Indigenous Maori Values in Kawerau, Bay of Plenty, New Zealand: Assessing Environmental, Cultural, Social, and Economic Impacts of the Te Ahi O Maui Geothermal Project Using the Mauri Model

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Key Words: Mauri, Geothermal, Power, Kawerau, Maori

Abstract:

The Te Ahi O Maui Geothermal Project is a cooperative effort between local Maori Trust landowners and outside energy companies to develop and utilize the geothermal assets under the Trust's land. The project is beneficial for all parties involved as focuses include not only economic gain, but environmental and cultural sustainability as well. This paper makes use of Mauri Model Analysis in order to comprehensively assess the likelihood that these efforts at sustainability will be achieved. The mauri, or life-force, of the land takes into account multiple factors and thus is a useful tool to speculate on likely outcomes. The TAOM project, including both likely plant designs, scores highly in all categories excepting environmental impact. Overall the project is well designed, especially considering the steps taken to sustain and even improve the culture and economy for the local population, considering how difficult environmental degradation to avoid with any large scale construction.

Introduction:

Geothermal power currently plays a crucial role in the energy grid of New Zealand (approximately 15% of total energy supply) and will continue to do so for the foreseeable future. Geothermal power is a reliable, relatively renewable, safe form of power generation which takes advantage of the natural thermal activity below New Zealand (Martin, 1998). The continued development of available geothermal sites is likely to become a necessity as New Zealanders' energy demand continues to rise. The land of the A8D Ahu Whenua Maori Trust in Kawerau, specifically block CIR310499, lies on top of the eastern margin of the Taupo Volcanic Zone (TVZ). The A8D Trust is operated by members of Ngāti Tūwharetoa te Atua Reretahi of

Kawera. The Te Ahi O Maui (TAOM) Geothermal Project seeks to take a minimal amount of geothermal fluid (approx. 15,000 tonnes per day) from the Kawerau geothermal field in order to produce 15 to 20 MWe of electricity (McDonnell, 2012). This is minimal compared to surrounding plants which can produce over five times that; however TAOM is a precursor to further development in the area(McDonnell, 2012). Minimal production will also minimize all risks associated with geothermal plants such as air pollution, subsidence, or damage to sites of cultural significance. TAOM is another step forward for geothermal development in New Zealand.

The TAOM Geothermal Project is revolutionary for its cooperative approach to the development process. Eastland Group Limited, Kawerau A8D Ahu Whenua Trust, and Innovations Development Group International (IDG) have partnered to develop the geothermal site under A8D Trust land by constructing a power generation station on the Trust's land above. The partnership has allowed for a methodology which balances the values of geothermal power in an economic sense with the traditional Maori values of the A8D Trust (Mikaere, 2012). Many geothermal plants have been developed on Maori land before, but generally include Maori beliefs and values in a very limited capacity. TAOM places the local iwi on the same level as the other two partners, integrating the local, traditional views and opinions on the geothermal project.

At the forefront of the Maori decision making process is the concept of mauri. Mauri is the life force inherent in all things (Hikuroa, et. al., 2011). It is intangible and immeasurable, but serves as a valuable scale by which to determine the wellbeing of any environment (Hikuroa, et. al., 2010). The preservation or, if possible, improvement of the mauri within the A8D Trust land is a crucial measure of success for TAOM. Mauri, in a modern sense, is valuable for its

multifaceted nature. Mauri places value not only on environmental factors, but also on economic, cultural, and social issues (Morgan, 2006). Any facets of these issues deemed important by the kaitiaki (guardians) of the land will be addressed as integral to the mauri of the land. A mauri model assessment determines the expected effects of the impacts to mauri of various development proposals.

