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The Geothermal Resource Clock – What's the Time ?

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ABSTRACT

Managing the time value equation is key to generating better value from a geothermal project. This paper explores timelines for the development of geothermal resources. Various case studies identify the timelines that have been achieved on geothermal projects at Ohaaki and Ngatamariki in New Zealand, and Southern Negros and Tiwi in the Philippines. Material is presented on ways to streamline the geothermal exploration and development processes considering the economic time value equation. Too long and the business case is not robust enough, too short and the information for decision making likely contains gaps that could be crucial to a robust project.

Key to timely geothermal resource development is a structured decision schedule that progressively refines the project viability. Establishing a core team who drive the process with a clear understanding of the bounding parameters and the information requirements at each decision step is essential. Relevant expertise applied in a way that appropriately considers risk is important.

The information capture around the geothermal resource must focus on characterisation of the energy production aspects of the resource and the development of robust reservoir simulation models to assist in determining plant capacity from scenario modelling. This is an aspect which a number of the older facilities were unable to benefit from as these modeling techniques were not available having only been developed since the mid 1980's.

Timely peer review will assist in increasing the robustness of the decision making, decreasing risk that might otherwise be present.

The case studies identify that the time taken from commencing exploration to energy production from a facility is of the order of ten years with four or five years taken from the commencement of serious exploration drilling until commencement of energy production. The high level activity schedule developed suggests seven years is possible from commencing exploration to having a facility producing energy.

1. INTRODUCTION

Managing the time value equation is key to generating value from a geothermal project. This paper explores timelines for the development of geothermal resources and discusses decision points that are commonly present in taking a geothermal prospect through to an operating facility. Understanding the decision points and using the defined bounding parameters importantly assists in scoping the various phases required. Establishing a small core decision making team is crucial to robust decision making and schedule management.

The paper also discusses several geothermal development case studies identifying the time lines that have been achieved in taking a geothermal prospect through to an energy production facility and beyond into the operational phase.

The case studies are from different era's of geothermal development with a variety of drivers and bounding parameters applying to each facility. The era's cover the mid 1960's through to the mid 2000's. The drivers for each of the developments are briefly discussed later in the paper.

2. DECISION POINTS

Important in taking any geothermal prospect through from exploration to a producing energy production facility is the identification and understanding of the decision points that are required along the timeline schedule. Focussed effort, managed to provide quality information for decision making is the key to timely execution of the project. It is important to understand the information requirements for the decision making at each of the decision points. In order to understand the level of information that may be required it is necessary to understand the broader contextual parameters that are bounding the development.

Decision points would typically occur at the end of each of the following phases:

- Initial assessment and scoping
- Exploration
  - Desk top and surface
  - Drilling
- Resource firming
- Facility Development
  - Permitting

The decision points are shown in a high level project activity schedule in Figure 1.

Typically there would be five major decision points in the schedule each which could have an outcome of proceed to the next phase, identify that additional information is required before the proceed to the next phase decision can be made or a decision to cease expenditure and relinquish the prospect.

Having inadequate information at a decision point is the most detrimental to schedule adherence with sound technical and process management required to ensure that this position is not one that occurs. Timely management of peer review processes is also important for quality review of interpretations and risk reduction. These peer review processes can result in schedule extension if they are not worked into the programmes to commence early enough to identify information deficiencies.

3. BOUNDING PARAMETERS

There are a number of bounding parameters and criteria that will influence the project. These need to be considered and established as part of the early scoping and initial project definition. Once established they can to be used to assist in guiding the level of activity required at the various stages of the project.

3.1. Project size

Asking and answering the question about what size development (installed MWe capacity) is required on a given prospect to make a viable entry level project is important to establish. Once established this parameter can guide the thinking around the amount of exploration and exploration drilling activity that might need to be undertaken in assessing that prospect.

Establishing this parameter and considering it relative to the probability of achieving that value should lead to early decisions about progressing exploration or relinquishing a prospect. Being strict in deciding is important because as the exploration process proceeds attachment to a prospect grows making decisions around relinquishing it much more difficult.

