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Managing Political, Industry and Community Expectations for Development of Geothermal Resources – a Multinational Comparison

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ABSTRACT

While many countries have geothermal resources, there are significant differences in regulatory environment, size and nature of the geothermal resource, geographical and climatic conditions affecting resource accessibility, available infrastructure for development of the resource and distribution of electricity from it, demand for electricity or process heat, electricity market dynamics, need for energy independence, political, industry and community expectations for development of geothermal resources, land ownership and access issues, competing land uses, cultural values attached to the resource, likely adverse environmental or social effects of development, potential for other uses such as tourism, etc. Each nation has a unique set of needs to be considered in the development of policy regarding geothermal resources, and has a unique existing regulatory framework in which that policy can be developed. Some regulatory frameworks enable the development of workable policy whereas others may have competing lobbies, established mind-sets or entrenched practices that limit the advancement of enabling and equitable regulatory environments. Waikato Regional Council's policy package for managing the protection and sustainable use of geothermal resources has been recognised world-wide as an example of best practice, and Council staff are in demand for providing advice to government ministers from other nations and their advisors. This has enabled staff to develop some familiarity with the different situations in other countries. This paper compares the New Zealand situation with that of several other countries and draws conclusion about what works for New Zealand, what parts of the New Zealand regulatory framework can be applied elsewhere, what parts would need modification for use elsewhere, and what parts are not applicable elsewhere.

1. INTRODUCTION

The success of the New Zealand geothermal industry is due to a range of factors. New Zealand has been blessed with abundant geothermal resources for the provision of electricity, direct heat, tourism and other uses. It also has abundant hydroelectricity resources, and solar and wind power resources are now being developed for electricity generation. Other main sources of electricity include natural gas and coal. By law, there is no nuclear electricity generation. The country's geothermal resources mostly are easily accessible, at reasonably low altitude (ca 320 m), and sit within a geographic setting of easy farming terrain with good infrastructure such as roads and nearby electricity networks. The country enjoys a high standard of living, with 100% of the population having full access to electricity. Unemployment is at 6.2%. The climate is mild, the country is relatively sparsely populated, and it enjoys political, social and economic stability. The legislative and regulatory framework is equitable and enabling of sustainable management of natural and physical resources.

New Zealand geothermal expertise is sought throughout the world for developing geothermal resources, and for advising governments on geothermal legislation and policy development. However, each nation has a unique set of needs to be considered in the development of geothermal resources, and has a unique existing regulatory framework in which its policy can be developed. This paper compares the New Zealand situation with that of several other countries and draws conclusion about what works for New Zealand, what parts of the New Zealand regulatory framework can be applied elsewhere, what parts would need modification for use elsewhere, and what parts are not applicable elsewhere.

2. THE NEW ZEALAND SITUATION

2.1 Background and History of Geothermal Electricity Production in New Zealand

New Zealand was the first country to develop a large geothermal power station, at Wairakei in 1958, after the pioneering work of Italy at Larderello. Wairakei and then Ohaaki power station in 1989 were developed by the New Zealand Government, which at that time was by law the exclusive generator of electricity. In addition to the exploration work done for Wairakei and Ohaaki, there was an extensive programme of geothermal resource research undertaken by various arms of the government across the Taupo Volcanic Zone, where all but one of the country's 21 known high-temperature geothermal systems are located. Much of this research data was made publicly available. The first privately-owned power station to be built was the McLachlan geothermal power station, also on the Wairakei field, in 1997, following a law change to allow private ownership of power stations, advocated for by McLachlan interests. New Zealand now has 15 geothermal power stations on 8 geothermal systems, with a useable installed capacity of 854 MWe (New Zealand Geothermal Association, 2014).