Background:

Pursuant to section 88 of the Resource Management Act of 1991, TAOM submitted a resource consent application for their geothermal project on December 13, 2012 (Resource Management Act 1991). In the application, Eastland Group Limited, Kawerau A8D Ahu Whenua Trust, and Innovations Development Group Incorporated asked for the approval to take geothermal fluid, to discharge geothermal fluid and vapor, and to otherwise alter the landscape in order to construct the necessary facilities in the optimal location (*Application for Resource Consent*). The planned output of this plant is 15-20 MWe. In order to achieve this nominal output, the plant would draw 5.5 megatonnes of geothermal fluid annually (averaged 15 thousand tons per day) from a number of new wells plus an existing well (KA22) (see figures 1 and 2). The final geothermal fluid output and intake of the plant, used in power generation, will depend on the technology chosen in the ultimate construction plans.

The long history of volcanic activity in the eastern TVZ has caused large scale rifting and provides the deep heat source for current geothermal activity. The active geothermal zone ranges from about 6 hundred meters deep in the south of the system to about 12 hundred meters in the north. Resistivity surveys from the 1950's, supplemented by some more modern deep penetrating surveys in the 70's and 80's, are the primary resource for the development of the area(McDonnell, 2012). The existence of this active geothermal zone has been evident for some

time as proven by the existence of well KA 22 prior to the TAOM project's inception (see figure 3) (McDonnell, 2012).

Air pollution has been a major concern for geothermal development, as it can make a presumably green technology like geothermal far dirtier if handled improperly. Air and meteorological monitoring at and around the site has revealed some valuable base information. Predominant winds at the proposed site are from the south and southwest and rarely exceed 5 meters per second. Additionally, current base levels of hydrogen sulfide in the vicinity of the site are above acceptable levels by most criteria. This is especially due to the nearby Tasman Paper Mill but also includes outputs from other geothermal plants in the area (Stacey, 2012). This will have to be taken into account when assessing potential discharges from the proposed TAOM plant. Readings for other geothermal byproducts such as ammonia, mercury, arsenic, and fluoride are unavailable (Stacey, 2012).

Sites of cultural importance to the A8D Trust have been identified by consulting the Trust and reviewing the history of the Maori land. Cultural sites include Okakaru hot pools, Tungarere Atea, Moturoa Papakainga, Lake Rotoitipaku, Waitahanui Urupa, and Te Wai U o Tuwharetoa (See figure 1). These sites have been marked using satellite technology and will be protected from any impact from the project. The sites will also be given a suitable buffer zone where possible. Contractors will be educated on the significance of these sites to further reinforce the importance of adhering to these guidelines (Buddy, 2012). An Archaeological Resource Assessment in 2011 discovered four archaeological sites which require further consents under the Historic Places Trust (Phillips, 2011).

Two options exist for the technical installation of the plant itself. These are either a steam condensing or an organic rankine cycle system. They are similar, though there are a few key

differences. The steam condensing system only has 75 percent reinjection, is water cooled in cooling towers, uses steam fluid, and has better thermal efficiency. The rankine cycle has 100 percent reinjection, is air cooled, uses pentane motive fluid, and has slightly lower operating costs (McDonnell, 2012). Most significant in terms of mechanics is the use of pentane in the rankine design. This means that instead of using steam from the geothermal fluid, that fluid is used to boil liquid pentane, powering the turbines and producing electricity. This allows for the 100 percent reinjection. Additionally, increased efficiency can be achieved for the steam system by boiling the brine a second time, maximizing electricity generation (McDonnell, 2012). Final concerns include the steam plume from the steam condensing system which is aesthetically unpleasing and the largely speculative belief that the rankine system is more sustainable due to its ability to maintain geothermal system pressure.

Monitoring of subsidence in Kawerau, which extends back as far as 1970, has identified both localized and broad occurrences of land subsidence due to compaction as well as the region's history of geothermal fluid extraction (Nicholas, 2012). The subsidence has been relatively minor, enough to upset only the more sensitive machines at the nearby Tasman Paper Mill. Regardless whether a steam condensing or rankine system is chosen additional subsidence due to TAOM is not expected. The small fluid intake and the potential for high reinjection rates make TAOM more sustainable than other plants in the area.

