In case of reinjection failure, a back-up holding pond accepts the effluents while repair is being undertaken. If the repair is unsuccessful, the power plant is shut down. Finally, the resulting cooling water sludge and machinery scales from the plant are fixed with cement prior to burial in cement-lined pits. This prevents the production of leachates which could potentially contaminate the groundwater.

As a standard activity, regular monitoring is done on water areas such as river systems, creeks, and groundwater sources to preserve their quality and sustain their use for drinking, bathing, and habitat for marine life.

3.3 Air

The major air component that a geothermal project is concerned with is hydrogen sulfide (H_2S). H_2S is inherent to the geothermal system and is evident in thermal manifestations, but geothermal development may increase ambient levels.

H_2S is monitored in all phases of the project due to its potential ill and even fatal effects to man during prolonged exposure or inhalation in great concentration. Monitored regularly are the following: wildlife habitat, population centers such as schools and church, thermal manifestations like solfataras and mudpools, and work areas like the power plant and rock mufflers. Furthermore, air quality models are prepared to predict H_2S values at various scenarios. As such, they are valuable planning tools in geothermal development.

Aside from H_2S, noise and dust are also monitored. The major sources of noise emissions are transportation vehicles and heavy equipment such as generators and compressors. On the other hand, dust can be generated through earthworks, wind action within the cleared areas, and movement of vehicles along access roads.

3.3.1 Civil Works Phase

To address concerns on H_2S and noise, personal protective equipment (PPE) such as gas masks, ear plugs, and ear muffs are used. The Jerome Analyzer, an automatic H_2S recorder, and noisemeter are provided to measure ambient levels of H2S and noise, respectively.

PNOC drivers are required to observe vehicle speed control so as not to suspend particulates that will cause dust. During the dry months, access roads are sprinkled with water as necessary. Natural dust suppression may be provided by rain during the wet season.

3.3.2 Well Drilling and Testing Phase

Noise impacts are mainly generated by drilling equipment and the vertical and horizontal discharges. The discharge also carries with it H_2S that is released to the environment. Dust remains to be a main product of increased volume of vehicles.

The measures used in the Civil Works Phase are also useful in this stage. In addition, silencers are placed near the discharging well to muffle noise.

3.3.3 Power Plant Operations Phase

The power plant and the operating wells are the main sources of noise and H_2S while vehicle movement remains the principal source of dust. The same environmental measures apply. Moreover, the closed FCDS ensures that steam is confined as it is transported from the wellhead to the power plant.

4. PEOPLE MANAGEMENT AND DEVELOPMENT

Protecting the land, air and water environments ultimately protects the people. Land , air and water are natural resources that man depend on for his everyday existence, especially in rural areas where geothermal projects are found.

Recognizing its social responsibility, PNOC holds social preparation activities early in the exploratory phase of the project. Included here are health monitoring, sensing community perceptions, holding dialogues, and conducting information drives. If there are indigenous communities in the area, PNOC follows relevant laws such as the Indigenous Peoples Rights Act (IPRA) in dealing with them.

PNOC avoids utilizing occupied areas that can economically and physically dislocate the residents. However, if it is inevitable due to the site specificity of the geothermal resource, limitations of directional drilling and potential health hazard findings by air quality models, then relocation is implemented. As an environmental measure, regular monitoring is done at the relocation site throughout the lifetime of the project.

Before relocation is implemented, the concurrence of the affected community to the relocation package is first secured.

PNOC provides just and timely compensation and benefits to affected communities; helps them regain and improve their standard of living; and facilitates the formation of a community institution that promotes unity, self-reliance and productivity among the relocatees. Should local residents refuse to relocate even after a series of negotiations, PNOC will just utilize engineering means like extended pipelines, even if more costly, so the geothermal project can proceed.

Socio-economic benefits to the people include alternative livelihood, medical outreach programs, increased business activities, employment opportunities and family income. The Department of Energy (DOE) Law demands developers to source their supplies and service requirements from within the host local government units (LGUs). Moreover, the local communities will have access to cheap, stable and reliable electricity; missionary electrification fund; and priority status on the load dispatch.

5. WATERSHED MANAGEMENT

Watershed management is important to both PNOC and the communities in the area. A well-maintained and enhanced watershed adds to the regenerative capacity of the geothermal resource by percolating the rain water back to earth for reheating and eventual extraction as high temperature two-phase fluid or pure steam. The same watershed is depended on by the people for their livelihood.

