Geothermal Sustainability Regulation in Iceland and New Zealand

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ABSTRACT

Geothermal energy is a clean and renewable energy resource. In many countries with naturally occurring hydrothermal resources (like Iceland) geothermal power plants have been successfully generating for more than 50 years. In an earlier publication (IRENA, 2015) the geothermal regulation in 4 countries were compared (Chile, New Zealand, Philippines and Kenya). One of the conclusions was a marked difference in the regulation around 'sustainability' and use/management of geothermal resources. Iceland is also a country with a large history of geothermal regulation and strong history of sustainable regulation and monitoring. This article focuses on both Iceland and New Zealand's geothermal regulation and specifically on the processes to manage sustainability, assess, 'prove' and report on geothermal resources.

1. INTRODUCTION

Geothermal energy is seen as a sustainable and reliable source of power generation with substantial unlocked potential in many countries around the world. However, as many authors have pointed out (incl IRENA, 2015; Lawless et.al., 2016) most commercial geothermal power plants around the world use the geothermal resource at a greater rate than 'natural recharge;, meaning the geothermal systems generally deplete at a certain rate, although after 'laying a system fallow' it will generally recharge in a similar timeframe as its use (i.e. human timescale). Terms of 'strong' and 'weak' sustainability have been discussed (incl Luketina, 2010) and Axelsson (2010) suggested a 4-point-scale of different levels of sustainability of geothermal use.

In the end, geothermal projects and their sustainable use, are implemented in different regulatory contexts. As outlined in IRENA (2015) this regulation and the definition, implementation and monitoring of sustainability differs markedly across jurisdictions (incl the four described in detail: NZ, Chile, Kenya & Philippines), with NZ having quite a strong sustainability framework. Iceland is also known as a country with extensive geothermal resources, project experience and sustainability regulation.

The aim of this article is to compare NZ and Iceland regulation and derive potential lessons. To do this, first some background regulation (ownership, electricity market, environmental regulation) needs to be described. A similar framework is used as in the IRENA/Geothermal Institute-2015 studies:

- New Zealand: public resource ownership; private and state-owned developers; experienced with ca. 1,000 MWe installed;
- Iceland: mixed public and private resource ownership; private and state-owned developers; experienced with ca. 670 MWe installed;

2. NEW ZEALAND

The majority of New Zealand's geothermal resources are located strategically in the Central North Island and geothermal power has been a significant part of its generation matrix since the 1950s, providing 17.2% of annual generation by 2015 (MBIE, 2015). They also provide significant direct heat for pulp-and-paper, dairy, agriculture and fishery industries, and for use in residential and commercial buildings, as well as hot pools and tourist attractions. It has been analysed as one of the most economic new sources of electricity generation for New Zealand, as gas prices have risen and most hydro power sites have been tapped (MED, 2011).

2.1 Resource ownership and access

In New Zealand, legal ownership of minerals, water and geothermal resources are treated as separate from land ownership, i.e. the landowner is not the automatic owner of the resources on or under the land. However, whereas most minerals (notably petroleum, gold, silver, coal and iron sands) are property of the Crown (Crown Minerals Act, 1991), water and geothermal resources are treated differently and their ownership is an issue of some historical contention. Geothermal resources were first regulated through the Geothermal Energy Act 1953 and the Geothermal Energy Regulations 1961, which stated that "the sole right to tap, take, use and apply geothermal energy on or under the land shall vest in the Crown, whether the land has been alienated from

the Crown or not" (Section 3 (1) cited in Malafeh, 2013). Maori traditional water rights were recognized to some extent. However, the Act and Regulations were recognized as providing little legal control over the sustainable use of geothermal water or protection of surrounding ecosystems. In 1967 the Water and Soil Conservation Act (WSCA) introduced a system of water rights (including geothermal water).

The Resource Management Act 1991 (RMA) is a wide-ranging act that regulates access to natural and physical resources such as land, air and water, with sustainable management of these resources being the overriding goal. The RMA is now the principal legislation controlling the use of geothermal resources in New Zealand, replacing most previous acts. It introduced a similar structure of resource consents to the WSCA-1967, but covering a wider area of 'impacts' including resource off-take and disposal/re-injection, emissions to air and water, and ecosystem and community impacts. By maintaining the main structure of the WSCA, geothermal energy in New Zealand is effectively regulated as a water resource, with the main consenting criteria defined in tonnes of water/liquid volume per day/year (rather than GJ or MWe). Geothermal regulation in New Zealand is therefore more water-resource than energy based.