The TAOM project is especially notable given the negative past the Kawerau Trust has had with development on their land. Te Kete Poutama is an area which contains several cultural sites of great importance to the Trust. This land was loaned to Tasman Pulp and Paper Company in an arrangement under the Tasman Pulp and Paper Act in 1954 and has since been turned into a waste disposal site for the paper mill. A recent mauri assessment of the area shows a decline

from a pre-dumping score of 2 to -1.7 in 2011 (see figure 4). Restoring the mauri will be a difficult process left to the Trust to tackle (Hikuroa, et. al., 2011). The unhappy history the Kawerau Trust has with large scale development emphasizes the significance of their role in TAOM. Tasman has been involved with TAOM as the potential for subsidence or earthquakes from geothermal fluid extraction is possible.

Methods:

The Mauri Model is based on the four interactive aspects of our ecosystem: economic, social, cultural and environmental. The main purpose of the Mauri Model is to determine whether the mauri was enhanced, diminished or remained neutral. The Mauri Model allows for the overlap and interaction between economic, environmental, social and cultural impacts, all of which are necessarily affected when humans develop their land. Mauri binds and holds together the physical and spiritual components of all things. When the mauri is affected it is a direct indication of the long-term viability and sustainability of that environment or particular object. As such, a system which in which mauri is depleted will suffer whereas one which sustains a positive mauri will thrive. A Maori Model assessment of Te Ahi O Maui, an inherently long term investment, will illuminate its viability in all four aforementioned categories.

Specific indicators were assembled in order to best assess the impact. A meeting with members of the Trust as well as a representative of Eastland provided an extensive list of factors to consider in the Mauri Model assessment. Furthermore, two different designs are on the table for the final plant. A separate assessment will be conducted for each design. A final Mauri Model incorporating each factor for each plant design will be the ultimate result. The chosen indicators will be given numerical values +2, +1, 0, -1, or -2 depending on the improvement or deterioration or mauri. A score of 2 indicates full Mauri whereas a -2 indicates completely

depleted Mauri. The Mauri Model not only displays the potential benefits the geothermal project holds, but reinforces the integration of modern, western approaches and traditional Maori beliefs.

Additionally an Analytic Hierarchy Process (AHP) Analysis will be conducted using the same conversations mentioned above as well goals provided on the websites of the respective parties. The AHP is useful to weight the categories used in the Mauri Model in order of most importance for each perspective. It should be noted that, similar to the Mauri Model, AHP uses a scale from -3 to 3 and so is only a rough approximation of actual opinions.

Results:

The AHP Analysis of the three interested parties revealed that each party placed environmental impact as most important, followed overall by cultural, social, and finally economic factors. It should be noted, however, that no one factor outweighed another by a margin greater than 22.22 percent. Environmental, cultural, social, and economic outcomes are important in considering the results of the Mauri Model assessment.

The Mauri Model assessment (see figure 6) made use of a large array of factors in each of the four categories. Focusing on effects on and around A8D Trust land, these results conclude that the land before the geothermal project began was reasonably healthy, as can be expected of largely uninhabited land, but was weak in the other categories, most notably the its lack of economic utilization. The steam condensing and rankine systems differ somewhat in their final results, but overall both cause significant cultural, social, and economic improvements for the land at the cost of environmental degradation.

Discussion:

Showing significant cultural, social, and economic benefits the TAOM geothermal project has a very positive outlook. It is unfortunate that the environmental outlook is not

positive, but it is difficult to avoid damage to the surrounding nature whenever development takes place. Additionally, should a Mauri Model assessment be conducted once the plant has been constructed, some factors, such as the construction damage, will be eliminated while others, such as damage to ground water, flora, and fauna, could be mitigated or improved given some effort. Ultimately, should the project be approved, the future of TAOM looks good for all invested parties.

The minor differences between the steam condensing and rankine systems are found in environmental and economic impacts. In both categories the rankine system comes out on top. Environmentally it is superior by 0.4, economically by 0.1. Given the rough nature of the Mauri Model, the economic difference is insignificant. Environmental's 0.4 differential can be considered significant, especially taking into account the high AHP scores for environmental consideration.