However, despite the New Zealand geothermal industry having enjoyed many natural and political advantages, its history has not been entirely without adverse effects or conflict. There were significant adverse environmental effects from the Wairakei and Ohaaki developments, and the native Maori people have had their land and geothermal resources used by other parties against their will. National legislation and government processes have been put in place to ameliorate some of these effects and prevent future occurrence. New Zealand is now seen my many countries as a leading light in some aspects of native affairs, geothermal development and environmental legislation. The purpose of this paper is to compare the New Zealand geo-political situation with that found in other geothermal nations so that conclusions can be drawn about what parts of the New Zealand regulatory regime are useable elsewhere.

2.2 Recent History of Environmental Legislation in New Zealand

Local government underwent a radical transformation in 1989 with a reform process that slashed the number of locally elected agencies from over 700 to less than 100 including 12 Regional Councils and 74 City and District Councils. City and District Councils are collectively referred to as 'Territorial Councils' (Dickie and Luketina, 2005).

Environmental legislation underwent a similar transformation in 1991, bringing together the activities controlled by 78 statutes into a single world-leading statute, the Resource Management Act (1991) (RMA). Its prime purpose is to promote the sustainable management of natural and physical resources. It is hierarchical in operation and ties together the activities of Central government, Regional, City and District Councils. It is concerned with the management of air, water, soil, land, geothermal, some minerals (e.g. shingle and sand) and coastal resources out to the 12 nautical mile limit of the territorial sea (Dickie and Luketina, 2005).

Regional Councils are primarily responsible for achieving integrated management of natural and physical resources within the region, the co-ordination of natural hazard management and land transport planning, and undertaking flood protection, biosecurity and land transport activities within each region. RMA responsibilities include the integration of regional and district activities and regulating water, air, soil, geothermal, some minerals and coastal resource use. Regions are defined by the boundaries of large river system catchments and extend to the limit of the 12 nautical mile territorial sea. The primary role of territorial Councils is to provide services for communities such as water supplies, wastewater treatment, roads, parks, libraries etc. Their RMA responsibilities include land-use planning and regulation. In 1991 the Resource Management Act was passed. It brought New Zealand's environmental legislation into one Act devolves the management of most environmental matters to sub-national units of local government known as regional councils (Dickie and Luketina, 2005).

The creation of the Waikato Regional Council (WRC) in 1989 brought together 40 local boards, councils and authorities exercising powers relating to such things as pest destruction, drainage schemes and soil conservation into one body. One of the first tasks of the WRC was to develop a Regional Policy Statement and Regional Plan to achieve the purposes of the RMA. Since the Waikato Region contains approximately 70% of the nation's geothermal resource, sustainable management of the Regional Geothermal Resource was recognized as an important issue for the region, and policies and rules were developed specifically for geothermal resources. The development of these policy documents has been detailed in Luketina (2010).

2.3 A Brief Summary of Waikato's Geothermal Policy

WRC has set in place a package of robust policy and methods to ensure that the geothermal resource is not prematurely depleted through ad hoc development.. The 15 high-temperature geothermal systems in the region are divided into four usage categories, with different policies and rules governing each category. The categories are: 1) Development Systems, where large-scale sustainable development is enabled, 2) Limited Development Systems, where some development may occur as long as there are no significant adverse effects, 3) Protected Systems, which are managed for the protection of valued Surface Geothermal Features such as geysers and geothermal ecosystems, and 4) Research Systems, where not enough is known about the system to classify it into one of the other three, and where only small-scale uses and research activities may be undertaken. Small geothermal systems are classified into a fifth category. Further details of these policy documents can be found in Luketina (2010)..

3. GEOTHERMAL CHALLENGES: INTERNATIONAL COMPARISONS

While New Zealand enjoys plentiful geothermal resources, an easy climate and geography, high standard of living, plentiful electricity supply, stable and transparent government, and streamlined environmental legislation, not all of these things are true in some other countries. Therefore the New Zealand policy and regulatory framework is not necessarily appropriate for other nations.