If the likelihood of achieving the desired outcome is too low or the exploration expenditure required too significant to warrant the expenditure then being prepared to relinquish a prospect early, if deferring exploration until the development climate changes to one where the outcome risk becomes more palatable, is sound.

3.2. Financing

Over arching are the parameters around financing. What criteria is the project meeting ? Is the project to be financed from a company balance sheet, a government power plan using country tax revenue, government grants, development agency funding or financial institution lending.

It is important to understand the appetite for risk that a developer and the financial agencies that might fund the venture are comfortable being exposed to. Do the decisions around the project have political involvement, are they government strategy driven or are the decisions commercial? A developer may choose to take more risk in the early reconnaissance and exploration phases in order to identify potential projects and then to shift to a more conservative profile as part of committing to construction of a facility.

A project might use different sources of financing at different stages of the project.

3.3. Project ranking

If a number of prospects are being considered then there is expected to be a requirement to assess the priority of the prospects on a potential value basis. Once prioritised effort is spent on those that are likely to deliver early. Considerations in the ranking include:

- Resource size
- Resource complexity
- Environmental aspects
- Natural hazards
- Community acceptance
- Legal complexity
- Grid connectivity
- Ease of securing a revenue contract
- Energy market conditions
- Stability of the political environment
- Political commitment to renewable energy
- Subsidies
- Feed in tariffs
- Unit size – grid or contractual requirements might influence.

It may also be that aspects such as the exchange rate play a part in determining priority and decisions to proceed.

3.4. Aspect of longer term viability

It is important that attention to longer term energy delivery aspects through the life of the facility are attended to at the project implementation phase. To do otherwise could have significant ramifications for the project viability in time.

As part of the process it is important to have an understanding of the necessary requirements to maintain the production levels in a way that deliver the project revenue stream. It is useful to have a longer term plan and strategy for delivery. Aspects that need to be considered include ensuring adequate resourcing is in place to operate and maintain the facility, the positioning of the facility with in the broader host community, the changes that will occur in the vicinity of the facility over the project life, changes that might be required in environmental aspects as a consequence of the drive for improved environmental performance, changes in health and safety management and changes in the planning law that will occur over the decades. Most of these require programmes to be established to position the facility to maintain its position and preferably enhance its position.

Often the facilities are established and the focus is on getting the facility commissioned in a timely manner with lesser consideration and attention for the post commissioning aspects. It is the view of the author that some of these post commissioning aspects need to commence early as part of the project implementation phase.

4. CORE TEAM

A focused core team with other advisers providing input is required. The core team usefully comprises a business analyst (Project lead), financing advisor, a legal \ planning specialist, geothermal resource specialist and project engineering manager. Supporting this team are the geoscientifc, reservoir engineering, steamfield engineering, power plant engineering, grid / transmission support, energy sales, permitting and liaison expertise. In the development of the resource feedback and adjustment based on information found through the exploration and drilling phases is important in maximising benefit from expenditure.

5. SCHEDULE

Meeting the decision making schedule is best managed by regular review of progress and of the information being collected and interpreted. The business case will be refined at each decision point. Figure 1 below is an high level activity schedule.

