POTENTIAL ENVIRONMENTAL AND SOCIAL IMPACTS OF SMALL SCALE, RURAL GEOTHERMAL DEVELOPMENT

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SUMMARY - Recent studies and exploration of small scale (< 5 MWe), rural geothermal development potential in Eastern Indonesia have established baseline data to assess the potential environmental and social impacts if such developments progress to production stage. The potential environmental impacts of the Ulumbu Mini-Geothermal development were minimised because of the small 'footprint' of the drilling operations and the short-term abstraction of water from the local river. A watershed management plan was recommended to investigate how farming activities can continue without sacrificing the environment. The potential social impacts were identified and efforts were made to promote community involvement and address any issues raised. Road diversions and installation of a water supply and sanitation system were carried out on behalf of the project for the local community. Small scale, rural geothermal developments present an opportunity in which many groups and communities can benefit whilst minimising the detrimental impact on the environment and the local inhabitants.

1. INTRODUCTION

One of the main aims of small-scale (< 5 MWe) off-grid geothermal developments is to provide power for rural and isolated communities which are currently dependent on imported fuels for power generation. These small-scale developments have not been viable due to high start up costs in relation to the MWe output. Recently there have been concerted efforts to minimise these costs (eg. improved drilling technology, modular plants etc) to make such developments attractive to governments and independent power producers (IPPs).

In recent years there have been a number of pre-feasibility and feasibility studies carried out on geothermal prospects in Eastern Indonesia funded by the New Zealand Ministry of Foreign Affairs and Trade (MFAT). These studies focused on providing power to rural communities far from any distribution network. These studies not only include scientific reconnaissance and investigations, but also sociological and environmental impact assessments.

Three areas which were investigated recently in Eastern Indonesia are: Ulumbu Geothermal Prospect, Flores Island; Hu'u Geothermal Prospect, Sumbawa Island and Sokoria Geothermal Prospect also on Flores Island (Figure 1). Each area has unique features and potential but there is a common link where impacts of development are assessed on an environmental and sociological level. This paper concentrates on studies undertaken at the Ulumbu field (Figure 2) as this field is the only one to have progressed to the drilling phase.

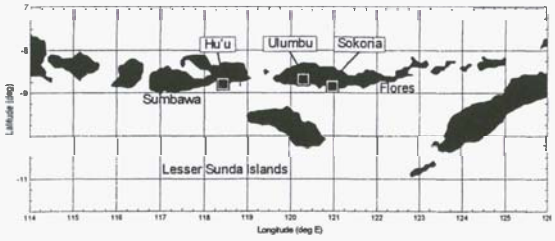

Figure 1. Location map of Ulumbu, Hu'u and Sokoria in Eastern Indonesia

2. ULUMBU GEOTHERMAL PROSPECT

An economic pre-feasibility study at the Ulumbu Geothermal Prospect on the island of Flores was commissioned in 1987 by MFAT. This was followed in 1989 by a technical, environmental and economic feasibility study for a 3 MWe power development. The Indonesian National Electricity Company - Perusahaan Umum Listrik Negara (PLN) commissioned the University of Nusa Cedanna to carry out an environmental impact assessment study of the proposed project in accordance with Indonesian government requirements.

Phase II (drilling) was proposed and funded by PLN with MFAT assistance in the early 1990's and drilling of three successful wells was

completed in 1996. MFAT commissioned the NZ Department of Industrial and Scientific Research (DSIR) Social Science Group to carry out a social impact assessment study during the period October - November 1990. Subsequent environmental and sociological monitoring activities were carried out during the Phase II Project period (1991 - 1996).

Completion tests and geochemical monitoring were carried out in 1996, however Phase III, the plant construction phase of the project, has not being initiated due to the economic crisis in Indonesia.

