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Challenges of New Zealand Geothermal Legislation

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ABSTRACT

The current New Zealand geothermal legislation presents a challenge to the regulator and industry in New Zealand by having to work to legislation dating back to 1961, legislation which predates the geothermal industry expansion of the past decade.

A review of the current geothermal legislation is underway. The new legislation will need to cater to traditional domestic bore users, small business users, large industry and future geothermal industry developments and expansions.

The formation of the Worksafe New Zealand High Hazard Unit for Geothermal and Petroleum is one of several steps the government has initiated to raise the focus of geothermal industry regulation.

The New Zealand regulator has met with large industry, recognised geothermal industry bodies, regional councils and domestic councils to discuss working with traditional prescriptive legislation and modern non-prescriptive goal setting health and safety legislation.

Going forward, the commitment is to have New Zealand geothermal regulation in line with recognised international geothermal regulatory authorities.

1. INTRODUCTION

The New Zealand health & safety landscape is in the midst of one of its biggest updates yet. With the Pike River Royal Commission and an Independent Taskforce on Workplace Health and Safety, changes including a new regulator WorkSafe New Zealand, and a greater focus in which the regulator, workers and companies all have responsibilities for appropriate outcomes are being brought to fruition. With this overhaul the many regulations affected by this update in New Zealand's health and safety in employment (HSE) environment are being looked at and aligned with the *Health and Safety Reform Bill* being worked on within the Ministry of Business, Employment and Innovation (MBIE).

Assessing the current state of the regulatory environment around the use of geothermal energy involves looking at what is needed to reflect the current state of the industry; current health and safety best practice, managing hazards associated with geothermal development, and looking toward what a future set of geothermal regulations would require to stay relevant in their application to wider geothermal industry use.

2. BACKGROUND

2.1 Background of New Zealand's Geothermal Industry

Like Japan, the Philippines and the United States, New Zealand has a landmass situated on the Pacific Rim, with an easily accessible and large wet geothermal energy resource located in what is known as the Taupo Volcanic Zone (TVZ). It wasn't until the 1950's that the New Zealand Government started development of the first geothermal power plant to exploit the geothermal resource at Wairakei, north of Taupo. The impetus for this development came in 1947 from severe electricity shortages following two dry years which restricted hydro electricity generation, and a desire by the Government for the New Zealand electricity supply to be independent of imported fuel.

In 1989 the sole user of the Wairakei steam field, ECNZ with subsidiary Trans Power New Zealand Limited were split up by the Ministers of Commerce and Energy. The separation of transmission and generation assets and the separation of Trans Power New Zealand Limited into a separate company came into effect. Through privatisation energy generation companies were created and allocated a mix of hydro and geothermal power stations.

2.2 Geothermal Electricity Generation

Those initial electricity companies' assets are now resident in the mix of electricity generation assets that Contact Energy (a private generator-retailer) and Mighty River Power (a mixed ownership generator-retailer) control. Both of which are the principal sources of recent projects.

There are also several developers outside of these two large energy companies including Bay of Plenty Energy, Top Energy and Maori Land Trusts e.g. Tuaropaki, Tauhara North No 2 and Geothermal Developments Ltd. In New Zealand, the biggest industrial use of geothermal energy is for the production of electricity.

With demand for energy reducing recently, drilling requirements ahead for the industry will mainly comprise work overs, abandonments, maintenance and current well operations. Utilisation of these available bores will most likely occur if demand for electricity rises above current generation capacity limits allowing economic development to become viable again.

Geothermal bores drilled prior to 2000 were predominantly to depths of 700m to 1800m; were vertical, and drilled with relatively small drilling rigs. The bores drilled between 2000 and 2013 were predominantly drilled to depths between 1800m and 3000m; were mostly directional wells, and were drilled with drilling rigs of two to three times the size of the earlier rigs (Hole, 2013). Directional drilling (or slant drilling) is the practice for drilling non-vertical wells.

2.3 Geothermal Direct Use Applications

Direct or non-electric use of geothermal energy refers to the immediate use of the energy for both heating and cooling applications. Industrial direct use of the geothermal resource has historically been centered in the Taupo and Kawerau regions of the Taupo Volcanic Zone. Alongside large scale electricity generation, industrial direct use has existed since the late 1950's, while commercial use has been rolled out over the past 25 years.