The PNOC's watershed management scheme includes forest protection, nursery maintenance, reforestation, forest resource and land use planning, and extension services. These are applied to the following areas that PNOC has full jurisdiction, control and regulation by virtue of Presidential Decree 1515 and Executive Order 223: Tongonan Geothermal Reservation (107,625 hectares), Palinpinon Geothermal Reservation (133,000 hectares), Bacon-Manito Geothermal Reservation (25,000 hectares), and Mindanao Geothermal Reservation (701 hectares) for a total of 266,326 hectares of watershed.

5.1 Forest Protection

PNOC protects the forest from hazards such as fire, illegal logging, kaingin-making (slash-and-burn farming), illegal occupancy and other conflicting land uses. Company-hired forest guards conduct intensive forest patrols in the area. Members of the local communities organized by PNOC are also tapped to assist the forest guards in forest protection activities like apprehending illegal loggers and slash-and-burn farmers. Furthermore, timber-harvesting is controlled by PNOC by handling the issuance of permits for tree cutting, transport and other activities within the reservation.

5.2 Nursery Maintenance

Each project site has a central nursery with a maximum seedling capacity of 200,000 to 500,000. The company also maintains several satellite nurseries where seedlings for various planting and reforestation activities are sourced.

5.3 Reforestation

PNOC leads reforestation activities with local hirees providing the manpower support. A pool of PNOC foresters studies the area and designs the reforestation scheme to be used.

5.4 Forest Resource and Land Use Planning

Foresters survey the watershed to determine the best way to use it. PNOC makes use of the Geographic Information System (GIS) Arc Info program in designing the forest plans and programs of the company.

5.5 Extension Services

5.5.1 Information and Education Campaign (IEC)

To enjoin the settlers to participate in managing the watershed, information drives and dialogues were started in 1984, followed by demonstration projects in 1985-1987. The commercialization of demonstration projects began in 1990. With this income-generating activity, illegal logging and kaingin-making (slash-and-burn farming) became less attractive to the settlers. The information drives were aided by forestry education packages consisting of coloring books for kindergarten, nature poems/stories/dramas for elementary, and reforestation as practicum for upperclassmen. This project has been coordinated with the Department of Education and Sports (DECS) and implemented through ecology sessions in key schools in the reservations. As a form of assistance, PNOC provides the class materials and lesson plans to teachers.

At present, information drives on PNOC's watershed policies and programs are regularly conducted by an extension officer and forest guards who double time as extension workers. The target groups are the local government agencies, private organizations and settlers.

5.5.2 Social Forestry

The New Zealand-PNOC Social Forestry Project was conceived in 1988 to provide sustainable livelihood to upland dwellers in PNOC's geothermal reservations. The project followed the multiple-use concept of forest management by allocating a portion of the forest for livelihood purposes while concurrently providing continuous plant cover for watershed protection. The farmer-settlers were allowed to develop and manage the forest and its resources. They were given trainings on new farming technologies and entrepreneurship skills.

The project was piloted in four geothermal reservation areas, namely, Tongonan in Ormoc, Leyte; Tublijon in Sorsogon; and Baslay and Bediao in Negros Oriental. Consequently, four farmer cooperatives were formed, namely: the Tongonan Farmers Association (TOFA), Baslay Farmers Association (BFA), Kapisanang Mag-uuma sa Bediao (KAMABE), and the Tublijon Farmers Association (TULUNGAN). Today, there are already 73 associations of this type in PNOC's geothermal projects.

As proof of social forestry's success, TOFA has already garnered prestigious awards such as the "Most Outstanding Rural Association for 1997" from DOLE-BRW and "Regional Winner-1999 ABS-CBN Bayaning Pilipino" from the Ugat Foundation and ABS-CBN.

5.5.3 Community Relations (Comrel)

The company's community relations (comrel) projects include support to education in terms of schoolrooms, books and facilities; health and sanitation in terms of medicine, clinics and medical/dental services; livelihood improvement in terms of skills and job trainings; socials and sports, as well as local infrastructures such as road, bridges, markets, basketball courts and health clinics.

6. ENHANCEMENT METHODS

The holistic environmental management system of PNOC evolved from the learnings gained by the company in the problems encountered, concerns raised, and conflicts resolved in its geothermal projects.