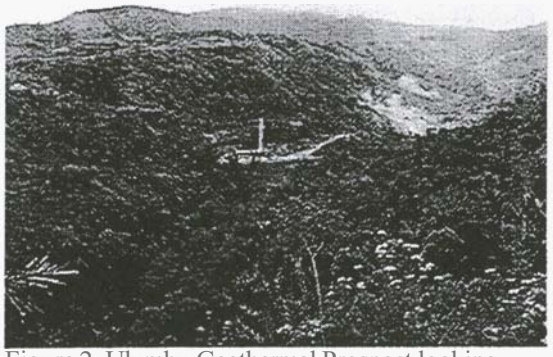

Figure 2. Ulumbu Geothermal Prospect looking up the Wai Kokor valley, fumaroles in background right.

3. WHY SMALL SCALE, RURAL GEOTHERMAL DEVELOPMENT?

Demand for electricity in developing countries is expected to grow rapidly in the coming years. The World Bank currently considers 5 MW plants as "mini-geothermal" but there is a significant market niche for much smaller units – down to the 100 to 1000 kW range. In remote areas, far from the utility grid, villages and facilities such as hospitals can replace their diesel generators with small-scale geothermal power plants.

Many people in rural areas who do not have electricity are willing to pay to get it. The rural poor often spend 10-20% of their disposable income on relatively costly energy services eg. diesel for power, kerosene for light, dry-cell batteries to run radios, and car batteries to run TVs. Others uses for geothermal power besides household include small agro-enterprises, district heating/ cooling etc (Battocletti, 1998).

The local population must be a stakeholder in the project for it to be successful. They can provide the best information and insight on rural energy issues. Cooperatives, non-governmental organisations (NGOs) and .community organisations can be highly effective vehicles for supporting the delivery of energy services and managing the resources. Small developments can bring employment and wealth to the local community, providing new skills and thus incentive for people to stay in the villages rather than work in the cities. There can also be spin-offs for the local community eg. crop-drying, fish-drying, improved water supply facilities.

Electricity sector reform is transforming the potential owners and operators of small geothermal projects from public utilities to IPPs. Reform is intended to improve the overall economic efficiency of the electricity sector and may open new opportunities for small geothermal projects in this more competitive market (Vimmerstedt, 1998).

4. OBJECTIVES OF ENVIRONMENTAL AND SOCIOLOGICAL IMPACT ASSESSMENTS

The introduction of geothermal project activities to rural communities may contribute to changes in peoples lives as well as their surrounding environs.

The social impact assessment provides socio-economic baseline data and identifies the possible effects of the energy resource development on the neighbouring settlements. Similarly, the environmental impact assessment identifies the risks and benefits of development and establishes baseline conditions for environmental management.

A frequent failing of projects is the non-execution of environmental and sociological recommendations established in the early phases of the project. Policy requiring that guidelines and recommendations be established (Environmental and Sociological Impact Assessment Studies) is in place, however, policy requiring the implementation of the recommendations seems to be lacking, and most often no budgetary provision for implementation of these recommendations is made.

5. APPROACH AND METHODLOGY

5.1 Sociological Impact Assessment

A broad consultative approach was taken as expectations and concerns from the local communities did not want to be unnecessarily raised if the development did not eventuate. If a future proposal were to be considered, a more participatory approach would be required to discuss it. And if it was deemed that no project was viable, then an explanation to the communities involved in the study was recommended.

Consultation took place with government officials, local administrators, key informants in the three different regions and villagers living close to the resource. Observations and discussion of daily life, activities and development in the villages, tourist areas and general district. Specific sectoral interests were considered for analysis by gender, age, ethnicity and religion. A highly respected, local and independent specialist (Dr Ataupah) conveyed information between the interested groups and PLN. His participation ensured that information was conveyed clearly and without bias.

5.2 Environmental Impact Assessment

The approach taken for the assessment of environmental impacts is to describe the general nature and characteristics of the environment around the geothermal project and then outline some of the effects and expected impacts due to development. The interactions within an environmental system are complex and so assessment of the impacts and consequences of development is extremely difficult; the evidence is however, that it is likely to be deleterious.