Smaller direct use applications are found in both the North and South Islands. The most common application is for bathing, with space and water heating to a lesser extent, and occasional direct use for frost protection and irrigation (Candra & Zarrouk, 2013; Climo & Hall, 2013; Harvey et al, 2010).

The diversity and level of use increases for higher temperature resources found in the TVZ, including greenhouse heating, prawn farming, glasshouse heating, kiln drying and a special tourism development. Geothermal direct use in New Zealand is dominated by the major industrial supply at Kawerau for geothermal direct use. New Zealand's largest geothermal direct user in Kawerau is the Norske Skog Tasman pulp and paper plant.

2.4 Legislative Framework

The principle statute concerning geothermal development was the *Geothermal Energy Act 1953* (GE Act), enacted at a time when facilitating energy development was a paramount objective of the Government. Both the GE Act and the associated *Geothermal Energy Regulations 1961* were founding documents on which geothermal development was based. In 1991 with the introduction of the *Resource Management Act 1991* (RM Act) and then the *Health and Safety in Employment Act 1992* (HSE Act) following soon after in 1992, they devastated the geothermal legislative setting. The HSE Act fully repealed the GE Act, while the RM Act stripped most of the clauses from the Regulations.

2.4.1 Geothermal Energy Act 1953

The *Geothermal Energy Act 1953*, had energy development, not conservation of the geothermal resources as its guiding objective. The Minister had the power to authorise access to any land for the purpose of survey or drilling, and the Governor-General had the power to take land under the *Public Works Act* for electricity generation or certain industrial purposes. A provision was made in the GE Act for establishment of Regulations, these followed in 1961, with the creation of the *Geothermal Energy Regulations 1961*.

The GE Act was the first piece of legislation in New Zealand to provide a definition of "geothermal energy". Geothermal energy originally meant "*energy derived or derivable from and produced within the earth by natural heat phenomenon; and includes all steam, water, and water vapour, and every mixture of all or any of them that has been heated [by such energy], and every kind of matter derived from a bore and for the time being with or in any such steam, water, water vapour, or mixture [; but does not include water that has been heated by such energy to a temperature not exceeding 70°C]*".

2.4.2 Water and Soil Conservation Act 1967

The *Water and Soil Conservation Act 1967* incorporated a definition for geothermal water. The Act had primacy over the GE Act in that water rights for taking and using the geothermal water were required for the license for using the geothermal energy, provided by the GE Act. Water rights were required for re-injection of fluid back into the geothermal field as this was considered to be *'discharging into natural water'*.

2.4.3 Rotorua City Geothermal Energy Empowering Act 1967

The *Rotorua City Geothermal Energy Empowering Act 1967* is the only piece of current legislation to still be in use using a definition for "Geothermal Works" and the definition for "Geothermal Energy" from the GE Act rather than the RM Act (but it does not keep the 70°C temperature limit). "Geothermal works" includes "any work or works established or constructed, whether finally completed or not, for the investigation, development, supply, and utilisation of geothermal energy, the prevention or disposal of waste, the disposal of water, steam or any other product arising from the development, reticulation, supply, or utilisation of geothermal energy, and any work or works from time to time deemed necessary by the Council for the safe and efficient control of the supply and utilisation of geothermal energy; and also includes all plant, apparatus, appliances, and materials comprising part of any geothermal work or works."

2.4.4 Crown Minerals Act 1991

The petroleum and coal mining industries are both covered by the *Crown Minerals Act 1991* (CM Act) which covers both resource allocation and health and safety. Geothermal energy by contrast was regarded as an attribute of water rather than something to be mined. Consequently it has not been covered by the CM Act (White, 2013).