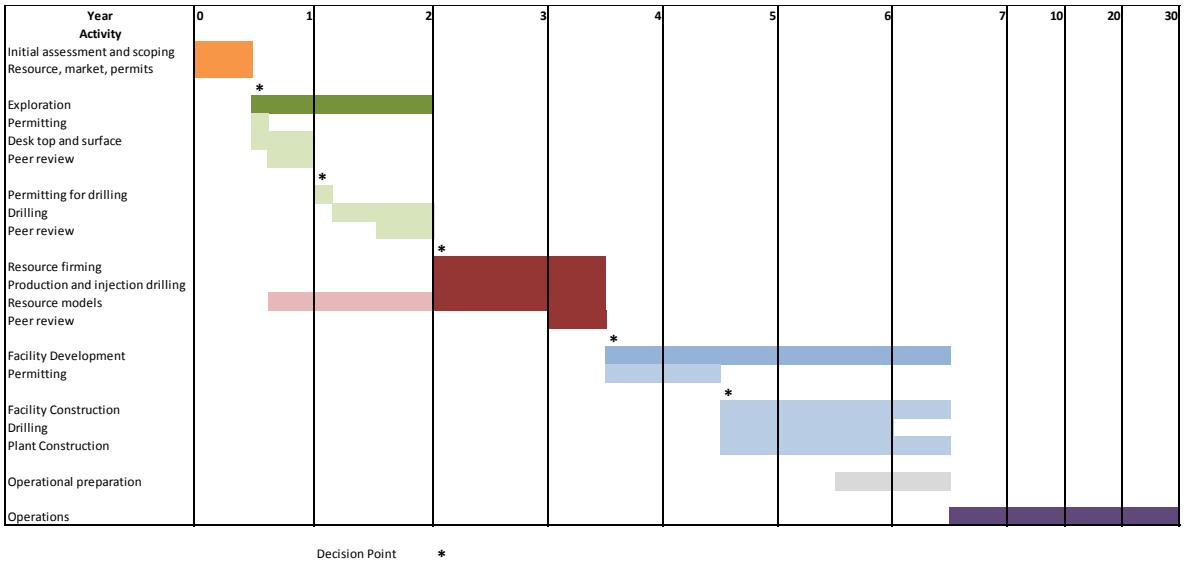


Figure 1 Project activity schedule with indicative timelines shown.

The schedule covers seven years from project initiation and exploration through to the facility being operational, followed by 23 years of operations.

6. PEER REVIEW

Peer review of the resource and technical aspects is recommended. The hands on project technical team are often so immersed in the detail and pressures associated with data capture that it is useful to review the material that is being collected and interpreted. The peer review team should report to the project manager / core team and should be involved early enough in the process to avoid unnecessary schedule delay. Peer review of work scopes can be useful in identifying potential data capture weaknesses. This is not often undertaken. Review of the modelling is recommended.

7. VIABILITY REFINEMENT

In its simplest form the process is the step by step refining of a business case leading to confirming facility viability or otherwise. At each stage of the firming up there are decisions to be made about expenditure to capture information required for the next decision point. The key question is "Is the information sound enough, with the project still being viable to warrant the next phase of expenditure ?" If the answer to that question is yes then funding has to be ready for immediate release if the development is to move forward on an uninterrupted schedule.

Three dimensional reservoir flow and energy modelling as part of the energy delivery from the resource is essential. This is the key focus area for the reservoir engineering and geoscientific team. The reservoir engineering and resource modelling have a key role to play from very early on in the development schedule. The activity needs to culminate in an energy and flow model that is robust enough to scenario model. With scenarios available then the facility sizing decision is to determine the appropriate size commensurate with the risk appetite of the company and finance providers. Taking a conservative position on the installed MW

first up is a prudent place to start out on the development path. The case studies discussed below identify one development that has downsized through time whilst another that has increased capacity in two steps subsequent to the initial development and the third that is early in its operational life.

8. CASE STUDIES

The next section of the paper discusses three case studies:

- Ohaaki in New Zealand
- Southern Negros in the Philippines
- Ngatamariki in New Zealand

These are plants with capacities in the range 80 to 200 MWe.

8.1. Ohaaki – New Zealand

Conceived in the 1960's the Broadlands geothermal development in New Zealand (later call Ohaaki) was a product of the Geothermal Investigations undertaken by the New Zealand government in the late 1950's and 1960's. The Wairakei and Kawerau geothermal field production had commenced and geothermal investigation activities had been enlarged to explore other potential geothermal prospects across the Taupo Volcanic Zone in the North Island.