The 'nationalisation' under the 1953 Geothermal Energy Act and subsequent legislation, was contentious and indigenous Maori people/tribes in some cases claim the ownership of these resources in terms of Kaitiakitanga or guardianship, which implies to manage the resource for the benefit of future generations. They believe that geothermal resources are a gift from their ancestors. Much of the controversy goes back to The Treaty of Waitangi (1840) that established the relationship between Maori People and the British Crown. The second Treaty article guarantees the possession of "Land and Estates Forest, Fisheries and other properties" to Maori people. However, there are on-going discussions about how this article should be interpreted (White, 1995). Some of the above-mentioned cases are part of historical claims against the Crown in front of the Waitangi Tribunals; some of which have been settled, some are still under negotiation.

In practice, the RMA (1991) vests the sustainable management of the geothermal resources (regardless of exact resource ownership) in regional authorities, under a requirement for a resource consent to use (exploit) a natural resource with numerous clauses and conditions to assure sustainable management of the resource. No specific consent or permit is needed in New Zealand to explore for a resource, apart from the potential impact of exploratory drilling and permission from the land-owner.

In the case of geothermal, the resources and therefore their management are mainly concentrated in the regions of Waikato (WRC) and Bay of Plenty (BOPRC). Whereas integrated resource management is largely vested in regional authorities, the central government does have the ability to steer some aspects through the National Policy Statements (NPS) or National Environmental Statements (NES), especially to harmonize activities or practices between different regional authorities. Two recent NPS have relevance for geothermal projects: on Electricity Transmission (2008) and Renewable Energy Generation (2011). These statements emphasize the aim of the central government to increase the renewable contribution in the electricity supply and require transmission and environmental decision-makers (including regional councils) to take these preferences into consideration. The government has set itself a goal to reach 90% of renewables in its electricity generation matrix by 2025 (presently at 80.7%, MBIE, 2015). Geothermal and wind energy are large contributors to achieving this goal.

Under New Zealand law, no royalty payments are required for the use of geothermal resources, although the RMA (1991) does contain a provision in Sections 112 and 360, for regional authorities to collect payments (royalties) for the use of geothermal energy. This clause has, however, never been used and implementation would be expected to be contentious. There are limited 'administrative' payments by developers to regional councils for monitoring, peer review programmes and consent applications.

Waikato and Bay of Plenty have historically aimed to maintain a 'single-tapper' policy, insisting that there is one developer per geothermal system, irrespective of multiple land-ownership. This was mainly to avoid the 'tragedy of the commons', where multiple users of the same geothermal system are incentivized to tap the resource at a higher (unsustainable) rate, out of fear other users might deplete the resource before them. In the 1990s this was successfully challenged in the High Court by an independent geothermal developer (Geotherm), who eventually won the case but went bankrupt. This ruling-in-principle led to multi-tapping as an option. The regional councils have adapted their policies since then, by allowing multi-tapping, but insisting on a 'joint management plan' for each geothermal system.

A geothermal project developer will need to negotiate and gain permission from the landowner above the resource, who controls the physical access to the geothermal resources. Negotiations generally result in a lease agreement or some other payment, or a partial ownership/co-investment in the project. Many geothermal projects are sited on land owned by Maori groups, reinforcing their role in NZ geothermal development.

2.2 Electricity market & renewable support policies

In the 1980s, successive labour and national governments embarked on a radical restructuring and liberalization of the economy including the electricity industry. Between 1986 (State-Owned Enterprises Act) and 2001, the sector was gradually separated in regulated, monopoly transmission and distribution lines

companies, while generation and retail (including to small, residential end-users) are markets open to full competition. In 1996 the New Zealand Electricity Market (NZEM) was created and started to trade all wholesale electricity (gross pool) between generators and retailers over a full set of pricing nodes (255 at present). In practise, over the years, generators and retailers integrated to manage risks, resulting in 5 integrated 'gentailers' covering ca. 95% of the market. New Zealand consists of two major islands - North and South Island - and a large number of smaller ones. The electricity grids between both islands are interconnected. In 2015, the total installed capacity was 9,603 MWe and the total energy generation was 42,861 GWh pa (MBIE, 2015). Electricity demand has grown quite steadily over the years with 1.5 – 2% over the previous decades, with expectations of 1-1.5% growth continuing until 2025. However, since the global financial crisis in 2008, demand growth has actually been virtually flat, which has created an oversupply of generation. Many planned generation investments (including geothermal) have recently been put on hold until demand picks up.

New Zealand generates a high proportion of electricity from renewable resources. In 2015, renewable energy accounted for 80.7% of generation of which more than 50% was generated from hydro-electric sources, and 17.2% from geothermal sources, which has been replacing the relative importance of coal and gas-fired generation. Wind generation has also slowly been increasing to 5% of annual generation. The bulk of hydro-electric generation is heavily dependent on variable hydro inflows. Reliable baseload and back-up generation (like coal, gas and geothermal) are therefore important to the stability of the system.