2.4.5 Resource Management Act 1991

A large number of laws are used to govern the protection of the environment and the allocation of resources. These were pulled together under the Resource Management Act 1991 which has the purpose "to promote the sustainable management of natural and physical resources." It uses a devolved regulatory model, with local government being responsible for its implementation. It allocates resources and controls resource use. The passing of this Act led to the repeal of many of the clauses in both the GE Act and the associated *Geothermal Energy Regulations 1961.*

The RM Act finally repealed the two different pieces of legislation the Water and Soil Conservation Act and the GE Act's ability to grant licenses and aligned the two definitions "geothermal energy" and "geothermal water" under the RM Act. Geothermal energy means "energy derived or derivable from and produced within the earth by natural heat phenomena; and includes all geothermal water". While geothermal water means "water heated within the earth by natural phenomena to a temperature of 30°C or more; and includes all steam, water, and water vapour, and every mixture of all or any of them that has been heated by natural phenomena". The RM Act includes a lower temperature limit of 30°C to capture all bores drilled in New Zealand, to better manage the resource and the environmental effects.

2.4.6 Health and Safety in Employment Act 1992

Similarly, many laws were pulled together under the *Health and Safety in Employment Act 1992* and it was this Act that fully repealed the GE Act for which the remaining clauses covered health and safety aspects. The HSE Act promotes the prevention of harm to all employees, placing obligations on the employers to achieve this through a duty to "take all practicable steps" of which duties extend through regulations.

The Passing of the HSE Act and consequent revocation of the GE Act meant that the remaining clauses in the *Geothermal Energy Regulations 1961* lost much of their context. Section 24 of the HSE Act saved the regulations, and enables them to be amended under this Act.

2.4.7 Hazardous Substances and New Organisms Act 1996

The purpose of the Hazardous Substances and New Organisms Act 1996 (HSNO Act) is to protect the environment, and health and safety of people and communities, by preventing or managing the adverse effects of hazardous substances and new organisms. In its relation to geothermal development it covers the use and storage of hydrocarbon refrigerants in binary cycle processes at geothermal power plants. The binary cycle process is when a geothermal resource temperature is below 180°C, a secondary cycle using a low boiling point fluid, such a isobutene, isopentane or an ammonia-water mixture, is used to flash to steam, driving the binary plants turbine (for more detail see section 4.3).

2.4.8 Regional Plans

At the local government level, Environment Waikato's Regional Policy Statement and its Regional Plan with respect to geothermal development have been recently revised. The Statement directs the form and content of a Regional Plan which is the key planning document under the RM Act. These documents enable developers to identify resources that can be readily developed and target their attention accordingly. Environment Bay of Plenty is now looking at the revision of their Rotorua Geothermal Regional Plan after the 2nd generation Regional Policy Statement became operative in October 2013.

2.4.9 Rotorua District Council Geothermal Safety Bylaw 2008

The objectives of the bylaw are twofold. The safety of the general public from the effects of Hydrogen Sulphide gas (H_2S) so far as is practically possible and the safe operation of and proper maintenance of the headworks, associated pipework and plant of geothermal production, and re-injection bores. It has a definition of "geothermal energy", similar to the RM Act, and also definitions for "geothermal extraction" and "geothermal fluid" not found in any other New Zealand law. It also more broadly defines "geothermal work" which encompasses far more than any other definition be it "works or work" from the *Rotorua City Geothermal Energy Empowering Act 1967* and the *Geothermal Energy Regulations 1961*.

Geothermal work is defined as "any work or operation connected in any way with the boring, sinking, drilling, making or maintenance of any well and includes all buildings, plant, machinery, and fittings associated with any such well; and includes every such well; but in respect of any such well that has been brought in and is under control, and has had installed a wellhead master valve, does not include any pipes or fittings beyond the well-head master valve, nor anything connected with the use of geothermal energy beyond the well-head master valve; and, in respect of any such well that has been brought in and is under control, but which has no well-head master valve, does not include any pipes or fittings above ground."

2.4.10 Specific Regulations / Standards

This section notes the relevant regulations and standards that have developed under the legislative framework, this includes:

The *Geothermal Energy Regulations 1961* – detailed in the next section.

Health and Safety in Employment (Pressure Equipment, Cranes and Passenger Ropeways) Regulations 1999 (PECPR Regulations) – these general regulations from a geothermal perspective cover pipes, valves and pressure vessels. These also cover use of refrigerants such as the hydrocarbon refrigerants used in a binary cycle plant. One effect of these regulations is to tie design done under international codes of practice back to New Zealand legislation.