At Ohaaki some of the early drivers were maintaining a geothermal drilling establishment that could continue to undertake exploration whilst continuing to support the drilling and well work over needs of the operational Wairakei facility. In 1965 BR 1 was drilled on the right bank of the Waikato River (Eastern side) which found high temperatures but little in the way of permeability. This was followed by BR 2 a very successful exploration well considered to be the field discovery well. Other drilling followed with 25 mid depth geothermal wells drilled by 1971. The focus on geothermal development changed with the significant Maui gas find discovered off the Taranaki coast in 1969. This pushed New Zealand towards utilising natural gas under a contractual arrangement that enabled the development of the off shore gas discovery. In 1971 geothermal investigations were curtailed for a period until an oil crisis in 1973 reinvigorated interest in indigenous resource development including geothermal drilling and investigations. Government power planning at the time controlled the timing of the expenditure at Ohaaki as all geothermal electricity generation was undertaken by the government as mandated in legislation. In 1974 the Government power plan included a 150 MWe development on the Broadlands Geothermal field. Environmental investigations commenced culminating in a Commission for the Environment Audit report in 1978, water permits for use of the Broadlands Geothermal field being granted in 1978 for a power development of up to about 150 MWe and land planning approvals being granted in 1979. Significant expenditure had been made in the well drilling and the field exploration and the decisions around the decision to build a plant with a capacity of 116MWe was committed to in 1982. Construction followed and in 1988 the first unit was commissioned with all the other units operational by May 1989. The plant was officially opened on the 31 October 1989.

The various well drilling phases up to 2011 can be clearly seen in Figure 2 (Carey et al 2013). It was a twenty three year journey from when the first exploration well was drilled to when the Ohaaki power plant came on line.

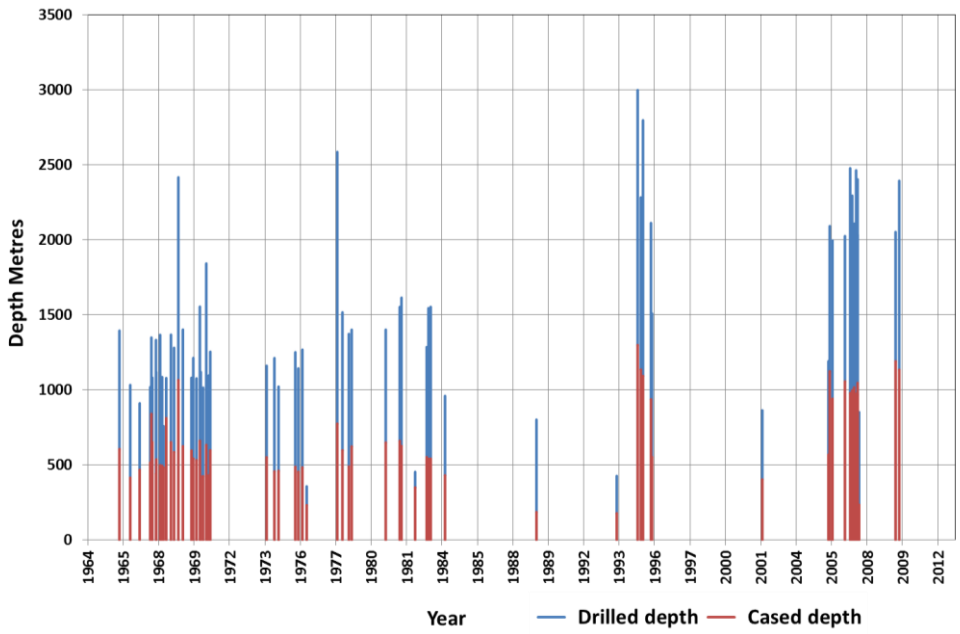


Figure 2 Well drilling activity to 2011 plotted as vertical depth versus year – Each bar represents an individual well. The red segment of the bar is the cased part of the hole and the blue segment the open hole.

Evident in the figure is that the cemented casing strings have been set at deeper depths post 1995 than had occurred earlier in time. Overall the depth of the wells has also increased post 1995.

The plant has been operating for over 25 years and the generation from the plant (Lee et al 2011) is plotted on the right hand axis in Figure 3.