New Zealand in effect has very limited support policies for renewable energy. In 2008 an Emissions Trading Scheme (ETS) was introduced, but successive governments have weakened the scheme and developments in international climate change negotiations have resulted in extremely low prices providing little support for renewables. Recently, after COP Paris (November 2015), prices have started rising again and are topping NZ$ 10/tonne again and a recent government review has strengthened the ETS again. General wholesale electricity prices are also relatively low (but volatile), averaging around NZ$ 80-90/kWh (MBIE, 2015), but due to the excellent geothermal resources, located in the Central North Island close to demand and transmission, geothermal projects are among the most competitive, new generation projects (at 80-100 NZ$/MWh). At the same time, older existing fossil fuel generation projects are under pressure to close or reduce operation: two 250 MWe coal-fired units have already been mothballed. Further closures of thermal plant have been announced in 2015, opening up the way for new investments in (geothermal and wind) generation.

2.3 Regulation of environmental impacts

As described in 2.1 the RMA is the main Act defining the management of both the resource use and environmental impacts in New Zealand. The RMA is considered a "meta policy" instructing regional authorities to take control of their own objectives, policies, rules and any other method to manage their resources (Dickie, 2005).

The RMA requires that each regional council must have a Regional Policy Statement (RPS), which should establish an outline of the main resource management issues, policies and methods to achieve the integrated management resources of the region. They may also develop a Regional Plan, which provides the rules about the use of natural and physical resources (WRC/Luketina, 2010). District councils have to develop district plans to regulate land use activities. These policies are guided by National Policy Statements (NPS) and the cumulative case law confirmed by the hierarchical Environment Court and High Court decisions.

The main environmental authorities involved in geothermal decision making and monitoring are:
- Ministry of the Environment (MfE);
- Regional Councils (like WRC and BOPRC);
- District and City Councils as well as Unitary Authorities;
- Environment Court and High Court.

Regional Councils and District/City Councils have slightly different areas of jurisdiction (the latter for instance largely cover noise and land use impacts, while to former cover wider, regional impacts on water- and air-sheds – more details can be found in Lawless et al, 2016). In practise applications for resource consent are combined and submitted as a one application and hearings for all aspects are combined for a 'one-stop-process'.

2.4 Sustainability and monitoring

Under the RMA sustainable management of the geothermal resource/water/energy is the responsibility of regional authorities. Geothermal resources have traditionally been used by Maori and are considered a 'taonga' (treasure) and are of cultural significance. This is provided for in the RMA Part II. Section 5, which defines sustainability: (1) The purpose of this Act is to promote the sustainable management of natural and physical resources; (2) In this Act, sustainable management means managing the use, development, and protection of natural and physical resources in a way, or at rate, which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety while: (a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and (b) Safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and (c) Avoiding, remedying or mitigating any adverse effects of activities on the environment."

Application of section 5 involves an overall broad judgment of whether a proposal will promote the sustainable management of natural and physical resources. This is further interpreted in the Regional Policy Statements and Regional Plans of the two regional councils managing the TVZ. In these policies sustainable management of geothermal resources takes into account more than the resource and environmental effects in a single system. The Regional Plans seek to provide for sustainable management of the regional resource *as a whole* over the long term by protecting some systems in perpetuity and allowing large-scale geothermal development in others. All known high temperature geothermal systems in the TVZ (i.e. those with surface expressions) have been assessed in terms of energy content, their natural, cultural and other feature values; and classified for either large-scale extraction/development, limited extraction, small takes for research only, or full protection from extraction; to sustain, on a regional basis, the natural character and prevent adverse effects on either natural or physical resources.

For *development* systems, it is accepted that full conservation and commercial use of energy are not compatible. In these systems, the principle is 'controlled depletion' and effects of this are managed by remediation and mitigation. Effects are accepted as a trade-off between conservation and economic development. The overall trade-off is that while these systems will decline, protected systems will not.

In New Zealand, no specific consent or permit is needed to explore for a geothermal resource, apart from permission from the land-owner, and resource consents for any potential environmental impact of invasive exploratory processes such as drilling. In practice, each geothermal power project has to apply for resource consent for actual development. The application process integrates all resource, environmental effects and stakeholder participation ('one-stop-shop'). At the consenting stage, developers are required to reasonably demonstrate extent and sustainability of resource use, as well as their avoidance and/or management of environmental effects. As information about geothermal systems is scarce and expensive to acquire, especially at early (greenfield) stages of development, the precautionary approach of staged development has generally been encouraged by consent authorities. Resource consents can be granted for a maximum of 35 years. They contain conditions that specify the maximum rate of take, the nature and location of discharge, modelling, monitoring and reporting requirements and review conditions that provide for adaptive management. Review conditions can be triggered when effects are deemed more severe than specified or anticipated. In cases of litigation, the Courts have provided decisions and case law, e.g. in the case of Wairakei-Tauhara (Lawless et al, 2016.), where the Environment Court supported WRC's classification of geothermal systems as a cornerstone of sustainable management of the regional geothermal resource.

