NEW ZEALAND
GEOTHERMAL
ASSOCIATION

East Harbour Management Services Ltd
PO Box 11-595, Wellington
New Zealand
Tel: 64-4-385-3398
Fax: 64-4-385-3397
E-mail: brian.white@eastharb.co.nz
www.nzgeothermal.org.nz

Submission on the Climate Change (Stationary Energy and Industrial Processes) Regulations 2008 (Draft for Consultation)

To Ministry for the Environment

On behalf of the New Zealand Geothermal Association

15 December 2008

Introduction

The New Zealand Geothermal Association would like to thank the Ministry for the Environment for the opportunity to comment on the draft Climate Change (Stationary Energy and Industrial Processes) Regulations 2008. There are major energy and environmental challenges facing New Zealand, for which our geothermal resources and their development are an integral part of the solution. The New Zealand Energy Strategy effectively places a strong reliance on geothermal electricity generation to meet its renewable electricity target of 90% renewable electricity by 2025. Geothermal energy can supply heat requirements also.

The New Zealand Geothermal Association (NZGA) is an independent, non-profit association that provides information on geothermal phenomena and utilisation for industry, government and educational organisations. In addition, the NZGA, as a member of the International Geothermal Association, contributes to the international exchange of information within the geothermal development industry. NZGA membership comprises participants, regulators, and interested parties within the geothermal community. It totals 218 members currently.

This submission will be published on the NZGA website. Some people will be surprised at the lack of opposition to the application of a carbon charge and fees to geothermal developments, but the Association recognises that the debate has moved well beyond that. In practice, many of the people involved with geothermal development nationally recognise that the low emissions associated with geothermal energy should be treated in a consistent manner with other emissions, and that the end result will be that geothermal energy will be still more attractive than it’s high emission fossil-fuelled competitors.

Just to be clear, geothermal energy is associated with generally low levels of emissions, so use of geothermal energy to displace fossil fuels will reduce emission levels overall. Uptake of geothermal energy will be made more attractive by the application of emissions charges, which will increase the cost of the high emission fossil fuel options.

The New Zealand Geothermal Association has stayed relatively quiet through the Climate Change consultation process. For that reason there are now some aspects of this submission that reflect back on the current content of the Climate Change Response Act 2002 (CCRA2002), and for which change is recommended.

Coverage of the Draft Regulations

The draft regulations cover a range of emitting industries and “mining-type” operations, essentially referencing the list of activities included in the CCRA2002. While the NZGA accepts that it is reasonable for all emitters to be covered by regulations, and therefore geothermal energy should also be covered, we emphasise the need for consistency. The most obvious exclusion from the list of mining activities is oil production.

The Chief Executive

While there is some reference to the CCRA2002 in the supporting documentation and below the regulations heading it is thought that the linkage could be made stronger in the regulations. One particular example is that of the "chief executive". Clause 4 (1) and Schedule 1 refer to as yet unspecified fees and charges payable to an unspecified chief executive. This person or their role is not defined anywhere in the draft regulations or the associated discussion document. It would be reasonable to define the chief executive as having the same meaning and function as specified in the CCRA2002.

Ability to Opt-in

The discussion document notes that some major consumers of coal and natural gas may wish to opt in to the NZ emissions trading scheme. The same option should apply to geothermal energy consumers for consistency. This would also require a change to the CCRA2002, as the current draft regulations reflect the content of the CCRA2002.

It appears that the option requires some critical size of consumption. For coal the critical consumption level is 250,000 t/year (equivalent to 5.6PJ/year) (clause 44). For natural gas the level is 2PJ/year (clause 47).

In the case of geothermal energy, Norske Skog Tasman at Kawerau receives around 7PJ/year of steam based on 14PJ/year of total flow from Ngati Tuwharetoa Geothermal Assets (NTGA), while various power stations would receive greater quantities of heat potentially from a different upstream company or joint venture. As a crude method of assessing the energy supply to various geothermal power stations, typical energy conversion efficiency is between 10 and 15% and load factors can be around 95%. This implies a 10MW geothermal station requires a total fluid take of around 2 - 3PJ/year. Examples with different upstream and downstream developers include the power stations at Rotokawa (35 and 132MW[1] each) and the new station at Kawerau (90-100MW).

It would seem that there are or could be a number of geothermal developers that could have a critical level of consumption (compared with coal or natural gas levels) to justify the opt-in option.

Some Basic Geothermal Engineering Aspects

A review of the draft regulations indicates some misconceptions around geothermal energy production. A simple explanation will be provided here so that appropriate rewording can be developed.

Geothermal developments normally involve several production wells. A simple schematic diagram is shown in Figure 1. The fluid in the reservoir is normally a saturated liquid in New Zealand fields, but as the water flows up the well bore a portion of the water flashes to steam as it loses pressure. Thus the two phases of steam and water will be present at the surface, along with the trace amounts of gas.