The management of the facility moved from Government control before and at the time of construction under various government Ministries, to State Owned Enterprise control later in the construction phase and commissioning phase through to 1996 when Contact Energy was separated as a separate State Owned Enterprise from the Electricity Corporation of New Zealand. In 1999 Contact was floated as a public company with keystone shareholder Edison Mission Energy. Ohaaki was a part of the Contact assets.

Investment decisions and the return on capital have influenced decisions with time. For the period through to the late 1980's government investigation and power planning budgets drove the expenditure. Post construction through to 1999 decision making was more commercially aligned under the State Owned Enterprise ownership model. Post 1999 decision making has been commercially driven. Ohaaki was in the Contact asset pool where expenditure priorities govern allocations and in the mid to late 1990's capital was being employed in projects such as combined cycle gas turbine power plants where returns were better than could be achieved from well drilling at Ohaaki.

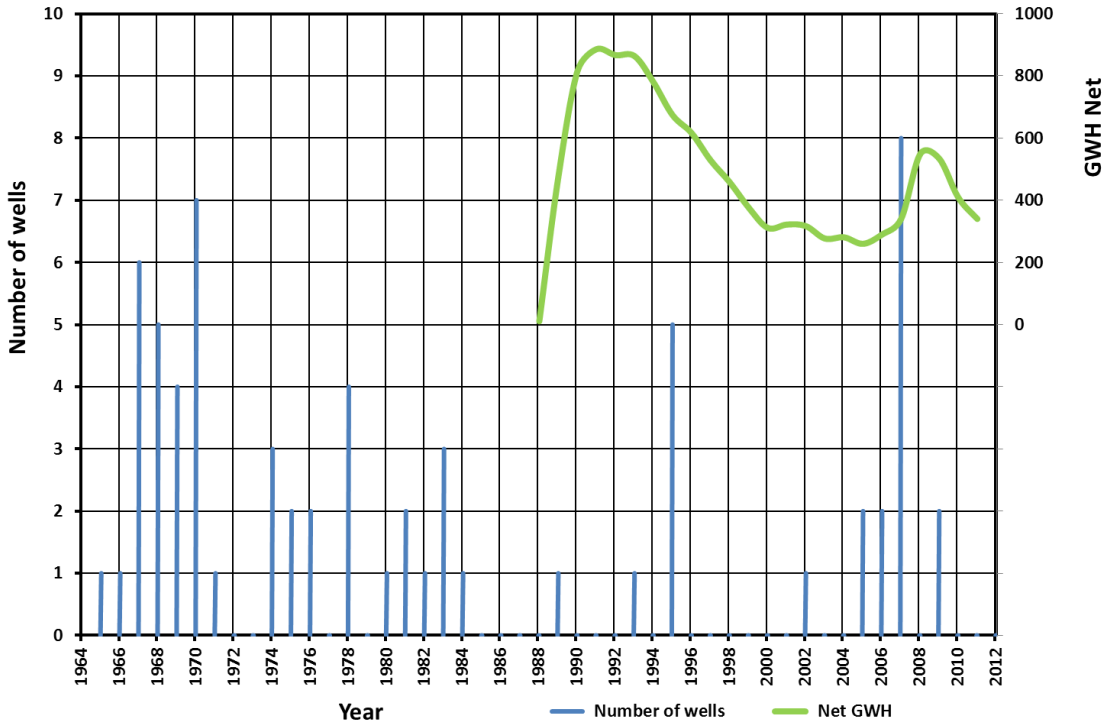


Figure 3 Ohaaki – Number of wells drilled per year and annual generation post commissioning to 2011.

It is interesting to reflect that decision making around the installed capacity at Ohaaki was made prior to three dimensional resource modelling being a tool available to assist in assessing facility sizing scenarios. These modelling techniques were in their infancy and early models using Mulkom were only just being developed by the University of Auckland at the time that the Ohaaki power plant development was being constructed (Blakeley et al, 1983).

The Ohaaki facility has had three major environmental permitting rounds through its lifetime to the present day. The initial permitting was undertaken in the late 1970's. There have been two subsequent permitting processes in 1998 and in 2013 required to enable the facility to continue to operate. The permits currently in place facilitate resource use for 35 years through to November 2048.