In practice, reviewing recent consent applications and witness evidence in TVZ, the main resource estimation methods used (in a regulatory context) are:

1. Probabilistic stored heat calculations;
2. Power density calculations with a variation as to 'proven resource' (around successfully tested wells) and probable (estimation/extension of the area beyond drilled area);
3. Production scenario analysis using computational reservoir models. As geothermal regulation in NZ has developed on the basis of water regulation (WSCA), it is common to specify consents and scenarios in terms of tonnes of fluid take per day or per annum. It is common to model these scenarios for the consented life (max. 35 years under the RMA) *plus 'a bit more'* (commonly 50 years+) to allow predictions that can demonstrate there should still be sufficient resource in the system to continue producing after the consent term expires. With a well-calibrated reservoir model it is also possible to do stored heat calculations before and after (proposed) production to compare with the outcomes of reservoir models. This does not seem to be regularly practiced, however. For the Ohaaki re-consent it was calculated that at the end of the consent period (after around 70 years of production) 91.8% of the original heat stored will remain in the reservoir (O'Sullivan and Clearwater, 2013).

Monitoring and reporting requirements (specified in consents and associated Information Protocols) have generally been strengthened and harmonized over the years, and will generally include:

- A range of monthly and annual reports stipulating impacts on the environment and basic production/field health statistics like fluid taken & re-injected, pressures, enthalpies, etc.
- 5-yearly System Management Plans to review past production vs predictions and consents, as well as a forward-looking field management plan; this generally coincides with an update and report on a new reservoir model;
- All reports are reviewed by an independent Peer Review Panel, that can request further information if it is deemed necessary;
- If effects are deemed outside the required consenting standards, adaptive management clauses can be invoked to alter the management of the geothermal system;
- Methods and standards have varied per system. Recently WRC commissioned a report (Maunder, 2014) suggesting the use of a common, harmonized geothermal reporting standard (a modified version of the Australian Geothermal Code) in preparation for the 10-yearly review of its Regional Plan (geothermal variation) to start in 2017;

3. ICELAND

Iceland is an island located on the border of the North-American and Eurasian tectonic plates. Its positioning and the fact that it is mountainous are the main reasons why there is an abundance of renewable resources to be

found there. In Iceland there is a high level of precipitation to sustain the hydraulic resources and the geothermal resources are a result of a volcanic belt which marks the divergent tectonic plate boundary, that runs through Iceland. Iceland is also considered a hot spot, an area where an unusually large amount of magma reaches the surface, resulting in increased volcanic activity. Over 50 years, Iceland has developed from being a relatively poor and underdeveloped society into a country with very high living standards. Fossil fuels were imported to the country as the primary source of energy for space heating until the seventies when the oil crisis hit the world, forcing Icelanders to develop other means of heating houses in this very northern island.

By 1985 over 80% of all homes in Iceland enjoyed space heating from geothermal resources and by 2015 around 90%, leaving the remaining 10% to be heated with electricity from renewable energy. By 1985 over 80% and by 2015 around 90% of all homes in Iceland enjoyed district heating from geothermal resources, leaving the remaining 10% to be heated with electricity from renewable energy. Even though Iceland only holds a population of a little over 330.000 inhabitants, the total electricity production is around 18 TWh. Around 29% of the total electricity production comes from geothermal resources and the remaining 71% stems from hydraulic power.

3.1 Resource ownership and access

The Act on the Survey and utilization of ground Resources ("Natural Resources Act") governs the exploration and utilization of geothermal resources in Iceland. The Natural Resources Act entered into force in 1998 after several draft bills had failed to pass through Parliament. The named draft bills had articles limiting the ownership by landowners of the geothermal resource to a certain depth or heat but none of them were agreed upon by the members of the Parliament. The members of Parliament generally agreed that such limiting of ownership did not conform to the constitutional property rights of ownership granted to landowners in Iceland. According to Icelandic law, ownership of resources in the ground is attached to the ownership of the land, private and public. This refers to resources in the ground, at the bottom of rivers and lakes and at the bottom of the sea within 'netting limits'. Geothermal resources cannot, according to law, be separated from private land unless a landowner has been granted a license to do so from the Minister of Industry and Commerce ("Minister").

The administration of geothermal resources in Iceland is in the hands of the National Energy Authority of Iceland ("NEA"), under the auspices of the Ministry of innovation and industries ("Ministry"). The NEA grants licenses in order to explore, utilize and produce electricity and heat with geothermal resources. All decisions, made by the NEA, regarding the granting, revision and revocation of licenses on the grounds of the Natural Resources Act can be appealed to the Appealing Committee on Environmental and Resources Matters. All other administrative decisions can be appealed to the Ministry.