Although geothermal energy is generally classed as renewable, large-scale extraction of geothermal energy in almost all cases involves the mining of heat from a geothermal reservoir at a greater rate than it is input naturally into the reservoir. This eventually will result in depletion to a point where extraction is no longer economic unless there are different, probably deeper, parts of the geothermal system that can be accessed to provide more energy. In addition, there can be substantial adverse effects from geothermal extraction, such as subsidence, an increase in local earthquakes, and contamination of freshwater resources. Sometimes there are competing and potentially more valuable uses of the geothermal resource that should be taken into account. The aspirations and wishes of landowners, native peoples, and nearby residents need to be considered. Therefore the benefits and disadvantages of geothermal developments must be weighed up carefully and the adverse effects minimized or avoided. This requires a robust policy and regulatory regime that enables appropriate use.

The main elements of New Zealand's unique environmental, societal and regulatory situation are examined here and compared to other situations in the world.

3.1 National Energy Supply

In New Zealand, geothermal energy is but one of several energy sources, including abundant hydroelectricity power stations, natural gas and coal reserves, some oil reserves, and growing developments of solar and wind electricity solutions. Geothermal generation accounts for 17% of the nation's electricity generation, and all 'renewables' for approximately 75%, the total being affected by weather-dependent variations in hydroelectric generation. New Zealand's renewable percentage is the third highest in the OECD. Geothermal power stations are often reasonably close to centres of population and could provide local security of supply if there were outages on the national grid for any reason.

In contrast to New Zealand, many nations, particularly small island nations, have to use imported diesel for most or all of their electricity. This has the disadvantages of being expensive, creating greenhouse gas emissions, and requiring dependence on an external nation for supply. In some cases houses and businesses have either no or limited access to electricity, and are required to burn fuel for cooking and illumination. This fuel may be locally-gathered plant material, and its continued collection may be unsustainable, or it may be imported fossil fuel (coal, or liquid or gas hydrocarbons) that is expensive to buy.

In places where high-temperature geothermal resources are available, it makes sense to improve national self-reliance and increase local energy supply by developing those resources if it is economically feasible to do so. This can assist with developing tourism and production industries, generating the economy and providing a better standard of living.

3.2 Energy Needs for Space Cooling and Heating

New Zealand enjoys an equable climate that does not create a large demand for space heating or cooling. Only a few towns experience any snow, for example, and maximum temperatures in summer do not often rise above 30 °C. Other nations, particularly in northern Europe and North America have much greater need for space heating. In those places, there is heavy demand for both direct heating solutions and for electricity for use in heaters. Because of the human need for a certain heat range in living spaces, very few settlements in cold climates do not have continuous electricity supply. Geothermal energy, where available, may be able to provide a cost-effective alternative to existing energy sources, either for direct heat or for electricity.

In contrast, in hot climates with a high standard of living, people demand air-conditioning, which needs electricity. Some innovative solutions involving using geothermal resources for refrigeration are also available. Developing nations do not have the same demand for air conditioning, except in tourist resorts.

3.3 Process Heat Uses

Heat is often needed in industrial processes, for example, for drying primary products, cooking, or fuelling biological or chemical reactions. While not providing the high temperatures needed for such industries as steel production, geothermal heat can be a good source of low-grade heat for aquaculture and greenhouses. The drying of primary products is an application that can be useful even in warm countries. It may be too expensive for a user of process heat to drill a well to obtain geothermal fluid, but often the fluid can be supplied as a byproduct of electricity generation, either as a cascaded use of fluid that has passed through the power station and still has some useful residual heat, or in the case of clean steam, the first use of the fluid before it is passed through the power station, or simply as excess fluid that is not needed in the power generation process at all.

Direct uses of geothermal fluid are much more labour-intensive than electricity generation, and therefore are able provide jobs for the local people. This can be a very significant benefit to the population and in areas where there is high unemployment, the creation of a direct heat industry in association with a geothermal electricity development should be considered.

In New Zealand, direct heat uses of geothermal energy include prawn farming, the growing of flowers, native trees and vegetables in glasshouses, the production of honey and powdered milk, and timber drying. In New Zealand's Waikato Region in 2010, geothermal direct uses provided approximately 550 fulltime equivalent jobs, many more than geothermal electricity generation (Barns and Luketina 2011).