Hazardous Substances (Classes 1 to 5 Controls) Regulations 2001 – these regulations cover controls that may apply to the use, handling, and storage of explosive, flammable, and oxidising substances that may be used in geothermal drilling or power production activities.

Hazardous Substances (Classes 6, 8, and 9 Controls) Regulations 2001 – these regulations cover controls that may apply to the use, handling, and storage of toxic, corrosive, and ecotoxic substances that may be used in geothermal drilling or power production activities.

NZS 2403:1991 Code of Practice for Deep Geothermal Wells – covers the deep wells typically associated with geothermal power or industrial direct use projects. It includes 7 parts: general; well design; well sites; drilling equipment, tools and materials; drilling practices; operation and maintenance of wells; and abandonment of wells. It makes frequent reference to American Petroleum Institute (API) standards, which are widely used by operators of drilling rigs and production facilities in the upstream petroleum sector. Industry representatives are currently reviewing this Code of Practice.

NZS 2402P:1987 Code of Practice for Geothermal Heating Equipment – covers the shallow wells associated with Rotorua's domestic home heating equipment that uses geothermal energy and water as heat sources.

Health and Safety Guidelines for Shallow Geothermal Wells 1996 – covers shallow wells typical of domestic applications. The guidelines set techniques but do not preclude the use of alternative techniques based on sound data and engineering.

Health and Safety Guidelines for Self-Management of Shallow Geothermal Bore Systems 2005 – this covers compliance and requirements that owners operating and managing shallow bore systems should follow, from construction to abandonment.

In the list above, the Code of Practice for Deep Geothermal Wells, is central to the industry. It was developed to preserve details of geothermal drilling experience and specifically designed to include details of methods, procedures, formula and design data which drilling engineers, having experience only in the oil industry, could not be expected to be familiar with (Bolton et al, 1990). At the time of this paper being prepared, Standards New Zealand had formed a committee to review the NZS2403:1991 Code of Practice for Deep Geothermal Wells to bring this in line with current techniques in use. The committee is compiled of representatives from the geothermal industry, Regulatory bodies and Standards New Zealand.

3. GEOTHERMAL ENERGY REGULATIONS 1961

3.1 Focus

The *Geothermal Energy Regulations 1961* are of a prescriptive form, typical of regulations before the "Robens" regulatory model was developed. The regulations focus is in managing the safety and drilling provisions for shallow bore systems in the Taupo Volcanic Zone. This is evident from the inclusion of a definition of "geothermal work" that is significantly different to the meaning of "Geothermal works" under the Geothermal Energy Act.

3.2 Content of the Geothermal Energy Regulations 1961

Over time, eleven of the 36 clauses (plus various sub clauses) of the regulations have been revoked as provisions of the GE Act were covered by other Acts. To provide clarity to industry the Worksafe New Zealand High Hazard Unit Guidance on Geothermal Notification has been prepared which clearly sets out the regulators expectations on industry. The guidance document interprets the remaining content of the Geothermal Regulations 1961. The Guidance document is located on the Worksafe New Zealand High Hazard website.

3.3 Gap Analysis

The *Geothermal Energy Regulations 1961* currently fail to adequately codify industry best practice and modern well operations. Because of this inadequacy the regulations leave a lot to be desired from both the industry's perspective and the regulators' perspective. This section deals solely with the 'gaps' found in the regulations, from a health and safety point of view (the next section identifies the legal issues with the regulations), identifying the major hazards and associated practices where the regulations fall short of providing sufficient rules.

The gaps found in the regulations, have primarily come about due to these reasons:

The overriding GE Act that the regulations originally supplemented has been repealed by the HSE Act and the RM Act.

The prescriptive nature of the regulations, dropped afterwards in favour of a superior Reuben's model approach as in the HSE Act and in the *Health and Safety Reform Bill*.

That the focus was originally on shallow geothermal bores, rather than deep geothermal bores (a distinction detailed below) and not at all relevant to engineered/enhanced geothermal systems (EGS).