An exploration license gives the license holder the right to search for the resource in question within a specific area during the term of the license. Only a single party is granted such license within a given geographic area. The NEA can grant an exploration license anywhere in the country regardless of whether the owner of the land himself has begun such exploration or granted it to others unless the party in question holds a valid exploration license. An exploration license is not a prerequisite according to the Natural Resources Act in order for the landowner to explore but without such license he would risk another party being granted such license on his own land. Exploration licenses are granted for exploration of natural resources both on public and private land.

Prior to the granting of an exploration license certain parties are requested to give a written opinion on the matter. According to the Natural Resources Act, these parties shall be the Environmental Agency, the Icelandic Institute of Natural History and in certain cases the Institute of Freshwater Fisheries. According to judicial precedent, the landowners in question shall also have the opportunity to hand in a written opinion. The NEA is on the other hand not bound by these opinions regarding the decision making.

The NEA also grants utilization licenses on the grounds of the Natural Resources Act. A utilization license grants the license holder a right to extract and use the resource in question during the term of the license in the quantity and on the terms which are laid down in the Natural Resources Act and the NEA regards necessary. Utilization licenses are granted for utilization of natural resources both on public and private land and can be granted for up to 65 years. The procedure for the granting of utilization licenses also requires the seeking of written opinions from certain parties. In these cases the parties shall be the Environmental Agency, the Nature Protection Agency, in certain cases the Fisheries Agency as well as the municipalities affected. According to judicial precedence, the landowners in question shall also have the opportunity to hand in a written comment. Alike, the NEA is not bound by any of the written opinions handed in. Exploration license holders do not hold pre-emptive rights as regards the granting of utilization licenses except for the needs of heating utilities.

When granting a utilization license, the NEA shall take into consideration that the utilization is carried out in a manner which takes account of environmental aspects, that the utilization of the resource is socio-economically beneficial and that account is taken of any utilization in the vicinity of the geographical area in question.

Granting of the abovementioned licenses is performed on a "first come first serve" basis. However, the NEA can post a single advertisement for applications for

exploration and utilization licenses in a certain geographical area.

The NEA grants power plant licenses on the grounds of the Electricity Act. The license gives the holder the right to construct and operate an electric power plant. However, such a license is not required for a power plant under the rated capacity of 1 MWe unless the power plant is connected to the distribution or transmission grid. One of the main objectives of the Electricity act is to promote the utilization of renewable energy. The regulation on Electricity takes it a step further and sets the prerequisite for the granting of a power plant license that the resource is renewable, otherwise such a license cannot be granted.

A major alteration to the geothermal law was made in 2008, when natural resources which were publicly owned could no longer be sold to private parties. However, instead of establishing the possibility of a long term right of use of the resources from the state and municipalities, as previously stated, for up to 65 years at a time, with the possibility of an extension.

Regardless of the aforesaid, a landowner can utilize natural resources on his own land to a certain extent. A landowner can therefore, without permission, utilize geothermal energy on his or her private land for household and agricultural use, including for greenhouse cultivation, industry and cottage industry, upto 3,5 MWth based on the heat extracted from the ground. The NEA must, however, be notified of any planned drilling and other major undertakings.

According to the Natural Resources act a utilization license holder has 60 days from the date of issue of the license to reach an agreement with the owner of the land and/or the resource in question or obtain permission for expropriation from the Ministry. In the event neither has occurred, the license shall be revoked by the NEA.

Before a license holder starts to develop a power plant on a property he shall reach an agreement with the landowners or the owners of the resource concerning compensation within 90 days from the date of issue of the license. Alternatively, expropriation needs to be requested to the Ministry within the same time period.

For public land and resources, the same rules apply and are subject to negotiation with the Prime Ministry regarding compensation for utilization or rent. However, there is no legal act establishing which elements such agreements should be composed of nor is there any legal framework for the payment of a market-based remuneration or criteria for the determination of such remuneration. The EFTA Surveillance Authority has issued a decision where the authority proposes that Icelandic authorities introduce a legal obligation establishing that any transfer of rights to utilise public natural resources for electricity generation takes place on market terms, which would be binding for all public entities. The respective earnings shall be put into amending land, maintenance, monitoring or similar projects on private land. However, there is no official tariff for land or resources owned by the state.

3.2 Electricity market & renewable support policies

Production of electricity from renewable resources dates back to ca. 1904 when the first hydropower station was established in Hafnarfjörður, in the vicinity of the capital of Reykjavik. The power plant was 0.9 kWe. The National Power Company, Landsvirkjun, was established in 1965 in order for the Icelandic State to exploit Iceland´s resources and attract foreign investors to the country for the purpose of creating power-intensive industries.

