Alternative Utilization of Low Enthalpy Geothermal Resource

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ABSTRACT

In the year 1998, PNOC EDC pursued the development of the Manito Livelihood Geothermal Project thru piloting of electrical and non-electrical application of low enthalpy geothermal system in the area.

The objectives of the pilot project are (1) to introduce a drying plant making use of low enthalpy geothermal system in Manito, Albay by demonstrating the direct application of geothermal energy in multi-crop drying system and (2) to operate a multi-crop drying system that can reduce post-harvest losses of agricultural products and increase their commercial values by improving the quality of the dried products.

Since the technical feasibility of a drying system using geothermal brine has already been established and reported by the UNDP funded project "Geothermal Agro-Industrial Demonstration Plant," the focus of this paper is to report the experience of PNOC EDC in undertaking the pilot project and the needs that have been established and must be addressed to be able to meet the project objectives of the pilot plant. Basic drying principle of the system shall also be discussed.

Introduction

The Philippines is rich in geothermal resources as it lies in the circum-Pacific belt of fire, a high heat flow region with active, dormant and extinct volcanoes. It has a current generating capacity equal to 1,756 MWe of geothermal energy that comes from the following areas: (1) Tongonan, Leyte, (2) Palinpinon, Negros Oriental, (3) Bacon-Manito, (4) Albay, Sorsogon, (5) Kidapawan, South Cotabato, (6) Tiwi, Albay, and (7) Makiling-Banahaw, Laguna. The first five aforementioned areas, with a total generating capacity equal to 1,092 MW, are being operated by the government-owned corporation, the PNOC Energy Development Corporation (PNOC EDC) while the remaining areas are by the Philippine Geothermal Inc. (PGI), of UNOCAL.

With over 20 years experience in geothermal resource development and power generation, the geothermal industry in the Philippines has become one of the major players in reducing the country's dependence in oil importation for power generation. During the 1995 Geothermal Resource Council, it was presented during the executive session that by year 2000, it is expected that Philippine capacity will be closely trailing the geothermal generating capacity of the United States (Javellana, 1995) and true enough, as early as the year 1999, the country is already the second largest geothermal producer in the world, i.e., next to the United States, with a total installed capacity of 1905 MW (UNDP November 1997, Terminal Report, Geothermal Agro-Industrial Demonstration Plant).

Embarking on the effort of accelerating geothermal development in the country is the geothermal arm of the Philippine National Oil Co., the Energy Development Corporation (PNOC EDC) which is mandated to undertake the accelerated development of indigenous energy resources to reduce the country's dependence on imported fossil fuel. In line with this objective, PNOC EDC undertook drilling of 3 medium depth exploratory wells (Wells MO1, MO2 and MO3) in the Manito area in year 1982-1983 as part of its exploration drilling for the now operational Bacon-Manito Geothermal Production field. Both MO1 and MO3 intersected acidic (pH=3.5) fluids and were immediately shut after short discharge tests while MO2 produced neutral pH (7.3-7.9) brine with discharge enthalpy of <900kJ/kg and an equivalent power output of 0.7 MW. Well MO2 after 3 months of flow testing exhibited calcite deposition in the borehole that resulted to rapid decrease in output and because of this, the well was subsequently shut. (West Japan Engineering Consultants, Inc. April 2000, Manito and Montelago Geothermal Prospects)

The Project

With the experience of PNOC Energy in geothermal resource development and power generation gained through the years, it has become apparent that the vastness of geothermal resources in the Philippines offered not only large scale power generation opportunities but in some areas a need to develop the alternative use of the country's geothermal resources in conjunction with the country's major enterprise, i.e., agriculture. This became a driving force for PNOC EDC to pursue the piloting of electrical and non-electrical application of low enthalpy geothermal system for livelihood project in rural areas, taking off from the "Geothermal Agro-Industrial Demonstration Plant Project" implemented by the PNOC Energy Research & Development Center (PNOC ERDC) under the United Nations Development Programme (UNDP) funding.

Thus, in 1998, PNOC EDC initiated the development of the Manito Livelihood Geothermal Project with the objective of piloting electrical and non-electrical applications of low enthalpy geothermal system in the area. The pilot project aims to utilize steam produced from existing wells for generating electricity that will be supplied to the host community and also as a heat source for non-electrical applications such as putting up air drying facilities of agricultural crops produced and harvested in the nearby farmlands.