Note that fields are dynamic in nature. New wells may be brought in to service with different enthalpies (heat content) or gas content to original wells. The field nature changes with time (including for fields developed with the practice of reinjection). An example showing the effects of these changes is given in Appendix 1.

---

[1] The 132MW Nga Awa Purua station is currently under construction and will be commissioned in 2010

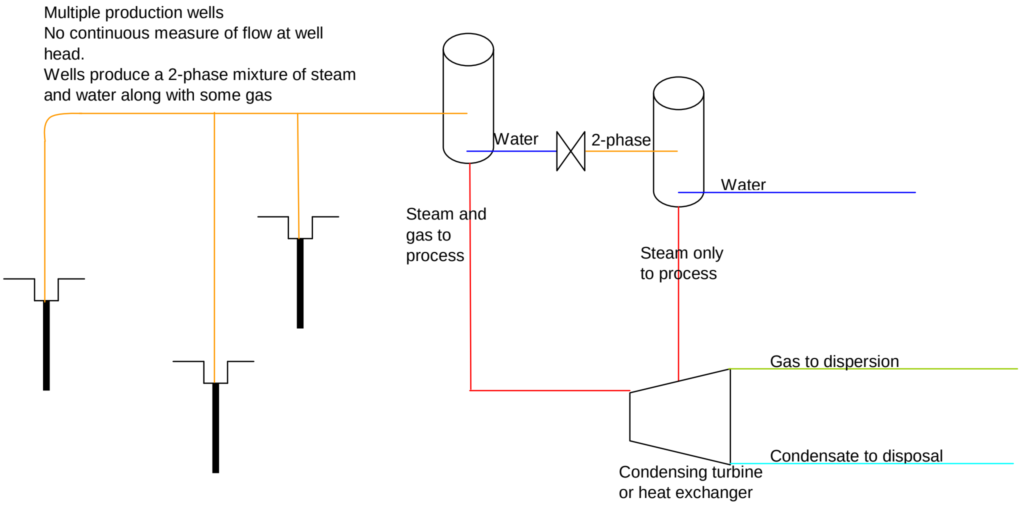

Figure 1: Simple schematic diagram of a geothermal development

In the early days of geothermal development, separators of steam and water were placed on each well head. These days, the more common practice is to have centralised separation plant receiving two-phase flow from the various production wells. **It is inappropriate to reference flows relative to (probably) non-existent well-head separators (Clause 18 (b)).**

There are no simple reliable ways of continuously monitoring quantities of two-phase flow from a well or in pipes. There are rough means of estimating relative contributions from various wells based on the injection of tracers from time-to-time. Accurate measure of flow is obtained after the separators when standard methods of steam and water flow measurement can be applied. **With this in mind it may be better to refer to measurement of flow at the separators rather than the well head (Clause 18 (a)).**

The separator works on centrifugal action. The heavy phase (water) is thrown to the outside then falls down the wall of the separator then out to the water collection system. The lighter phase moves inward then out through the steam pipe. In practice, this steam pipe collects both steam and non-condensable gas, since the gas is light compared to water. Only minute quantities of gas might flow out with the water.

In some cases, greater efficiency of resource use can be obtained by operating the supply of steam to the plant at multiple pressures. Water is dropped in pressure upstream of multiple separator vessels. The lower pressure causes more steam to “flash” off the water, allowing this lower pressure steam to be used in the process.

Note that as almost all of the gas would have been removed with the first stage of steam flashing, then subsequent steam will have trace gas in it. This will complicate the emissions factor in terms of CO_2-e per tonne of steam. It may be more correct to define the emissions factor in terms of the first stage of flashing only i.e. relate it to high pressure steam supply quantities only (but see later recommendation).

This may be complicated again by the fact that some wells may be directly connected to lower stages of flashing i.e. may operate at lower pressures. If this is the case then they could add gas to these lower pressure steam supplies. An alternative approach may be to simply define the emissions factor in terms of total fluid discharged, assessed by adding together all steam and water flows after the separators. **Note that the New Zealand Geothermal Association recommends that gas be measured relative to the total mass of fluid discharged from the reservoir rather than relative to a steam flow.**

Eventually steam is piped to turbines and associated condensers or to heat exchangers in binary cycle plant. The condensers or exchangers can accumulate the gas brought with the steam unless this is extracted. Standard practice is to lead this gas (predominantly CO_2) to the cooling tower for dispersal to atmosphere in the cooling tower plume.

Note that continuous measurement of flow of steam and water from the separators is undertaken routinely so does not involve any increment in cost. Measurement of gas flows is irregular.