As previously mentioned, the increase of electricity from geothermal has been relatively steady over the last 50 years, going from 3 MWe installed capacity in the seventies to 670 MWe in 2015. The exploration and utilization of geothermal resources has been encouraged by the state since the seventies. The State Electricity Authority, and later its successor, the NEA, have been focused on the development of geothermal from its establishment in 1967. The Energy Fund, run by the NEA under the auspices of the Ministry, has supported geothermal projects through grants and loans. The Energy Fund's main objective is to encourage the economical utilization of domestic energy resources by granting loans and handing out grants, in order to minimize the utilization of fossil fuels. This may be done by granting loans to explore geothermal prospects where it is economically viable to reduce the cost of society for space heating with geothermal; to hand out grants to build prototypes of equipment to research and utilize energy resources; to award grants to special projects regarding economical energy utilization, including educational and informational purposes; and hand out grants encouraging the utilization of domestic energy, replacing fossil fuel energies and strengthening international co-operation in that same regard. In the early stages of the Fund, the loans would convert into grants if the exploration proved unsuccessful. This was done in order to minimise the risk involved in such projects.

The Icelandic electricity market was liberalized in a few steps, starting in 2003, initially with the implementation of EU Directive concerning common rules for the internal market in electricity, no. 96/92/EC, into Icelandic law by ratification of the Electricity Act. The Electricity Act stipulated that power plant licenses were granted by the Ministry as opposed to by the Parliament with specific legislation for each power plant which was the case prior to the existence of the act. During the last decades, electricity from geothermal resources has been growing more and more cost-competitive compared to electricity from hydropower (Bjornsson, 1995).

Today power producers are owned by the state, municipalities as well as by private entities. The main producers are Landsvirkjun, the national power company, with 71% of the total electricity produced;

ON Power, Reykjavik´s municipal power company, with 19%; HS Orka, the only privately owned power producer, with 7%; as well as many smaller producers. Landsvirkjun is the only power producer which sells electricity on the wholesale market in Iceland. The electricity produced today is a combination of three renewable energy sources, hydropower, geothermal and wind generation on a very small scale.

The Energy Forecast Committee is a co-operation between the key role players of the energy sector in Iceland as well as of Statistics Iceland, Registers Iceland and the Ministry of Finance. The committee utilizes energy statistics data gathered by the NEA and takes into consideration assumptions concerning the development of Icelandic society, in order to create a forecast for geothermal utilization in Iceland. The committee has predicted a total increase in geothermal energy use from 28.1 PJ in 2014 to 48.6 PJ in 2050 (Ketilsson, 2015).

In 2012, the EU Directive on the promotion of the use of energy from renewable sources, no. 2009/28/EC, was implemented into Icelandic law. Later, the regulation regarding Guarantees of Origin was introduced into the law, with the objective of ensuring that each energy unit across Europe is only registered once. Guarantees of origin specify from which energy source electricity is produced and allows electricity users to support the production of electricity from renewable resources. Landsnet, the Transmission System Operator in Iceland issues the guarantees of origin. These guarantees can be bought and sold from the date they are issued to a certain power producer until a final customer "uses" them to support the production of electricity from renewable resources. The reason for a customer buying such guarantees can vary, from a legal obligation to marketing purposes. The market for guarantees of origin is separated from the electricity market and does therefore not reflect the buying and selling of electricity in general.

In accordance with the directive a National Renewable Action Plan ("NREAP") has been composed, setting out the Government´s strategic approach and concrete measures on how Iceland will meet the mandatory national targets for 2020 laid down in the directive. The NREAP was published in December 2012. The NREAP is a policy document laying down the Government´s emphasis in energy strategy and policy for the country over the following years. The aims are: to replace imported energy with renewable domestic energy; to have all projects harnessing sustainable energy, follow a precautionary and protective approach in hydroelectric and geothermal energy production; to support diversified industry, emphasising the development of ecologically beneficial high-tech industry; to aim at sustainable utilization avoiding aggressive utilization of geothermal areas, encourage better energy utilization and connecting the Icelandic electricity system to Europe. The share of energy from renewable energy sources in 2005 was 63,4%. According to the methodology of the Directive, the corresponding target for 2020 is 72%. However, Iceland has already achieved its goal of 72% and had a share of around 75% when the NREAP was written in 2012. Furthermore, according to the NREAP, Iceland´s share is forecasted at around 77% in the year 2020.

Support schemes to encourage the production of electricity in Iceland with renewable energy sources are minimal, largely because electricity production is already around 99.9% from renewables. There is however an opportunity for foreign investors to apply for an investment agreement with the Government of Iceland under the Act on Incentives for initial investment in Iceland, no. 41/2015. It has been common practice in recent years that foreign investors making large investments in Iceland have entered into an investment agreement prior to a Power Purchase Agreement ("PPA"). Approved investment incentives include reductions of taxes and charges, a fixed income tax rate for a period of 10 years, as well as exemptions from customs and excise duties on importation. The incentives are thus provided for the investment and not through the PPA.