As an initial step, the clean-out and re-discharging of the only neutral well in the area, well MO2, was undertaken. MO2 yielded a mass flow of 83.5 kg/s and enthalpy of 907 kJ/kg with an equivalent power output of 0.9 MW. The geothermal fluid from well MO2 is two-phase, steam and brine. After steam separation, brine was to be collected in a sump before pumping it to a reinjection well MO4R, 1.5 km (1.18 mi.) away from the sump, at an injection load of about 80kg/sec. There was a necessity of drilling a fourth well, MO4R, for fluid re-injection because the two other existing wells (MO1 and MO3) are too far to connect and be utilized for brine disposal.

The pilot project makes use of a decommissioned 1.5 MW non-condensing steam turbine from the National Power Corporation's (NPC) Palinpinon Geothermal Power Plant in Southern Negros. Hot fluid flowing at 49 kg/sec from production well MO2 supplies the steam requirement of the 1.5 MW back pressure turbine at 6.3 ksca (6.18 bara) at mass flow of 7.0 kg/sec of steam equivalent to a net power output of 0.85 MW considering the turbine efficiency and steam pressure available in the pilot area.

Two-phase fluid with approximately 13% dryness at a temperature of 210°C from well MO2 passes to the separator and provides steam to power the 1.5 MW backpressure turbine and the two heat exchangers of the drying facility. The plant layout is given in Figure 1.

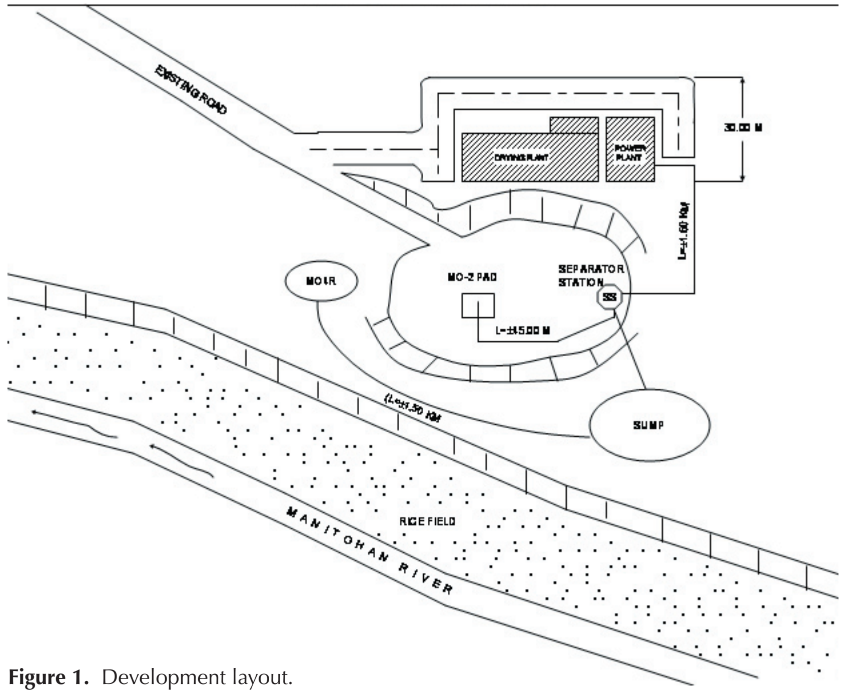

Figure 1. Development layout.

The drying plant on the other hand is composed of three typical tray-type drying units, which use steam leaving the backpressure turbine at 2 ksca (1.96 bara) pressure, and 120°C (248°F) as heat source for drying of agricultural products (crops). Exhaust steam from the turbine is the energy source for heating water in the primary heat exchangers. Secondary heat exchangers were installed where the heated water is subsequently used to heat air for the multi-crop dryer. The dryer has a drying capacity of 3 tons of copra (dried coconut meat) per day per unit and is also capable of drying other agricultural like cassava, mango and pineapple and marine products such as fish and squids. Figure 2 shows the details of the tray-type dryer design.