The AHP Analysis (see figure 5) has each party considering environmental impacts tied for the most important factor with either cultural (the Trust and IDG) or economic (Eastland). As such, the difference between the steam condensing and rankine systems in the environmental field should be weighted more heavily. Additionally, as each of the three groups weights cultural, social, and economic, factors significantly it can be safely concluded that the TAOM project has an overall positive outlook. Though the environment will be damaged, cultural, social, and economic improvements will be significant enough to make the project worthwhile.

Conclusion:

The partnership between Eastland Group Limited, Kawerau A8D Ahu Whenua Trust, and Innovations Development Group International sets a new standard for the integration of local interests with those of geothermal power development. Realizing this is not just an economic

venture, this Mauri Model assessment is valuable to accentuate the pros and cons of the TAOM project in terms of environmental, cultural, social, and economic standards. Applying numerical values to the often intangible effects of local culture and social interactions particularly provide a larger picture of what exactly a geothermal power plant's development entails. Understanding all facets, all benefits and damages, of this development can allow TAOM to develop as a remarkable project for its sustainability and its success in all four of the aforementioned fields.

Looking at the Mauri Model results, TAOM has done a good job of planning to benefit the community. All three parties stand to benefit culturally, socially, and economically. Furthermore, as has been stated previously, it is possible for steps to be taken to improve the mauri of the environment in the future. Ideally the environmental score would be improved with in the planning stages as changes are made in an effort to get the project approved. Alternatively some of the expected profits could be reinvested to improve infrastructure and improve environmental mauri.

While this Mauri Model shows an auspicious outlook for TAOM, it would be far more comprehensive if the same Mauri Model assessment were completed by Eastland, the A8D Trust, and IDG. Advancing efforts to make the Mauri Model easily accessible would allow projects such a TAOM to ensure the results match their true feelings. The results in this paper represent the research of an interested outsider and, given Mauri Model's utility as a tool of approximation, should not be disregarded. All the same the active involvement of the interested parties would ensure accurate results.

The mauri, the life-force, of Kawerau and the Trust's land stands to benefit from TAOM as the plans stand now. Even considering the AHP analysis the cultural, social, and economic benefits are clear. This positive outlook is a testament to the cooperative effort the TAOM

project truly is. The project has room for improvement, but stands as an example of success in not only preserving, but appreciably improving mauri.

Appendix:

Figure 1: Map of the proposed TAOM development including the preferred route for electrical wires, water/gas pipelines, and the lands excluded due to Kawerau Trust cultural significance (Stacey, 2012).