8.2. Southern Negros - Philippines

Palinpinon was born out of rapidly growing demand for electricity and also the 1973 Oil crisis that influenced the Ohaaki Development discussed above. In 1973 the Philippines government established the Philippines National Oil Company (PNOC) with a mandate to accelerate the commercialisation and uptake of geothermal energy. There were a number of geothermal resources that were the focus of effort, including the Southern Negros Geothermal Resource.

An initial agreement for financial and technical bilateral aid was signed between the New Zealand and Philippines governments in early 1973. Exploratory wells were to be drilled at Tongonan. In 1975 the program was expanded to include the Southern Negros Geothermal Resource.

Surface exploratory geoscience commenced in 1973. Exploration well drilling commenced in 1976 but it wasn't until the sixth or seventh well was drilled in 1979 that the prospect was considered suitable for larger scale power generation. The well drilling activity with time is plotted in Figure 4 as blue bars representing the number of wells drilled in a given year.

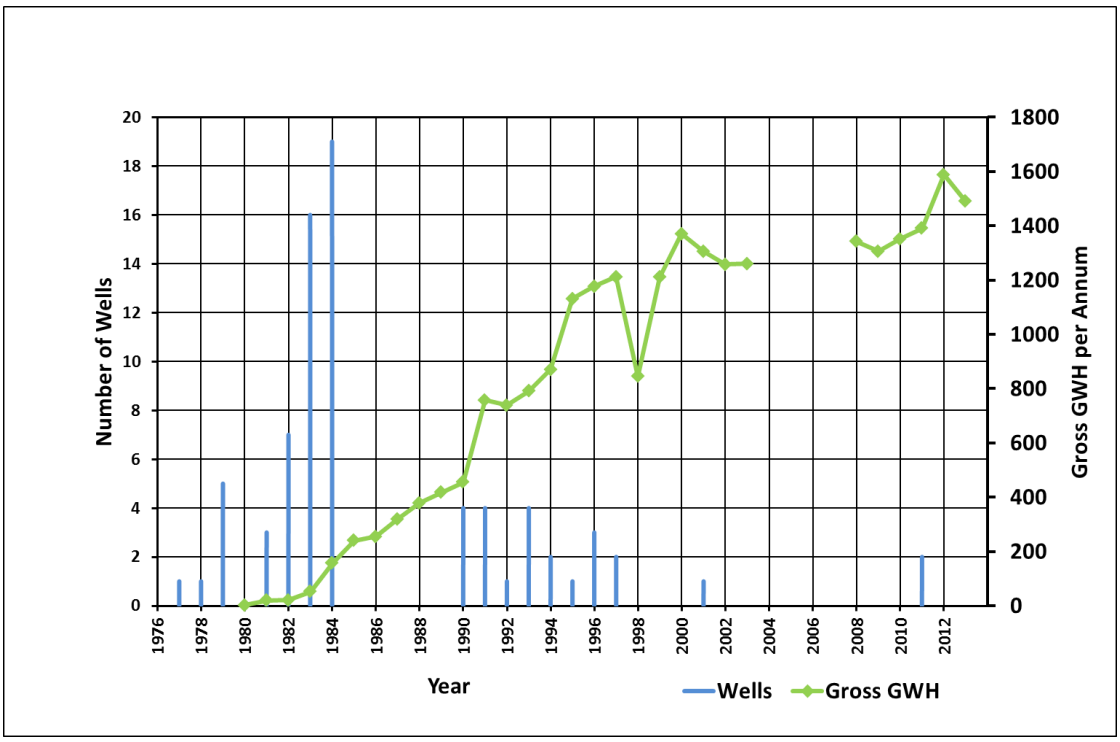


Figure 4 Palinpinon well drilling activity (left hand axis) and generation (right hand axis) with time (Benito et al 2005 and 2010, 2012, 2013 EDC Annual Reports).