3.4 Swimming and Tourism

Not all countries are able to accommodate a large tourist industry, because of various reasons including safety concerns for visitors and lack of infrastructure. However, for many countries, geothermal tourism can be an excellent, sustainable source of foreign income. It can be either attached to a geothermal power station, or an independent use. Swimming and bathing facilities can be developed for balneology and leisure in a way that engages the tourist in an experience of the local culture. At Rotorua, Taupo, Tokaanu and many smaller geothermal areas in New Zealand, swimming pool complexes, hotels and motels take hot water or steam directly from the shallow geothermal resource for use in bathing and spa facilities.

Rather than taking geothermal fluid directly from the ground, some tourism enterprises are attached to geothermal industrial processes. For example, in Iceland, the Blue Lagoon bathing facility is a magnificent tourist attraction that uses water discharged from the Svartsengi geothermal power station. A geothermal prawn farm in New Zealand has developed a large tourism operation around site visits and dining on prawns in the onsite restaurant. Nearby, the Wairakei Terraces provides artificial geothermal terraces, an artificial geyser, and bathing facilities as part of a tourism facility showcasing Maori culture. The geothermal fluid is provided by the Wairakei Power Station.

3.5 Sustainability

When developing uses of geothermal resources, it is important to determine the best use of the resource. Large-scale electricity development to date has involved mining of the heat (and in some cases fluid) and can only last tens of years before the accessible reserve is depleted. On a geyser field it will most likely render the geysers and sinter-depositing springs extinct, as has happened at Wairakei and Ohaaki in New Zealand. Nowhere in the world do natural geysers coexist on the same geothermal system as a geothermal power station.

At Rotorua geothermal system in New Zealand, multiple shallow takes for homes and motels led to the demise of many flowing springs and geysers in the 1980s. There has been significant recovery of the Rotorua geothermal system over the 27 years since bores were closed to protect the surface features and remaining geysers; however two geysers have ceased erupting but many springs (especially in the northern portion of the field) have resumed flowing. One geyser at Whakarewarewa has resumed boiling and overflow, but no eruptive behavior (Scott *et al.*, 2015).

Geothermal tourism can be developed without any artificial extraction and can be sustainable indefinitely because it does not deplete the geothermal resource. Large-scale extraction eventually depletes the resource, and is incompatible with nature tourism based on the phenomenon of geysers and sinter-depositing springs. Therefore, when developing a geyserfield for electricity generation, the question must be asked whether that is the best use of the resource in the long term. There may be other geothermal systems that do not have such vulnerable features that can be used instead, thus preserving an important potential tourism resource, even if tourism is not envisaged in the near term.

In New Zealand's Waikato Region in 2010, geothermal tourism provided economic value similar to that provided by geothermal electricity generation, and provided approximately 10 times more employment than geothermal electricity generation (Barns and Luketina 2011).

3.6 Environmental Effects

Adverse environmental effects from geothermal development can be severe and irreversible. Any geothermal development must consider all possible effects and how they are to be avoided, remedied or mitigated. There is a long list of potential adverse effects, both on the geothermal system and on other natural and physical resources. Any geothermal system will be prone to its own particular set of adverse effects, and the potential mix of solutions will be unique to the area. Potential adverse effects to be taken into account include increased risk of hydrothermal eruptions, landslides and induced earthquakes; contamination of surface water and aquifers; increase in steam output and decrease in geothermal spring discharge; subsequent effects on rare and fragile ecosystems dependent on the discharge; cracking of aquicludes and subsequent draining of lakes; discharges to air of steam and non-condensible gases, which can have the effects of blocking vision, causing changes to the local microclimate, nuisance smells and toxic concentrations of some gases; for binary plants, discharges to air of working fluid hydrocarbons; the effects on property and infrastructure of ground subsidence. Shallow reinjection can lead to ground inflation and increase in spring discharge (Luketina 2012).