Emissions Factors

It is unfortunate that the draft Regulations had not been progressed far enough to have wording associated with the option of unique emissions factors as outlined in the discussion document. The emissions factors (in terms of CO_2 equivalent emissions per tonne of steam) associated with particular geothermal developments are partly a function of the field, but also a function of the plant design, operating pressures and of particular sectors of the field already connected to the development (which can change with time) – see the appendix for a sample calculation. **The Association recognises the value of default factors as highly simplistic approximations, but supports the ability of developers to have these regularly adjusted where they clearly do not align with operating experience.**

In addition, as outlined above, we believe emissions factors (whether unique or default values) are better expressed in terms of total flow rather than some steam fraction. This type of emission factor is more a function of field than a steam-based factor which is influenced by the process.

There are clear difficulties in defining emissions factors for geothermal resources and these are partly alluded to in Schedule 2 Table 6 of the draft regulations which is repeated below.

Emissions source category	**Field**	**Emissions factor tCO_2-e/t**
Geothermal	Wairakei	0.00547
	Mokai	0.00644
	Ohaaki	0.04187
	Poihipi	0.00432
	Rotokawa	0.01942
	Ngawha	0.09552
	Kawerau	0.10240
	Tarawera	0.11655
	All other fields	0.04767

Firstly, in looking at this table, the Wairakei field includes both the Wairakei development and the Poihipi development. Thus the table already shows two values for the same field. The two Wairakei stations have previously drawn from different parts of the reservoir (with different properties), but there is already some linking of both stations through to Te Mihi.

I am not aware of any Tarawera field. There was an area licensed for geothermal exploration known as Tarawera Forest which included such specific fields as Tikorangi and possibly the upflow area of Kawerau. **There is probably a need to define the actual “fields” or “classes” more specifically.**

There are a number of unusual emissions factors in the table above. Most notably, Kawerau emissions factor appears higher than Ngawha. It is understood that Mighty River Power is making a separate submission showing that Kawerau emissions factor, at least for the 100MW Kawerau station should be about 0.02755 rather than 0.10240 i.e. about a quarter of that currently shown.

While the exact derivation of the default value for “all other fields” has not been given it appears to be almost a simple average of the various values in the table, heavily weighted by the non-existent Tarawera field and the erroneous Kawerau value, and without accounting for the very small total discharge associated with Ngawha. NZGA has previously provided figures which show the mass-weighted average emissions from New Zealand geothermal fields is about 100g CO_2/kWh of generation, which is a value almost exactly 1/6th that of Ngawha i.e. about 0.016 tCO_2-e/t. Alternatively, taking 100g CO_2/kWh of generation and using 7t of steam per MWh suggests the average figure for all fields should be about 0.014 tCO_2-e/t of steam. Either way it would appear that a **default value for all other fields should be closer to 0.015 tCO_2-e/t** i.e about 1/3rd that suggested in the table above.

The NZGA recommends that calculation of the default emissions parameters (for “all other fields”) be documented in tables and regulations.

Bearing in mind that we have recommended that emissions factors should be expressed in terms of total field emissions, **all factors should be restated as gas content in total fluid take**.

To avoid any implication of precision or consistency, however default emission factors are eventually defined, **the default emissions factors should not be given to more than two significant figures**.

Where developers choose to make assessments of their actual emissions, then they should have the freedom to develop rolling averages and determine frequencies of measurement.

The NZGA has seen a number of other draft submissions. **The NZGA supports the annual review and updating of default emissions factors, and suggests the inclusions of other factors for other fields as these are developed e.g. for Ngatamariki**.

The NZGA notes that other draft submissions oppose the need for regulatory changes to allow amendment of emissions factors, whether default or unique. **NZGA supports the concept of default and unique emissions factors sitting outside the Regulations**, to be administered by some responsible agency.

The regulations need to define whether the factors are forward looking or retrospective. **As a general principle, NZGA supports factors that closely match actual discharges**. Therefore, if measurements are made at the end of a period then factors which should apply would be the average of the beginning and end values.

Sampling of Gases

NZGA notes that regional councils are placing increasing obligations on developers to sample their fluids for gases (though normally focussed on H_2S). Approved methodologies use established sampling and analytical technology, developed for the purpose of geothermal field management, and could be adapted to the sampling for CO_2 or alkanes. Steam samples collected for the determination of gas concentrations are routinely taken at geothermal wells and at power plant inlets. Gas concentrations can also be measured in reinjection flows. The difference between these two flows logically yields the gas discharge to atmosphere.