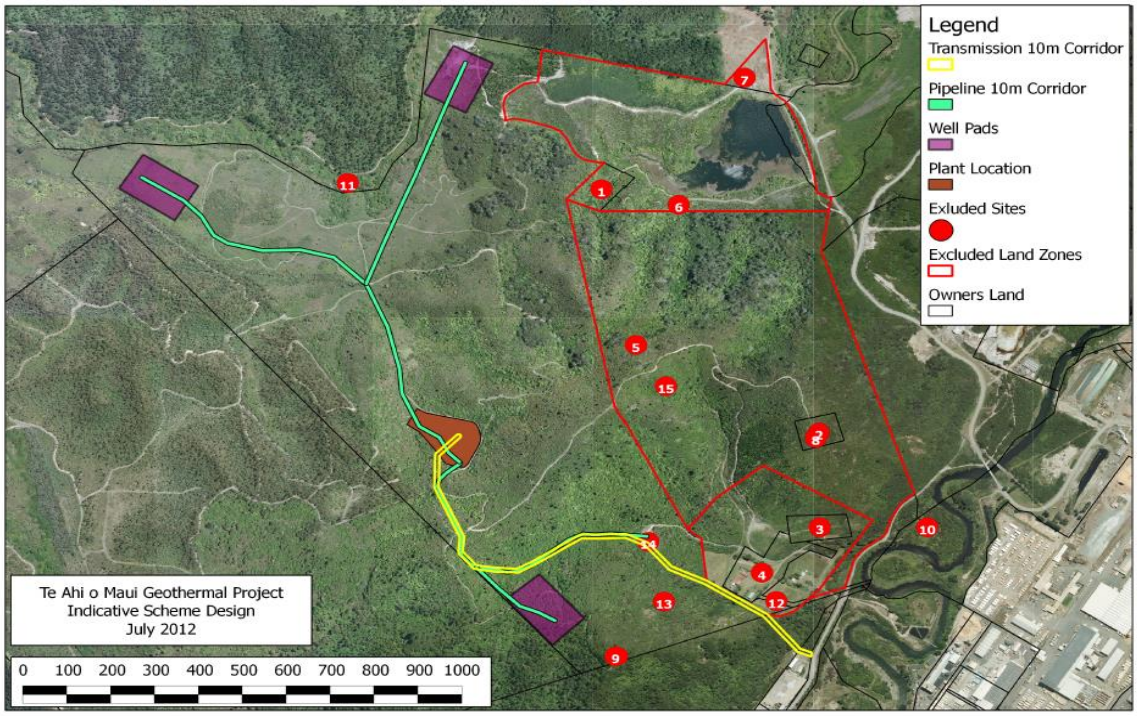

Figure 2: Rough locations of potential well sites on the Kawerau Trust land (Stacey, 2012).

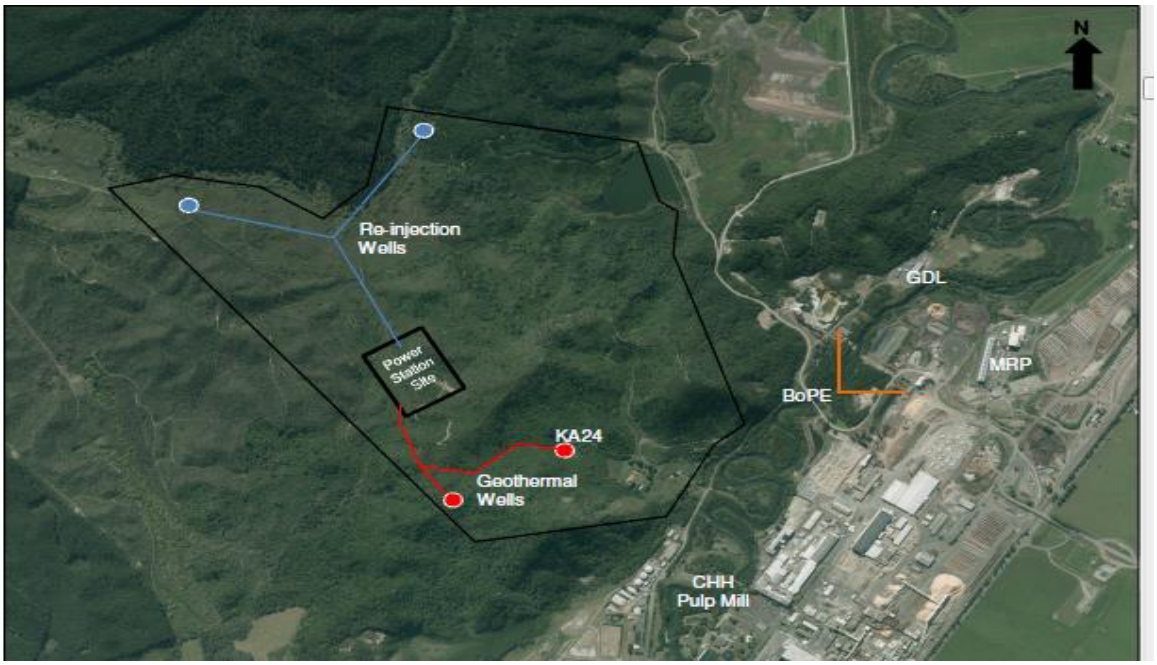

Figure 3: Geothermally active areas under Kawerau Trust land marked in red (McDonnell, 2012).