General environmental measures cannot meet all the demands of every project site as each one is unique, especially on matters that relate to culture and ancestral domain. Thus, there is that need for the environmental management system to be flexible and dynamic. It should be updated when it comes to technology, comprehensive yet not lacking in focus on the essential elements that will fulfill the project's environmental management needs, and proactive so it can anticipate potential problems.

PNOC supports and enhances its environmental management system with technology review, legislative work, networking, research, training, optimization plans, and consultation. It develops its human resources so it can formulate better schemes, solutions and approaches in its projects. Because of training, its staff have initiated streamlining of its monitoring operations, and developed ISO/IEC 25-compliant laboratory procedures and ISO 14001-based environmental audit systems. The staff also undertake researches in highly specialized fields such as bioindicators, whale sharks and wildlife habitat.

PNOC actively participates in legislation. It initiates drafting of policy proposals to respond to gaps in the law. It has actively participated in both the Senate's and Congress' Technical Review Committees for the Philippine Clean Air Act of 1999, and is doing the same now for the Clean Water Act.

PNOC networks with colleagues in the energy sector and shares its expertise and experiences. Many of its environmental staff are accredited DENR EIS reviewers for various development projects. PNOC's environmental measures were adopted by DENR as guidelines for other industrial sectors. Moreover, PNOC supported the establishment of the multi-sectoral monitoring of projects and drew up the mechanics and procedures for it. DENR adopted these methods and are now an integral part of the Philippine EIS System Procedures (DAO 96-37).

Moreover, PNOC continues its pioneering consultation initiatives which have become a model to other project developers. The policies on public consultation of the Congress and DENR were finalized in 1995 utilizing PNOC's experiences.

Public consultation demonstrates PNOC's willingness to listen to the project stakeholders, especially the communities in the area, whose opinions and concerns are assimilated to the total design of the project. It likewise manifests PNOC's willingness to adopt new and better methods to improve its operation. In return, a fruitful co-existence marked by trust and sharing is expected in the geothermal project.

7. CONCLUSION

The success of PNOC's holistic environmental management system is manifested by the enduring relationship it has nurtured with the communities in its geothermal reservations, the continuing power production of its geothermal projects, and the enhanced watersheds under its management.

The challenge now lies in more stringent legislations, and greater environmental awareness and demand from various sectors. Although holistic and comprehensive already by industry standards, PNOC's environmental management system can still become better through the enhancement methods it has been implementing in its energy projects.

Proactive and dynamic, PNOC's environmental management system can become more relevant and responsive to the needs of the changing times. Flexible and resilient, PNOC can rely on its environmental experience to surge through challenging times.

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Table 1. PNOC-EDC Operating Geothermal Projects
(Energy Times, Vol.7, No. 4, April, 1999)

Geothermal Contract Area	Project	Installed Capacity (MW)	Commence-ment of Operation
Tongonan (Leyte)	Tongonan I	112.5	1983
	Upper Mahiao	125	1996
	Malitbog	231	1996/1997
	Mahanagdong	180	1997
	Optimization	50.9	1997
Bacon-Manito (Albay/ Sorsogon)	Bacman I	110	1993
	Bacman II	40	1994/1998
Palinpinon (Negros Oriental)	Palinpinon I	112.5	1983
	Palinpinon II	80	1993-1995
Mindanao (Mt. Apo)	Mindanao I	47	1997
	Mindanao II	48.25	1999
TOTAL		**1,137.15**	

Table 2. PNOC's Environmental Management Measures

Module	Project Phase	Environmental Measures
LAND	Civil Works	Civil Works Committee
		Limited Clearing Area
		Reforestation/Biological Stabilization
		Ripraps/Gabions
		Compensation for Crop Damage
		Relocation
	Well Drilling and Testing	Directional Drilling
		Multi-well Pad
	Power Plant Operations	Reforestation
WATER	Civil Works	Stabilization/Rehabilitation
		Earthworks Maintenance
		Spoils Disposal
		Silt Barriers
		River Drainage System
	Well Drilling and Testing	Well Casing
		Sump System
		Limited Testing Period
		Regulated Discharge
		Closure of Acidic Well
	Power Plant Operations	Reinjection
		Closed Fluid Collection and Disposal System (FCDS)
		Sludge Fixation and Burial
AIR	All Phases	Jerome Analyzer/Noisemeter
		Personal Protective Equipment, PPE (gas masks, ear muffs)
		Vehicular Speed Control
	Power Plant Operations	Closed FCDS