The impact from the reasons above is quite large as measured by the amount of revoked and unnecessary sections still in the regulations. What's left is a very narrow safety focus that the regulations do administer. This is where the gaps appear. The regulations clarify health and safety for four scenarios and for bores and drilling. The four scenarios are in regulations 26-29; safety of geothermal work, safety and first-aid equipment, precautions against hazardous gases and the use of explosives. Regulations 31-35 deal with particular bore and drilling provisions. The Worksafe New Zealand High Hazard Guidance on Geothermal Notifications clarifies specific guidance for dangerous incidents requiring notification, these include: general health and safety, bores, pipelines, safety critical equipment, release of geothermal hydrocarbon, fire or explosions, the release or escape of dangerous substances, well collapses, and subsidence or collapse of seabed/ground.

4. THE MAIN HAZARDS ASSOCIATED WITH GEOTHERMAL WORKS

The particular hazards are, but are not limited to:

Well blowouts and casing failures.

Well discharge presenting dangerous Hydrogen Sulphide gas (H_2S), or Carbon Dioxide gas (CO_2) clouds.

Binary cycle plant (concerning the level of hydrocarbons on site).

Pressure equipment.

Hydrothermal eruptions.

4.1 Well Blowouts

The first of these is a hazard inherent around any drilling rig, which is that there is a possibility of a well blowout. A blowout is defined as an "uncontrolled flow of steam, water, gas or rock material at the ground-surface – either inside the well or escaping from the well at depth." Measures to prevent, or mitigate the consequences of, a well blowout are not adequately covered by current regulations (NZS2403:1991). The New Zealand geothermal industry willingly works under this Code of Practice and is actively cooperating on improvements and updates to it.

4.1.1 Casing Failures

A modern problem not covered under the definition of well blowouts, is of casing failures occurring at depth beneath the surface of the earth. This decreases the integrity of the well and its production efficiency and may pose a risk to safety if a surface blowout was to happen as a result of the compromised bore. It is nonetheless a drilling issue to be aware of, as this occurs with higher frequency then surface wellhead failures (See Southon 2005, Hole 2013).

4.2 Well discharge

The current *Geothermal Energy Regulations 1961* cover the discharge of wells. The regulations offer a broad prescription stating that "(1) Geothermal works shall be designed in such a manner that, as far as practicable, the accumulation of hazardous gases is prevented". Nowhere does it detail the potential hazardous gases of hydrogen sulphide and carbon dioxide that could occur on site or reference any best practice. H_2S has the properties: colourless, flammable, heavier than air, and rapidly dispersed by wind or air movement. Carbon dioxide gas (CO_2) is colourless and odourless. It is non-flammable and heavier than air with a potential to accumulate in confined spaces or areas below ground level.

4.3 Binary Cycle Plant

The risk associated with geothermal binary cycle plants in operation stems from the inventory of hydrocarbon on site. This technology is currently covered by the PECPR Regulations and HSNO Act.

4.4 Pressure Equipment

In addition to the conventional construction and industrial type accidents met in most engineering developments, geothermal production requires the extensive use of pressure vessels – pipes, valves, separators, pressure relief devices, etc. including casing and drill pipe through to power plant equipment.

These dangers are currently covered under the *Geothermal Energy Regulations 1961,* the Code of Practice for Deep Geothermal Wells and the Health and Safety Guidelines for Shallow Geothermal Wells.

General pipes and pressure vessels are designed to usual codes, and deal with relatively low pressure steam applications, compared to pressures generated in steam boilers. Consequently, risk associated with this plant is less than at other steam plants. The PECPR regulations cross-reference AS4343 Pressure Equipment Hazard Levels; this standard provides a rational and consistent approach to storage and handling of all fluid types and covers all hardware downstream of the well (White 2013).

4.5 Hydrothermal Eruptions

Hydrothermal eruption remains a unique possibility in the geothermal sector and this may be at a location remote from the constructed facilities. Hydrothermal eruptions can occur naturally, but can also be triggered by reservoir changes due to development (Bixley & Browne, 1988). A consideration of the level of risk associated with hydrothermal eruptions indicates that PECPR and well site regulation is probably not enough. Major damage or loss of life could result far away from the installed and operated equipment. This provides a possible case for a coordinated emergency management response and what may be a simplified safety case. In the event of a hydrothermal eruption, independent of the cause of an eruption, a field operator supported by their engineers and scientists, would be well-placed to advise emergency services on a technical response e.g. should the eruption crater be flooded with water or should nearby wells be shut in to manage the ongoing risk (White 2013).