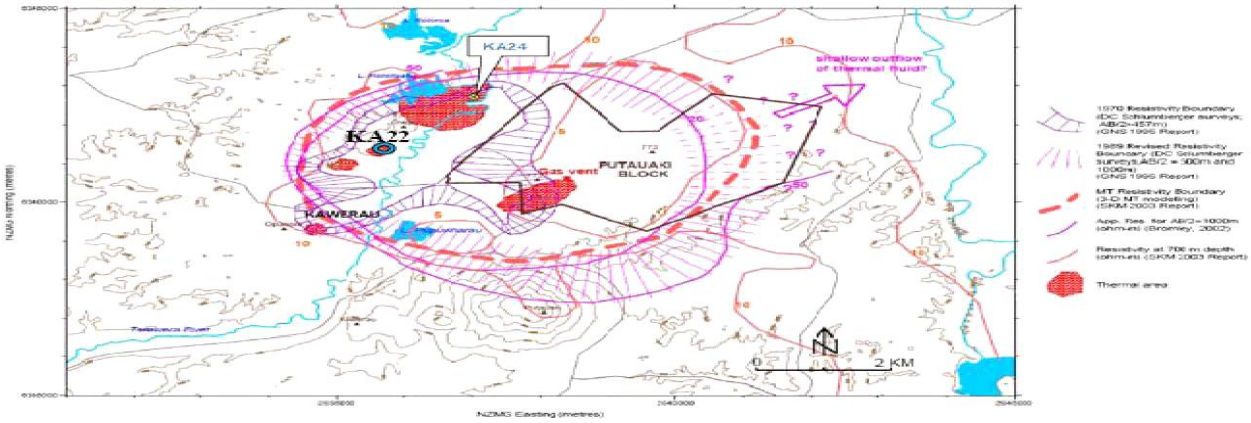

Figure 4: Scale used in the Mauri Model (Hikuroa, et. al., 2011).

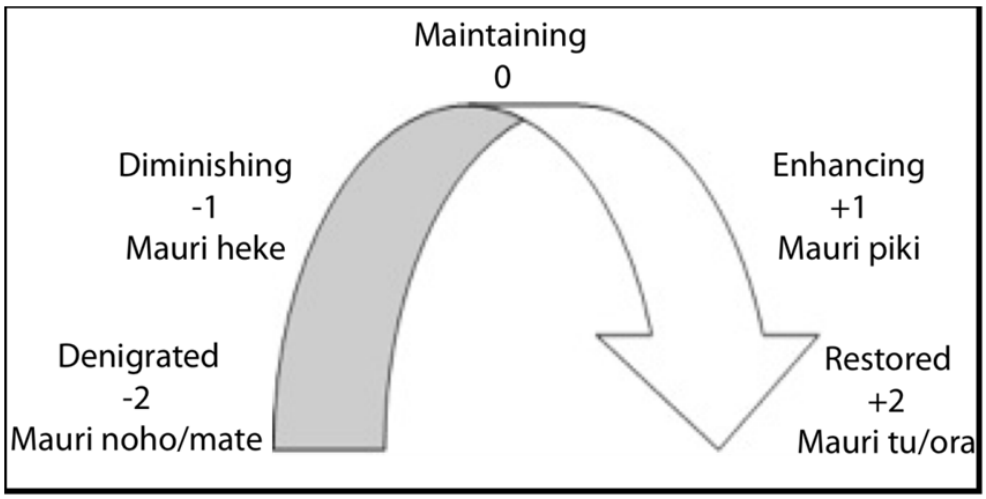

Figure 5: Analytic Hierarchy Process (AHP) Analysis for the three major parties involved in TAOM (Priority% rounded to nearest tenth).