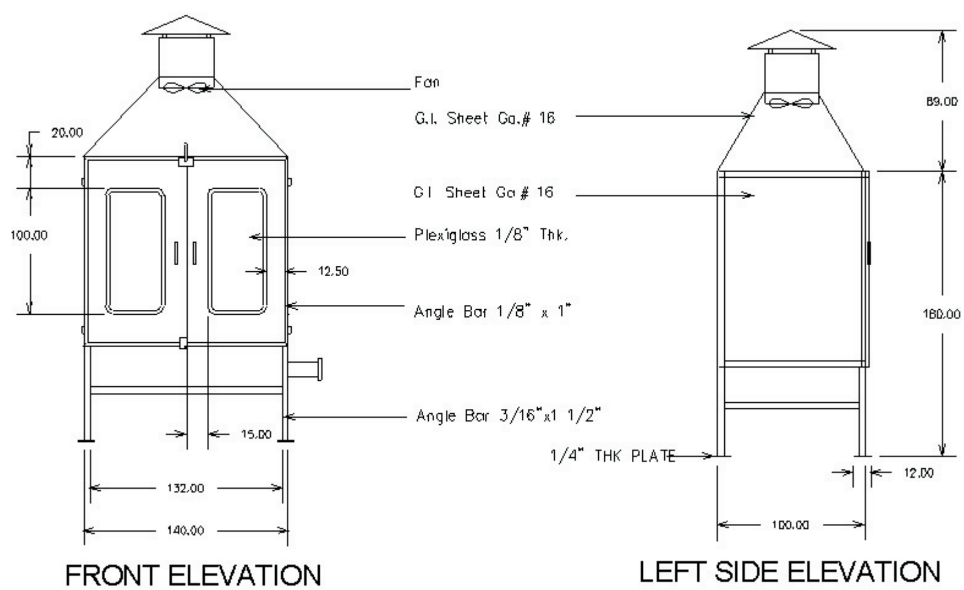

Figure 2. Front and side elevation of tray-type dryer.

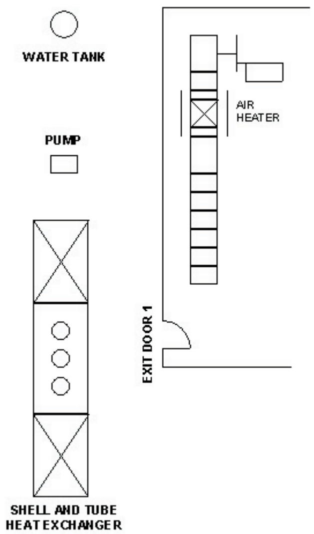

Figure 3.1. Drying plant lay-out.

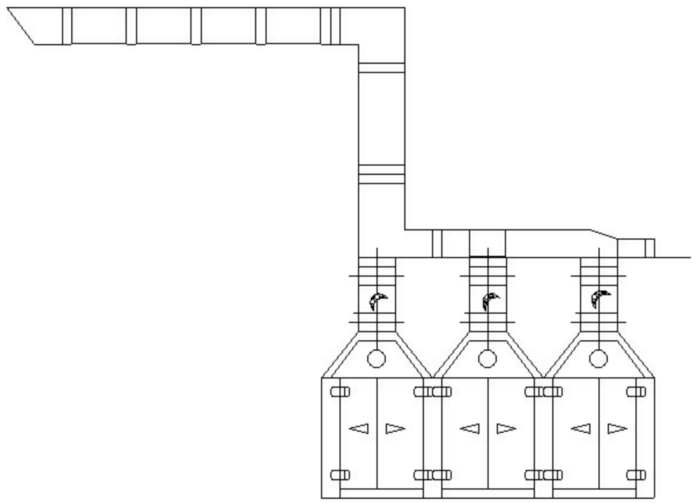

Figure 3.2. Cabinet dryer and ductings.

The drying process begins with the exchange of heat between the air from the blowers and the heated water from the primary heat exchangers. The heated air is then blown from the bottom of the drying tray and as the hot air passes through the drying tray, the hot air absorbs the moisture from the material being dried and the humidified air is ducted at the top of the dryer. The cycle goes on until the desired moisture content of the product is attained. The drying plant layout is given in Figures 3.1 and 3.2.

The drying plant is designed to process three tons of agricultural products per day or a total of 792 tons per year. Available agricultural products for drying in the area are rice, coconut and pili nut (a local nut) with at total annual production of 636 to 2001 tons. However, the current dryer design could only handle bulky agricultural products like coconut and pili nut, the total annual production of which is 441 tons. The drying capacity therefore is not optimized at 441 tons per year.

The 1.5 MW backpressure turbine of the project provides power to run the fluid collection and reinjection system (FCRS) as well as electricity to the residents of Manito mainland. PNOC EDC inked an electricity supply agreement with the local electric cooperative (ALECO), which is responsible for supplying electricity in the area. PNOC EDC's electricity selling price to the local cooperative is 15% lower than the rate of the National Power Corporation, the government-owned power company in the Philippines that supplies electricity to electric cooperatives. Out of the 1.5 MW rated plant output of the power plant, only 800 kW is generated because of steam supply limitation and inefficient steam utilization of the backpressure turbine. The generated power is still enough to run the FCRS and supply 120 kW to ALECO, which is almost equal to the total load in the Manito area.