The general approach has been to describe the environment in terms of a series of interconnected systems - starting with physical parameters (such as climate), then biological systems (e.g. flora and fauna), followed by a comment on the social system. The important point is that the Ulumbu ecosystem was not in equilibrium prior to the feasibility studies. Changes in the types of land use and a loss of forested areas has been an ongoing process and has been, and is, bringing about rapid changes to the landscape.

6. POTENTIAL ENVIRONMENTAL IMPACTS

The potential environmental impacts that were identified are listed below - these direct and indirect impacts are common for all three areas studied in eastern Indonesia.

- Air emission effects to human health, agriculture, and native wildlife and vegetation
- increased noise and vibration.
- Change in surface water and ground water quality and quantity.
- Thermal and chemical shock to aquatic organisms
- Vegetation removal and habitat loss
- increased vegetation clearance due to improved roading access

The Ulumbu site was visited by an environmental scientist before, and again after, drilling operations. The purpose of the first site visit was to establish a baseline of the surrounding environment prior to the commencement of drilling operations. Another reason for the visit was to provide specific recommendations to reduce or mitigate the likely effects from the planned drilling activity. At the same time, the opportunity was taken to observe current trends and activities within the watershed.

The Ulumbu area is becoming increasingly intensively cultivated and rivers are extensively used for crop irrigation. Extensive areas of natural forest exist in the region at the upper watersheds but they are being encroached upon by people extending their agricultural practices or moving into the area. The land is steep and although the volcanic soils are relatively fertile, a significant amount of soil erosion is occurring. There is a significant amount of cash cropping being initiated, especially vanilla orchids, coffee, vegetables and fruit.

The project used a limited amount of water fiom the local river (Wai Kokor) for a relatively short period of time during drilling operations. Given the great dependence on the river for irrigation of crops to the level that the local rivers rarely actually flow to the sea, any sustained abstraction from the streams was considered cautiously. The natural hot springs discharge a quantity of brine into the Wai Kokor which can be detected at significant distances. downstream. The local people do not like the taste.

The construction of a small dam above the natural hot springs had been carried out manually to minimise any impacts on the surrounding landscape. Had bulldozer access been made, then there were very strong concerns that this would promote access to that side of the valley and a subsequent expansion of agricultural activity (deforestation). Although there is a "well-trodden path" because of construction activity the effect is only short term, unlike the consequences of a bulldozed vehicle track.

The water supply pipeline fiom the dam to the well pad had also been hand-laid and is not permanently set up since it will be redundant after the completion of drilling. A smaller line could be installed later to meet the needs of the power station. A weirbox was later installed to enable estimates of the relative amounts of water being abstracted and the normal volume of water.

Two pad sites were cleared in the event of either or both being used. The area comprised approximately 100 x 70 m per site. Reconstruction of roading and bridges fiom iteng – Ponggeok – Lale was carried out. As Lale was the nearest village to the Ulumbu site (2km

distance) a road diversion was created so the increase in traffic would bypass the village. Compensation was paid to the landowners.

The hilly upland terrain has meant that both of the pad sites have steep edges that are susceptible to severe erosion. This seems to have been a particular concern with the site that was eventually chosen for drilling operations where the bank was likely to erode and deposit significant quantities of sediment into the Wai Kokor. Such erosion would also rapidly reduce the effective size of the pad itself. Efforts reduce this risk have been carried out by the construction of tiered gabions. While the supply of stone material for the construction of the gabions has been a lucrative activity for local farmers little effort to stabilise the pad sites with vegetation was evident. The biostabilisation of the pads and other road cuttings is an important remedial activity for the project. On gabions and areas with steep slopes there needs to be more than just surface covering by grasses. For this to be successful a nursery should be initiated in the vicinity of the pad sites. The nursery should also start to grow other species for stabilisation/restoration of areas. These could include some fruit tree species and especially creepers to quickly cover the slopes. The reasons behind fruit trees being recommended are that local residents currently grow a wide selection and value their produce and because of this they are likely to take an active interest in their successful establishment. The local residents are also more likely to continue to ensure the plants' survival after the completion of the project.