Kawerau A8D Ahu Whenua Trust

Dimension	**Priority%**	Environment	Cultural	Social	Economic	**Sum**	**Sum +9**
Environment	33.3	0	0	1	2	3	12
Cultural	33.3	0	0	1	2	3	12
Social	22.2	-1	-1	0	1	-1	8
Economic	11.1	-2	-2	-1	0	-5	4

Eastland Group Limited

Dimension	**Priority%**	Environment	Cultural	Social	Economic	**Sum**	**Sum +9**
Environment	33.3	0	2	2	-1	3	12
Cultural	16.7	-2	0	0	-1	-3	6
Social	16.7	-2	0	0	-1	-3	6
Economic	33.3	1	1	1	0	3	12

Innovations Development Group International

Dimension	**Priority%**	Environment	Cultural	Social	Economic	**Sum**	**Sum +9**
Environment	33.3	0	0	1	2	3	12
Cultural	33.3	0	0	1	2	3	12
Social	19.4	-1	-1	0	0	-2	7
Economic	13.9	-2	-2	0	0	-4	5

Figure 6: Mauri Model Assessment of Pre-TAOM conditions as well as the two most likely designs for the proposed geothermal plant (Overall results rounded to nearest tenth).

		Pre-TAOM	Steam Condensing	Organic Rankine Cycle
Environmental				
Air Discharge	Non-condensible Gases	-1	-2	-1
	Green house gas	-1	-2	-1
	Plume	2	-2	2
	Construction Dust	2	-2	-2
Noise	Construction	2	-2	-2
	Operations	2	-1	-1
Geothermal Reservoir	Sustainability	0	-1	0
Induced Seismicity		-1	-1	-1
Land Subsidence		-1	-2	-1
Ground Water	Te Wai U O Tuwharetoa	1	0	0
	Ruruanga	1	0	0
	Kaiawatea	2	0	0
	Wharekitoitoi	2	0	0
Ecology	Flora	2	-1	-1
	Fauna	2	-1	-1
Visual Impact		2	-1	-1
Geological Surface Features		2	2	2
Infrastructure Impact	Plant	2	-2	-1
	Pipelines	2	-1	-1
	Transmission Lines	2	-1	-1
Cultural				
Marae	Cooking	2	2	2
	Heating	2	2	2
	Cleaning	2	2	2
Papakainga		2	2	2
Waahi Tapu	Tirotirowhetu	2	2	2
	Otukoiro	2	2	2
	Value of knowing (Cultural Mapping)	1	2	2
Mana	Culturual Fulfillment/Land Use	0	2	2
Identity	Presence of Project	0	2	2

	Development of project	0	2	2
	Inheritence of project	0	2	2
Sustainable Energy Generation	Tikanga	1	-1	-1
	Contempory	-2	2	2
	Sowing Seeds	-2	2	2
Social				
Health	Human	2	2	2
	Bathing Facilities (Hot Springs)	1	2	2
Relationships	Industry	0	-1	-1
	Land owners	0	1	1
	Community	0	1	1
Education	Owners	0	2	2
	Community	0	2	2
Community	Geothermal as a social norm	0	2	2
Legislation	Resource Management Act	0	2	2
	Knowledge of and compliance with all other relevant legislation	0	2	2
Economic				
Project Economics	Income	-2	2	2
	Capital Expenditure	2	-2	-2
	Operational Expenditure	2	-2	-1
Employment	Construction	-2	2	2
	Operational	-2	1	1
	Indirect Employment	-2	1	1
Energy Independence		-2	2	2
Scholarships	Owners	-2	2	2
	Community	-2	2	2
Development Model	Commericalisation of model	-2	2	2
	Sucessful implementation	-2	2	2

Overall results	**Pre-TAOM**	**Steam Condensing**	**Organic Rankine Cycle**
Environmental	1.2	-1.0	-0.6
Cultural	0.7	1.8	1.8
Social	0.3	1.5	1.5

Economic	-1.2	1	1.1
Mauri Model Assesment	0.3	0.8	1.0

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