Problems Encountered and Recommendation

PNOC EDC during the piloting of electrical and non-electrical application of low enthalpy geothermal system for livelihood projects in rural areas, in this case the Manito Geothermal Livelihood Project, encountered several problems. Most of the problems that have stopped successful implementation of the project are non-technical. Although rapid calcite formation in MO2 well has been one of the most recurring problems, this has been remedied by putting up a calcite inhibition system which prevents calcite deposition and maintains fluid production from the well without the need for frequent and costly mechanical well workovers.

One of the technical problems encountered, which would have been addressed if the project shows economic feasibility, is the old 1.5 MW backpressure turbine, which has a steam utilization of 7 kg/sec per MW. If a condensing turbine will replace the old unit, the steam utilization will be improved to 2.0-2.2 kg/sec per MW. This will result in higher output and higher energy sales to the local cooperative, which will in turn subsidize the operating cost of the project.

The most glaring problem that could not be given short-term remedy is the establishment of an organized group who will oversee the operation of the drying facility. As mentioned earlier, the drying facility is short of agricultural products to be dried and the predominance of idle land in the area, which is just waiting to be cultivated, could supply the required volume of agricultural products. Only from optimizing the capacity of the dryer will the project be economically feasible. Otherwise, it will just be another geothermal power project, an expensive geothermal energy source for that matter.

PNOC EDC has initiated addressing lack of agricultural products for drying. It has planted part of the area near the MO2 pad with cassava, one of the agricultural products identified by the Manito Municipal Planning Office (MMPO) having high commercial value. Cassava is being sought by the alcohol industry as replacement for the dwindling supply of molasses. There are other agricultural products identified by MMPO like peanuts, tiger grass and abaca. In fact, PNOC EDC has participated in the abaca rehabilitation program of MMPO and has started to plant 15 hectares of idle land. However, efforts of both sectors were wasted because MMPO, which is under the local government in the area, cannot sustain the project anymore because of lack of funds. PNOC EDC on the other hand could not sustain the project on its own and has tried to look for grants and other form of funding to continue the project. Embarking on the comprehensive development of the idle land in the area entails at least US$ 0.50 million. PNOC EDC was able to submit a project proposal for endorsement by National Economic Development Authority (NEDA), the Philippine agency handling international project funding, to Japan International Cooperative Agency (JICA). To date, there is no approved grant yet for the project.

The experience of PNOC EDC in undertaking the Manito Livelihood Geothermal Project establishes further the technical feasibility of alternative use of geothermal energy, in this case for agricultural drying. The economic feasibility is the remaining hurdle that has to be overcome. It is in this area that government support is badly needed. Clearly defined government programs are needed to be able to solicit support from the private sector and to be able to consolidate all the efforts of the local government and the non-government organizations.

It has been demonstrated by the Manito Livelihood Geothermal Project that low enthalpy wells could be used for both electrical and non-electrical applications. It was able to meet its objective of improving the quality of dried coconut meat (copra), which has higher commercial value. However, the project was not able to sustain its objective primarily because of lack of funds and a well-organized non-government operator. It is in this regard that strong government support and programs are needed. PNOC EDC is hopeful that its proposal for JICA grant shall be approved so that it can start its comprehensive program for sustaining the project.

Impact Analysis

The analysis presented herein is limited in a sense that it does not include analysis of the effects of the project in increasing the income of the farmers, the value added and reduction in product losses due to the pilot project. These factors cannot be substantially evaluated since the NPC's decommissioned turbine has bogged down while the project implementers are still starting to optimize the use of the drying equipment and to introduce modifications in the processing systems. When the turbine bogged down for the third time, PNOC EDC has deferred any plans to rehabilitate the system and started pursuing the option of replacing it with a new unit of condensing turbine upon availability of a foreign grant.

Overall, the project targets are being attained. What remains to be done is to identify specific implementation and policy strategies that will improve the sustainability of the pilot project and other renewable energy based drying system. Renewable energy and cogeneration technology similar to this pilot project offer cheap and sustainable energy resources for crop drying. Drying facilities for agricultural products that cater to needs of a community, will not only reduce production cost but will improve the supply and quality of food products or raw materials derived from domestic agricultural products to the international market.

The pilot project establishes the need for a viable execution of a comprehensive program of implementing the drying and power generation project using low enthalpy geothermal resources to be able to sustain the project. Continuous technical development is pursued for a purpose and in the end advances in technology must also address the question: What is the contribution of the project in alleviating poverty in the area.

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