5. THE LEGAL ISSUES

This section notes the legal gaps in the *Geothermal Energy Regulations 1961*. The regulator and duty holders are faced with a number of choices as they try to interpret the *Geothermal Energy Regulations 1961*, as many clauses have lost their context. Now that the Geothermal Energy Act no longer applies to the Regulations, in a legal sense should they sit under the HSE Act as it is the overarching legislation for all health and safety regulation. Currently due to the older style of regulation the Regulations sit alongside the HSE Act in certain circumstances, not under. This is an issue that could lead to confusion.

In practice, the Chief Geothermal Inspector's effort is directed at making sure directors and senior managers are aware of their health and safety obligations, rather than ensuring that each bore and "geothermal work" is fit for purpose. Inspectors have distilled rigorous information requirements set out in the regulations into Details of Works Notices (DOWNs applications) and these are enforced (White 2013).

The Regulations were saved by section 24 of the HSE Act which enables them to be amended under the HSE Act as well. Due to their age and legislative history, there are a number of problems with the regulations. These problems mean that, should WorkSafe or MBIE seek to enforce the regulations, there is a greater possibility of challenge of MBIE's or WorkSafe's actions.

5.1 Problems

Some of the obvious problems include:

Old assumptions about the presence of Ministry of Works engineers or Department of Scientific and Industrial Research scientists should be eliminated, and a simpler reference to WorkSafe should be made.

There are aspects of the regulations that are outdated. For example, the regulations place obligations on holders of "licences" and "authorities" under the GE Act, and any reference to rentals should be removed from regulations. Licensing and rental clauses are not applied, in practice, these licences clauses should probably have been revoked when the RM Act was passed (See Appendix 1, section 2 for an in-depth legal discussion on this matter).

The fines outlined in the current regulations have little deterrent effect. It would be better that the regulations stayed silent on penalties so that the penalties of the HSE Act could take precedence.

Some terms are not clear. For example, the regulations refer to the Minister, but it is not clear which Minister this is. "WorkSafe" has replaced the former definition of "Secretary" except in clause 14B, which refers to the "secretary" but now means the CE of MBIE responsible for setting intervals for paying rentals under that regulation.

Some of the powers in the regulations do not rest with the appropriate authority. For example, a consent authority under the RM Act.

There should be no reference to land acquisition since all land negotiations are on a willing buyer-willing seller or willing lease arrangement. These are also commercial matters irrelevant to health and safety considerations.

These issues mean that should Worksafe New Zealand seek to enforce the regulations, there is a greater possibility of challenge of their actions.

6. TOPICS TO CONSIDER IN ANY FUTURE UPDATE

The following section looks at the many different topics and approaches to updating the *Geothermal Energy Regulation 1961*. This is a preliminary format, as such the sections are brief and include only an introduction to the options that have been considered; it is not an in-depth analysis of the topics and approaches. The subsections here are in no way the only options available. The subsections look at four approaches:

The first, how a set of future regulations could use the *HSE (Petroleum Exploration and Extraction) Regulations 2013* approach to make it easier for health and safety best practice and drilling practice to be consolidated over the two very similar industries.

Looking at whether a safety case or major accident prevention policy approach to the health and safety of the hazards mentioned above is a viable option.

The regulations don't cover the whole cycle of drilling practice that the NZS2403 does. The regulations could be expanded to codify the life cycle of geothermal drilling operations, from design to abandonment and decommissioning.

The need for a tailored design of the regulations focusing on shallow bore systems, hazards and the need for inclusion of regulation for deep geothermal bores and engineered geothermal systems (EGS).

The HSE (PEE) regulations have brought new "goal-setting" health and safety regulation to the upstream petroleum sector in the form of a safety case regime.