There was a ten year period from when exploration commenced and a seven year period from when the first exploration well was drilled until power was first delivered from the Pal 1 power plant. A statutory geothermal contract area was established with a 55 year term for tenure (1976 to 2031) (EDC 2010). PNOC was the steamfield developer and the National Power Corporation (NPC) the Power Plant owner and operator. Two small (1.5 MWe) atmospheric exhaust power plants were installed (around 1980) supplying power to Dumaguete and power for the Pal 1 construction (Sta Ana and O'Sullivan 1988). The construction of the 112.5 MWe Palinpinon 1 (Pal 1) power plant followed with turbine generator units operational by May 1983. Generation from Pal 1 increased as demand grew and as island interconnectivity was established to Panay in 1991 and Cebu in 1995 (Malate and Aqui 2010). The island interconnections can be clearly seen in the generation data in Figure 4. Ten years after Pal 1, between 1993 to early 1995, Pal 2 was commissioned being four modular 20 MWe condensing power plants (Benito et al 2005).

Up until the end of 2006 the Philippine government controlled the Palinpinon facilities with steam being sold between the government agencies PNOC and NPC under a steam sales agreement. PNOC-EDC became a publically listed company in December 2006. At this time the steamfield was run under a public company structure whilst NPC continued to own and run the power plants under a government structure. In October 2009 Green Core Geothermal (a subsidiary of EDC) purchased the Pal 1 and 2 power plants and since that time both the field and power plants have been owned and run by the Energy Development Corporation and the subsidiary company.

In 2014 the 20MWe Nasuji plant (one of the Pal 2 20 MWe power plants) is being phased out and replaced by a 50 MWe plant.

Similar to Ohaaki, decision making around the installed capacity for the Pal 1 plant was made prior to the development of three dimensional resource modelling techniques. Early simulation modelling studies of Palinpinon commenced in 1983 (Sta Ana and O'Sullivan, 1988).

The Palinpinon facility has long term permits in place and hasn't had to be re-permitted in the way that Ohaaki has required re-permitting. There have been land use aspects that have required specific approvals with time.

8.3. Ngatamariki – New Zealand

The Ngatamariki geothermal field was identified and explored as part of the New Zealand Government's geothermal investigation programme. Ngatamariki exploration drilling occurred towards the end of the investigation programme which drew to a conclusion in 1987 as the New Zealand Government moved from Government Ministries to State Owned Enterprises and funding for the geothermal investigation programme ceased. The well drilling undertaken on the Ngatamariki resource is shown in Figure 5. Each bar represents a drilled well at the specified time. The figure shows well depth with the red segment of the bar being the cased section of the well and the blue segment the open hole section. Four wells deeper than 1200m had been drilled as part of government investigation programme.

Interest in the resource waned for a number of years as the mid term market conditions were considered not conducive for development. Interest in a possible power development was reinvigorated by Mighty River Power (MRP) as they were looking to increase and diversify their renewable electricity generation portfolio. In 2000 land rights were acquired and a joint venture arrangement was entered into in 2004 with the Tauhara North Number 2 Trust. A range of geoscientific surveys and reservoir

assessments subsequently followed looking to update and extend the resource information that had been derived from the earlier investigation work.

The investigative work undertaken by MRP focused on identifying the potential resource capacity and environmental aspects. The work included resource wide magnetotelluric surveys, reservoir engineering assessments including interference testing and the development of three dimensional reservoir simulation models to assist with business decision making. The simulation models were initially single porosity constructs but as the work progressed and the understanding of the resource developed it was identified that dual porosity models were required. (Clearwater et al 2012).