3.3 Regulation of environmental impacts

The Environmental Assessment Act, no. 106/2000, stipulates which projects are subject to environmental impact assessments. The objectives of the act are: to ensure that an assessment of the possible negative environmental impact of a project is made prior to any consent is granted by administrative bodies; to minimise such negative impact; to promote co-operation of stakeholders and concerned parties; to make known to the public the environmental impact of projects; and to mitigate measures to meet with possible negative impacts and give the public the opportunity to comment and contribute information before opinion on environmental impact assessment is issued.

The act stipulates that all power plants with 50 MWe installed capacity or more shall always be subject to environmental impact assessment. Certain other projects and constructions may be subject to an environmental impact assessment such as deep drillings in high-temperature geothermal regions, geothermal drilling in low-temperature areas where mineral sources are present or hot springs exist on the surface, or in the near proximity of geothermal heating production amounting to 2,500 kW gross power or more. An opinion of the Icelandic National Planning Agency is issued for each of these cases where the environmental impact assessment is not imperative.

In order to be granted a utilization license from the NEA an opinion of the Icelandic National Planning Agency shall have been issued with a final decision. The same applies for power plant licenses. Exploration licenses do not allow for any drilling or any single exploration constructions and does therefore not require the opinion of the Icelandic National Planning Agency with regard to environmental assessment prior to the licensing.

3.4 Sustainability and official monitoring

The Act on official monitoring, no. 27/1999, applies to official monitoring of geothermal resources and production of electricity from geothermal. The aim of the act is that official monitoring leads to the welfare of the nation, security and health, security of property, environmental protection, normal business environment and consumer protection. Official monitoring shall not lead to discrimination or compromise the freedom of act unless public interest demands.

The act stipulates that when rules for official monitoring are composed the respective authority shall evaluate the need for monitoring, the value of monitoring as well as cost associated with such monitoring for the society.

The Natural Resources Act as well as the Electricity Act both stipulate the efficient utilization of the geothermal resource. Monitoring of the resource is responsibility of the NEA. Article 25 of the Natural Resources Act stipulates that parties extracting energy or groundwater from the ground shall conduct such extraction so as to maximise long-term efficiency. This includes not extracting more geothermal energy or water than necessary and that drilling shall be conducted in a manner which causes the minimum possible inhibition of further utilization later.

In Iceland the first step towards identifying a geothermal resource is geological and geophysical surveying. In order to locate the resource, geophysical resistivity surveys have proved crucial in Iceland, supported with geological and geochemical findings, as well as other geophysical surveys. The resource is not proven until initial drilling has been performed. In Iceland, the success rate of high temperature geothermal wells over the long history of utilisation is 74%, and has increased to as much as 86% in some fields in recent years, as technology has advanced. A numerical model is made of the resource, based on the scientific data gathered, which assesses how much fluid can be extracted in a sustainable way over the pay-back time of the power plant, usually 25-30 years. This numerical model is often revised after the power plant has started operation, in some cases every five years.

Utilization license holders are required to hand in detailed information on the utilization of the resource in question. Also, a detailed list of the required information is defined in each utilization license and further in its annexes. This includes information such as the amount of fluid extracted or reinjected into each well in the geothermal field each month, the temperature of the water reinjected into the geothermal reservoir each month, results of water level measurements in wells where the water level can be measured and are within the geothermal field, results of measurements of the enthalpy of the fluid from every production well, chemical analysis of the geothermal water and steam, results from simulations of the geothermal reservoir, results of measurements made to monitor changes in the geothermal reservoir, information on drilling in the industrial area and a summary of improved understanding of the physical characteristics of the geothermal reservoir based on the results of latest drilling.

The NEA has included sustainability requirements in utilization licenses, including a limit on steam depletion, a limit on pressure drawdown and temperature etc. These can be used to assess whether the utilization is sustainable, and violations can result in the license being revoked. When a utilisation license has been granted, the license holder is required to submit yearly reports to the NEA, providing details on the utilisation of the resource according to the specifics of the license. The NEA currently collects information on production, use, gas emissions, temperature, pressure and many other aspects of utilisation. Since 2015 the NEA has also made it mandatory for license holders to develop a response plan in cases of induced seismicity from geothermal utilisation.

All information handed in to the NEA pursuant to the National Resources act, as well as any results of analyses of submitted samples, are to remain confidential during the effective term of the license and any extensions thereof, as well as during the effective term of any right of precedence as granted to an exploration license holder following the term of the license. Afterwards, the NEA may disclose such data or use it for the purpose of granting further licenses.