6.1 HSE (PEE) Regulations Approach

This describes how the approach to regulating geothermal energy or geothermal drilling operations could mimic the *Health and Safety in Employment (Petroleum Exploration and Extraction) Regulations 2013* (HSE (PEE) Regulations) and consequently fully align with the *Health and Safety Reform Bill*. The HSE (PEE) Regulations are the latest regulations to cover both onshore and offshore petroleum drilling and production operations. Geothermal drilling operations are all based on land and nearly all occur in the Taupo Volcanic Zone.

The Geothermal Energy Regulations 1961 lack many of the newer and finer points of detail found in the HSE (PEE) regulations, but it is worthwhile to look at the HSE (PEE) Regulations as a possible model for any future geothermal industry regulation. The initial thought is of straight adoption. The problem with wholesale adoption of the petroleum regulations to the less hazardous geothermal industry is that the costs of implementing the framework applied to petroleum operations will be higher in relation to the benefits. The geothermal industry drilling regime is similar to the petroleum industries, as emphasised by the many API standards that are used in practice and referenced in NZS2403:1991 but is less hazardous.

6.2 Safety Case, Emergency Management Plans and Major Accident Prevention Policy

This subsection highlights what the inclusion of process regulation in the form of safety case implementation and emergency management plans could mean for deep geothermal drilling operations and shallow bore direct use operators.

Current emergency management involves System Management Plans (SMPs) must be developed as a requirement of the Regional Plans under the RM Act. These SMPs cover issues exemplified by co-ordinated incident management systems. Unfortunately, while these set out responses in a range of emergencies (tsunami, earthquake, volcanic eruption, etc.) they do not cover specific geothermal risks like blowouts, hydrothermal eruptions or dangerous gas clouds.

Through the precedent set by the HSE (PEE) Regulations safety case regimes can be looked at in their application to the geothermal industry. Under the HSE (PEE) Regulations, operators of drilling rigs and production facilities (onshore and offshore) are required to prepare a safety case, which must be accepted by WorkSafe before operations commence. The safety case sets out the control measures that have been (or will be) implemented by the operator to prevent and mitigate the effects of all potential major accident hazards and must demonstrate that the risks associated with those hazards have been minimised to a level that is as low as reasonably practicable. The safety case regime does not apply to onshore production facilities with smaller production rates and/or smaller stores of liquefied flammable gases on-site (‘lower-tier production installations’). A major accident means an event connected with an installation, including a natural event, having the potential to cause multiple fatalities of persons on or near the installation.

If this regime is applied to geothermal drilling, then there may be a case to exempt drilling rigs carrying out lower-risk shallow well operations. Given the small costs associated with shallow well development (typically in the order of $20,000), introduction of a safety case regime to this activity (and its associated costs) could be detrimental to small-scale geothermal development. Incorporating the Health and Safety Guidelines for Shallow Geothermal Wells 1996 into future regulations or giving them more legal weight by creating a code of practice would seem more appropriate to this scale of industry. Overall there is a basis for lesser documentation, but allowing detail levels that match scale and risk, including emergency management systems could be created with schedules to be completed for specific projects or companies.

A safety case regime (or similar) would not be so detrimental to deep geothermal drilling, given the significant costs associated with those operations. Typical deep bores drilled in 2013 cost approximately NZ$8.5 million (Hole 2013).

The HSE (PEE) regulations require lower-tier production installations to prepare a ‘major accident prevention policy’ in lieu of a safety case. To be classified as a lower-tier production installation, a site must meet the following criteria:

> “the actual or expected average oil production over any continuous 12-month period is below 820 barrels per day; and
>
> the actual or expected average net gas production over any continuous 12-month period is below 15 million standard cubic feet of gas per day; and
>
> the amount of liquefied flammable gases (including liquefied petroleum gas and natural gas) that is or is likely to be at the installation does not, at any time, exceed 50 tonnes” (HSE (PEE) Regulations 2013, p.8)”

The first two criteria would not be applicable to geothermal operations, but the third (c) could. Concerning binary cycle plant use on a geothermal installation, a certain amount of hydrocarbon has to be present for it to operate optimally. A 20MW binary cycle plant could have an inventory of around 100 tonnes of hydrocarbon (White 2013). This is double the limit for a petroleum lower-tier production installation, so comparative geothermal facilities would by this criterion need a safety case.