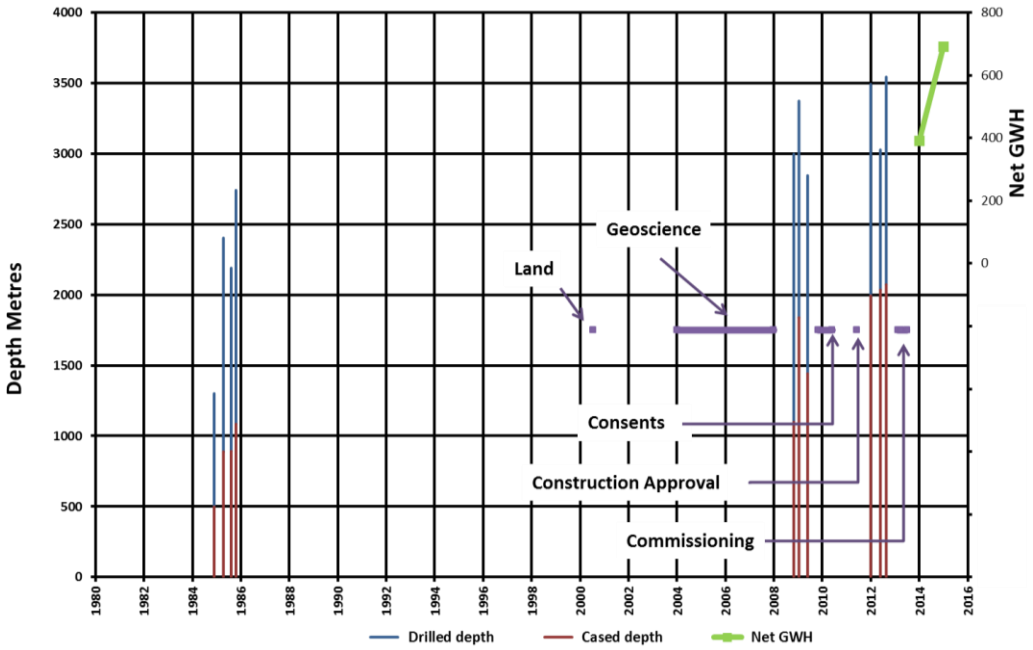


Figure 5 Ngatamariki Geothermal Resource – Well drilling, schedule details since 2000 and energy generation.

Detailed environmental assessments supported the consent applications lodged in November 2009. The consents were granted in May 2010 for about a 100 MWe development. There was a period of peer and internal review with the notice to proceed with construction given in June 2011 for an 82 MWe (net), four unit binary power plant facility (Glendining 2011). Additional drilling was undertaken and construction completed with commissioning of two of the units occurring in the second quarter of 2013 and all units operational by the end of June 2013 (Boseley et al 2013).

There was a nine year period from when MRP commenced exploration and a five year period from when the MRP exploration well drilling commenced until power was first delivered from the Ngatamariki power plant. For Ngatamariki the phases prior to committing to construction required about 50% of the NZ$466 Million project budget (Glendining 2011). Seven out of 10 reservoir depth wells had been drilled ahead of the decision to proceed with construction.

9. CONCLUSION

Key to timely geothermal resource development is a structured decision schedule that progressively refines the project viability. Establishing a core team who drive the process with a clear understanding of the bounding parameters and the information requirements for each decision step with regular progress monitoring is essential.

The information capture around the geothermal resource must focus on characterisation of the energy production aspects of the resource and the development of robust reservoir simulation models to assist in determining plant capacity from scenario modelling. This is an aspect which a number of the older facilities were unable to benefit from as these modeling techniques were not available having only been developed since the mid 1980's.

Timely peer review will assist in increasing the robustness of the decision making decreasing risk that might otherwise be present.

The case studies identify that the time taken from commencing exploration to energy production from a facility is of the order of ten years with four or five years from the commencement of serious exploration drilling until early facility operations commence (refer Table 1 below).

The activity schedule developed in preparing this paper considers seven years possible from commencing exploration to having a facility producing energy. This period includes 1 year for facility permitting which may or may not be relevant in a given circumstance.

This paper is a compilation of geothermal facility information to which I would be pleased if you would contribute your facilities development journey. Please email your information to b.carey@gns.cri.nz to augment the dataset or provide views on a coherent schedule in your specific circumstances.

Table 1. Years from commencement of activity until the power generation facility was operational

Facility	Exploration Drilling	Surface Exploration
Ohaaki	24	28
Palinpinon	7	10
Ngatamariki	5	9
Tiwi*	4	9

* Susman et al 1993 Table 2.

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