Concerns were raised over the effects of the release of noxious gases and high noise levels during the drilling operations and during the well testing programme. Throughout the drilling operations the site was equipped with a sophisticated automatic gas monitoring and alarm system, and regular operation safety drills were carried out in accordance with national and international safety regulations. The drilling area was clearly sign posted as a dangerous and secured area, and security guards are posted 24 hours a day.

The well testing programme was limited to 6 vertical discharge episodes, with a maximum duration of 5 hours, and one long term continuous horizontal test lasting 7 days. As expected the vertical, unsilenced discharge tests were dangerously noisy at the well site, and extremely noisy at distances of up to 1 kilometre.

All local residents were provided with disposable ear plugs and were prevented fi-om approaching the well site during these short term tests. The long term horizontal discharge test was carried out using a separator muffler which reduced the noise levels. The location of the well site within the Wai Kokor valley shielded all except one non permanent residence or "guard" house. At the nearest kampung the noise of the long term discharge was discernible at only background levels. As indicated above, this test was limited to a period of 7 days.

The fluids produced from Wells ULB-02 and ULB-03 have proven to be *dry* steam, and reservoir engineers indicate that these wells will likely continue to produce *dry* steam. Effluent brine disposal, and the problems associated with brine pollution of waterways will not be an issue.

7. POTENTIAL SOCIOLOGICAL IMPACTS

Implementation of the following aspects will be required to prevent and mitigate negative impacts and maximise the beneficial aspects of geothermal project development activities. There are six issues around which recommendations for managing potential negative social impacts:

- Satisfactory and constructive negotiation on land use, acquisition and compensation
- Assessment of sources, utilisation and protection of water supply
- Appropriate placement of project baseline
- Health and safety standards and precautions
- Gender and situational specific analysis of impacts on women/men and community development
- Consultation with local communities and special interest groups

The initial sociological study of the three areas was kept 'low key' as the study team were reluctant to undergo a full participatory study and run the risk of raising expectations or concerns that a project would eventuate. However, as the Ulumbu project has progressed, the main issues raised in the initial study can now be reassessed and real impacts quantified.

Concerns were expressed in the initial feasibility study at Ulumbu, that the influx of personnel associated particularly with the drilling operations, would place a considerable strain on the limited health services provided to the area, and upon water supplies and sanitation. The entirely self sufficient nature of the drilling operation, and the location of the drilling camp well away from existing populated areas almost totally negated these effects. Adverse health effects were avoided by construction of sealed septic tank sewage systems both at the drilling site and at the drilling camp and total containment of all drilling effluent on the drilling site.

An **MFAT** funded water supply system for local villages has significantly enhanced hygiene and sanitation. This "spin-off' project has not only provided clean water and washing facilities in the area, but also water flushed toilet facilities connected to properly designed and constructed septic tank systems. A training programme was introduced which addressed the use of water, hygiene and sanitation, and the operation and maintenance of the system. Since completion of this project in October ***1995,*** these facilities have been in constant use. Whilst it is too early to be able to report statistics on the reduction of hygiene and sanitation related diseases, it is quite evident that the quality of life in these villages has been considerable enhanced.

Dr Ataupah has acted as a community liaison person for the project and his involvement has ensured the success of the consultative process:

- His ease of communication to all parties (including fluency in the Manggarai language), so that the effort needed to obtain or provide information was not an impediment.
- His credibility within the region. He is viewed as not being the project proponent but a diplomatic channel between the community and the project.
- The fact that when concerns were raised by the communities, they were acted upon (e.g. road by-pass of Kampung Lale and land compensation).

Consultation activity has on most occasions involved GENZL's project Engineer/Manager and specialists attending the meetings both to provide information and assess community attitudes. This consultation process, and the involvement of Dr Hendrik Ataupah will continue throughout Phase III, the plant construction phase of the project.