Non-condensable gases sampling should be carried out in production wells and at the steam field-power plant (or heat plant) interface using ASTM Standard Practice E1675 for Sampling 2-Phase Geothermal Fluid for Purposes of Chemical Analysis (as applicable to sampling single phase steam only). The CO_2 and CH_4 sampling and analysis procedure consists of collecting non-condensable gas samples from the main steam line with glass flasks, filled with sodium hydroxide solution and additional chemicals to prevent oxidation. Hydrogen sulphide (H_2S) and carbon dioxide (CO_2) dissolve in the solvent while the residual compounds remain in their gaseous phase. The gas portion is then analyzed using gas chromatography to determine the content of the residuals including CH_4. All alkanes concentrations are reported in terms of methane. **The non-condensable gases sampling and analysis should be performed at least annually and more frequently, if necessary**.

Reinjection and Sequestration

It is noted that reinjection is standard practice internationally and is becoming so in New Zealand. The Te Mihi development that will replace the current Wairakei plant will use reinjection extensively as an example. There are several aspects of reinjection that need to be discussed in relation to the draft regulations.

Firstly, Clause 18 (c) specifies that the total number of tonnes of geothermal liquid re-injected into a geothermal field during the year should be recorded. While we have no objection to these measurements which would be undertaken routinely in the course of normal reservoir management and monitoring, this information is currently not relevant to the calculations of emissions so **injection flows should not be required under these regulations as currently drafted**. The formula suggested in Clause 19 (1) of the draft regulation takes no account of reinjected fluid in its calculation.

There may be some small quantities of gas reinjected with brines or cooling tower blow down. These are trace amounts but if they represent real reductions in the total emissions and the developers can justify measurements to assess them, then the developers should be given the option of making measurements and reducing the net assessed emissions and associated cost accordingly. This will require an adjustment of the formula in Clause 19 (1) and would require measurements of the various injection flows.

There may be a case for specifically monitoring the deliberate injection of gas for carbon capture and sequestration, for both the geothermal industry and for the gas production industry, then giving a credit for its injection. There is already significant reinjection of gas in the New Zealand gas industry (at one time it exceeded 10% of gross production) and there should reasonably be some credit for this carbon sequestration. Similarly, if some trials are made at injecting gas into geothermal fields then credit should also be given. There have not been any successful trials of gas injection in geothermal fields in the world to date but the option may still be of interest, especially if done on an out-field basis. Gas could possibly be injected at some depth in the well with pressures adequate to ensure redissolution. The concerns with such trials would be the risk of gas returning to production wells and then overloading existing gas extraction plant, or of the creation of acid conditions in the reinjection wells. While no developers may take up this option, it parallels practice in New Zealand gas and oil fields so ensures consistency.

In the case of geothermal energy there can be further applications for the gas. As an example at Mokai, trials are being made to strip H_2S from the predominantly CO_2 gas stream. If this trial is successful then some of the cleaned CO_2 will be delivered to nearby glass houses to displace manufactured and purchased CO_2. Effectively the glass houses will sequester a portion of the carbon. Production of clean CO_2 from the Mokai field will directly offset production and emission from the manufactured source. Credit should be available for this sort of application.

The final formula should be adjusted to bring these various factors into account.

Conclusion

We trust these comments are helpful, and would be happy to be involved in further discussion.

Yours faithfully

Brian White
Executive Officer
New Zealand Geothermal Association
Ph 0274 771 009 Email brian.white@eastharb.co.nz

Appendix 1: Illustration of the Effect of Changing Reservoir Characteristics and Various Operating Conditions on Emissions Factors

The overall enthalpy (heat content) of a field can change quite dramatically over time. In one field the enthalpy ranged between 1,100kJ/kg and 1,350kJ/kg over the space of 20 years. Even greater enthalpy swings are possible.

Let us say that the gas content from the field was constant but quite high at 0.5% of the total discharge, and was entirely composed of CO_2.

Further, let us look at two processes: one separating and receiving steam at 10bara pressure and the other separating and receiving at 7bara. Saturated steam properties are obtained from steam tables.

	Hf (kJ/kg)		Hfg (kJ/kg)		Dryness		%Gas in Steam	
Pressure	10bara	7bara	10bara	7bara	10bara	7bara	10bara	7bara
Enthalpy								
1100	763	697	2015	2066	16.7%	19.5%	3.0%	2.6%
1350	763	697	2015	2066	29.1%	31.6%	1.7%	1.6%

While the enthalpy change has not been major, the emission factor (gas in steam) has changed by 70% for the higher pressure process and 60% for the lower pressure process. In the light of these sorts of changes it is prudent for a developer to be able to adjust his emissions factor with time.

The calculations show that the emissions factor in terms of CO_2 emitted per tonne of steam produced is different for the two processes because of the differing amounts of steam flashed off the total flow. There will be several fields in New Zealand with quite different plant at multiple locations in the same field e.g. Wairakei (Te Mihi vs Poihipi), Rotokawa (existing binary plant vs Nga Awa Purua station under construction) and Kawerau (NTGA steam supply to the mills vs Kawerau station). While this effect is not as great as that of changing enthalpy, there is a case for differing emissions factors on the same field.