The Icelandic Parliament passed the Act on the Master Plan for Nature Protection and Energy Utilization, no. 48/2011, in 2011. Its main objective is to ensure that the utilization of land where possibilities for energy production are to be found and based on a concise evaluation of the protection value of nature and cultural heritage, how economic and profitable different possibilities of energy production are and other socio-economic values. The Master Plan is a tool to reconcile the interest of nature conservation and energy utilization that are often placed on the opposite sides.

The NEA proposes power plant options, above 10 MWe installed power, for assessment to the committees working under the Master Plan. A steering committee receives advice from expert committees that consist of specialist in various fields. The steering committee also seeks consultation with interested parties, public agencies, the public and non-governmental organisations during various phases of the work on the Master Plan. The Master Plan consists of three categories for power plant options: the “on hold” category, the “utilization” category and the “protection” category. After passing through the Master Plan, a power plant option, larger than 10 MWe can be further developed.

4. CONCLUSIONS

Both Iceland and New Zealand have a long history of developing geothermal resources. Despite their different backgrounds of ownership, resource and

electricity market regulation, they both have strongly developed sustainability/environmental regulation. These are summarized in the table below.

The above regulations are supported by a detailed framework of planning, resource proving and monitoring that have been enhanced in recent years (and is to be updated again soon in New Zealand).

Mutual lessons can be learnt by sharing information and experiences. Publication of resource information gathered by the public authorities is kept confidential to varying degrees.

In neither New Zealand, nor Iceland a standardized reserve/resource reporting framework (like the SPE-Petroleum Resource Management System) has been introduced yet. A modified version of the Australian/Canadian Geothermal Code (2010) had been proposed for New Zealand (Waikato) in 2014, but the development of the UNECE-IGA Resources Framework – Geothermal Specifications, will likely replace this in 2017.

Table 2: Comparison Iceland – New Zealand Regulation

	Iceland	**NZ-RMA-Geothermal**
Resource Ownership	Resource linked to land ownership, but much public land, hence: mixed public (state) & private ownership.	Public, but not necessarily state ownership
Resource access, exploration & production licensing	Exclusive license for exploration for a set period. Utilization licenses granted by the NEA for max 65 years with possibility of extension.	Open slather during exploration until exclusive production (resource) consent granted under the RMA, which cannot be granted without information to advise of likely effects; Max resource consent period is 35 years; Private access deals/contracts with land-owners for physical access.
Resource allocation ***principle& process***	Utilization of geothermal energy > 3.5 MWth the need a utilization license on the grounds of the Natural Resources Act. Power production projects > 1 MWe need a power plant license from NEA on the grounds of the Electricity Act.	Under RMA Sustainable Management requires resource to be available for future generations; multiple users per field/system allowed
Resource policy and planning	Master Plan generates a plan for the possibilities of utilization or protection of natural resources. Generally there is only one developer per field/area but the Natural Resources Act stipulates that the NEA can grant licenses to more developers jointly if they have done research jointly previously and divided the exploration cost.?	Clear regional geothermal resource planning policy based on the whole portfolio; some fields classified as 'protected' (for future generations), while/so others can be classified for development and 'controlled depletion' (Axelsson-2-3-4). Multiple developers on one field/system allowed but need joint management plan
Electricity market	Liberalized electricity market since 2003 with 3 major private and publically owned power companies. 99.9% renewable generation (ca 29% geothermal).	Liberalized electricity market since 1996 with a mix of 5 major private and part-state-owned power companies. All renewable & non-renewable power sources compete freely with very few subsidies. Ca. 80% renewables (15% geothermal; 2015) and rising. A target of 90% by 2025.
Environmental impacts of processes	Icelandic National Planning Agency.	RMA accounts for all environmental externalities of processes, as well as resource principle & allocation
Resource proving and reporting	- Strict requirements for granting of utilization license. License often includes sustainability requirements. - Annual reporting of data by license holders to the NEA. - Additional monitoring as needed by relevant authorities. - The majority of resource surveying from the beginning of development until 2003 was performed by the NEA, or its predecessors, and is therefore publicly available. All surveys commissioned by the NEA, or other public entities since then are also public. The majority of this data is available online. Energy data is published by the NEA, and detailed data can be available upon request.	- Strict resource 'demonstration'/ proving at time of RMA-consent, but different methods for different projects & regions. Use of Australian/Canadian Geothermal Code has been proposed; - Annual reporting but more on effects than resource; - No clear link back between developer reporting and WRC/TVZ aggregate, sustainable resource overview; - Justified on basis of public resource and sustainability; - More reports can be requested by Council and/or PeerReviewPanel, but generally very limited 'original' data; - Much old data exists from 1960-80s government drilling campaigns, but not all publically accessible (or to Regional Councils)
Publication of information	All information confidential to NEA during the effective term of the license and extensions thereof.	- RMA-1991 and LGOIMA-1987 have specifications for public transparency and reporting, but implementation /interpretation differs per regional council.

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