8. ENVIRONMENTAL & SOCIOLOGICAL MONITORING PLAN

Despite the existence of numerous agencies and management authorities in Indonesia, the real managers of the land are local farmers and villagers. Constrained by poverty and lack of technology, their need for arable land has profound effects on the land and water resources of both upland and lowland areas. Mounting pressure on scarce land and forest resources, stemming fiom rising human and animal populations, is leading to severe environmental degradation throughout several regions of Indonesia. While not currently so acute in Flores, the same pattern is likely to follow.

Too often geothermal projects, while widely thought of as environmentally friendly, are not integrated within the local community and environment. Instead, a project tends to be superimposed on top of it, that is, its development and operation occurs largely in isolation fiom the local people and the local setting. Relatively few people gain long-term employment (and then usually menial tasks) and the power primarily goes to city industries etc.

Unfortunately in the case of the Ulumbu Mini Geothermal Power Project many of the early recommendations were not implemented. However, funding made available from the MFAT contributions to the Project did enable a comprehensive environmental and sociological monitoring programme to be implemented, as well as two significant "spin-off' social development projects to be executed. These two "spin-off" projects were the installation of a water supply and sanitation system to the Kampung Lale and Kampung Wewo area; and the construction of a section of road to allow the diversion around Kampung Lale of all traffic moving to and from the Ulumbu site.

A watershed management study is needed to investigate how farming activities can continue, without sacrificing the environment. There is the possibility of using the harnessed geothermal resource after power production for crop drying or processing. Such an enterprise would involve the local people in an activity with which they are directly familiar - farming, while at the same time improving their living standards. It is an opportunity for the local community to directly benefit from the energy resource.

This is consistent with the World Bank finding that the principal emphasis in watershed management must be on solutions that raise incomes. These are often not only the easiest to put in place but they may also help to deal with other problems. For example, undertaking soil and moisture conservation practices on farms will increase food output and raise incomes, and will also have an incidental but helpful effect on downstream sedimentation.

Another possibility would be the use of the spent steam for the development of a series of hot pools as a tourist resort.

As mentioned earlier, the sedimentation level of the river is likely to be wrongly blamed on activities of the power projects. Of greater concern is the likely effect of deforestation on the flow rate of the streams. Deforestation can lead to changes in the hydrological pattern of stream flows and in this particular case the concern lies with reduced flows during dry periods. There is a great dependence on crops irrigated by the local rivers.

Any crop loss due to drought or insufficient water to irrigate, would probably raise suspicions about the projects' influence while the real cause is likely to be the gradual cumulative effects of watershed deforestation.

9. CONCLUSIONS

The environmental and sociological concerns outlined above have mainly dealt with the early stages of development. Future key concerns associated with power transmission corridors and power generation plant have not been covered.

There is a critical need for the clear delineation of the fact that either a project becomes "part" of the community or is "apart" from the community. From this, the level and extent of support a project places on potential social and economic impacts and watershed management must be determined.

The support of a watershed management study, establishment of a re-vegetation nursery and programme, and possible direct use of the excess heat for community crop drying would signal a desire to become part of the community.

Solutions are required which give priority to the identified development needs of the people and include them in environmental planning and rehabilitation. In order to get the support of the communities there must be consultation, information, education and evidence that the lives of the rural poor are to be improved as a result of the geothermal development. Their agricultural systems may have to be intensified even further in order to reduce the amount of land necessary to support existing communities.

Off-farm employment may have to be increased to compensate loss of land and contribute labour, skills and income locally. Opportunities for education, training and micro-enterprise and small business development could be created for the community in off-farm work. This could be achieved by proactively including the communities in contracts to provide support services with improved and fairer marketing schemes instituted. Resources e.g. family planning and health services which are available to the project could extend to the communities children and or families during the course of the project with an aim for the communities to develop them in a self sustaining way once the project development phase is completed.

The opportunity for the communities affected to access affordable electricity, as well as education and information how to use it productively should always be an outcome of small scale rural geothermal development. This Ulumbu project offers the potential to serve as a role model in this region.

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