6.2.1 Notification of Dangerous Occurrences

Any future regulations should refine and provide guidance for the notification and reporting of incidents, which in different circumstances, could lead to a major accident. The HSE (PEE) Regulations precedent could be copied to cover all drilling practice and make it particularly easy to follow for all drilling operators to know their reporting requirements.

6.3 Codifying Practice over the Full Life Cycle of a Geothermal Bore

Safety starts at the design phase of a project. Equipment is designed to accepted codes using sound engineering practice by competent engineers. This is current practice in the geothermal industry. A future set of regulations would be the best place to incorporate the current Code of Practice for Deep Geothermal Wells, to codify all industrial geothermal projects from design to abandonment.

The Code of Practice is a key document in the design of a well, but it lacks the necessary health and safety focus that would completely cover the life cycle of a geothermal well. Any future regulations could broadly address, right from the design phase the identifiable hazards along every step of a geothermal well drilling project from initial design to final abandonment. This would allow capture of any hazards potentially capable of harm throughout any future EGS systems as well. The ability for identification and assessment of hazards along with established and monitored principles for safe design, construction, and maintenance right to the abandonment of wells would be an ideal aim of a future update.

6.3.1 Testing

Well testing is something innately risky in the drilling industry. Completion testing of a well is when the most risk intensive set of tests are performed. These are carried out after drilling is completed but prior to the running of the perforated liner. After the perforated liner has been run, the hole is safe, and therefore the risk significantly reduced (Hole, 2013). Testing should be something looked at in any future regulation. It would dovetail with the goal setting approach the HSE (PEE) regulations have taken and be included as part of an independent well examination scheme copied from the HSE (PEE) Regulations.

There is a broad case for inclusion of regulation to cover the full life cycle of a deep geothermal well, while the case is less clear cut for shallow wells. The life cycle of a shallow geothermal well is significantly less risky due to the reasons raised above in this report, and so to include a more tailored approach for geothermal wells involving different levels of regulation based on the wells design specification (i.e. for drilling and testing) is looked at below.

6.4 Tailoring for different Bore Use and Industry

This is the main concern – the regulations are not fit for their current purpose. To address this problem, any new geothermal regulations need to have in mind that the industry is both large scale, high cost and at the other end very small scale, low cost. EGS will become commercially viable over the next decade or so and the regulations have to keep in mind the even larger scale of operation this may entail. These systems are in need of future research to fully understand their viability in New Zealand, and impact on workplace health and safety.

To cover deep geothermal bore operations and the associated hazards, a tailored approach focusing on large scale operations needs to be looked at for future inclusion. This approach can be applied to the two other sectors; small scale shallow bores and advanced drilling operations (i.e. EGS). Shallow geothermal bore regulation should ideally be far less intensive to match the level of risk. Enhanced geothermal systems outlined in the former Ministry of Economic Development (2010) report show that the operations are still in their infancy and the potential hazards from drilling deeper are not yet fully understood.

The next stage of review should aim to identify suitable differences between the bores, and a classification of geothermal drilling (either geothermal work or energy) based on either depth, temperature or enthalpy. This can be used to differentiate the two scales of industry as has similarly been done in the HSE (PEE) Regulations.

7. CONCLUSION

Two of the identified health and safety hazards associated with the geothermal industry are power plants and pressure equipment. Basic occupational health and safety are already covered by the range of HSE legislation; the state of the industry, its background and its current future outlook has been identified; the legal issues associated with what is left in the Regulations has been outlined and future policy questions noted.

Through collating a broad range of information relating to the New Zealand geothermal industry and the geothermal energy regulatory environment, we can understand that the new *Health and Safety Reform Bill* aims to protect workers from incidents that would seem to have a low-frequency-high consequence rate, incidents requiring process safety is the key to any future update of the geothermal energy regulations. The HSE (PEE) regulations provide a benchmark for the geothermal industry to be judged against while the topics left open for greater discussion in the next phase of the review can be looked at as the basic issues that need to be addressed. This is alongside the incorporation of regulation to safely guard the industries workforce from the specific hazards of the geothermal working environment.

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