4 REGULATORY, SOCIAL AND CULTURAL ISSUES

Populations that have a cultural link to geothermal springs or the area overlying a geothermal system can be disadvantaged by geothermal development. This should be considered unacceptable to any local or national government. If it occurs, experience tells us that due to lingering discontent, the problem does not go away until the aggrieved parties consider full justice has been done. Existing native rights, either under international or national law, should be preserved and the people of the area fully engaged as equal participants and beneficiaries of the development. This requires that they be active participants in any decision-making process about the nature of the development. In one analysis, public participation is seen an eight-runged ladder divided into three segments of Citizen Power, Tokenism and Nonparticipation. Within the Citizen Power segment, Citizen Control is the highest level of public participation, involving participants or residents owning or governing a program, institution or company, having full charge of policy and managerial aspects, and receiving profit and social benefit from the operation. The lowest level of participation is described as Manipulation (Arnstein, 1969).

The issues of local people versus national interests in geothermal developments occurs in many countries. Iceland, having a homogeneous population whose survival depends on abundant access to heat and electrical energy, may be one of the few countries where there is little tension between these local and national interests, although in any instance, people may protest over other matters such as environmental effects that are not directly related to indigenous rights.

4.1 New Zealand

The nation of New Zealand was founded on the Treaty of Waitangi, signed in 1840 by representatives of the native Maori and the British Government. The treaty guaranteed the Maori people sovereignty over their lands and waters. However, much land was subsequently taken by force from them and a new set of laws imposed that disadvantaged them. The Waitangi Tribunal was established in 1975 as a permanent commission of enquiry to hear claims from the Maori people and to suggest remedies. As a result of tribunal recommendations, a substantial part of the land containing New Zealand's geothermal resources has been returned from government ownership to Maori ownership. The individual Maori tribes are now in a position to consider developing their geothermal resources.

In cases where the land was never alienated, Maori-led development has already occurred. On Mokai geothermal system, the individual Maori land-holdings amalgamated into Tuaropaki Trust, formed a power company and built a geothermal power station. Using the Income generated they built geothermally-heated glasshouses and a milk drying plant to provide employment for their people and diversity income streams. The waste organic matter from the glasshouses and milk plant are turned into compost in a worm farm, which is then used to grow native plants, which are planted along farmland streams to enhance water quality and native fish habitat.

At Rotokawa and Ngatamariki geothermal systems, the native landowners, through the Tauhara North No. 2 Trust, are joint venture partners with an established electricity company in the Rotokawa, Nga Awa Purua, and Ngatamariki Power Stations.

4.2 Vanuatu

In 2013 the Government of Vanuatu signed an agreement with KUTh Energy of Australia to develop two small geothermal power stations on the main island of Efate, reducing the island's dependence on diesel and widening the area supplied with electricity. About 73% of the population in Vanuatu is not connected to grid electricity (Reegle, 2014a). Senior government ministers, officials and land-owner representatives undertook a fact-finding trip to New Zealand to learn about geothermal power generation and the regulatory environment. A tourism industry based around scuba diving is an important economic activity, and some geothermal springs are considered a minor tourist attraction. Concerns around potential geothermal developments on Efate include effects of subsidence on low-lying areas, and ensuring that the local people who hold ownership or traditional use rights over the land are adequately engaged in any development.

4.3 Papua-New Guinea

Papua-New Guinea (PNG) is a relatively undeveloped country with extensive mineral and geothermal resources, many of which are co-located near accessible coastal locations. To date the only geothermal power station is at Lihir, one of the largest gold mines in the world, based on Niolam Island, aka Lihir Island. There is ongoing low-level tension between the mining company and customary landowners over various topics including encroachment of mining-related projects onto customary land, and the fulfillment of land-owner compensation agreements.

Like Vanuatu, PNG is developing a national policy and regulatory framework to enable geothermal development while protecting the environment and ensuring social equity for landowners and native peoples. The country has the potential to substantially benefit financially from further development of the mining industry, which will need electricity. The country has a rugged geography and many places are accessible only by air or sea. Due to the undeveloped nature of the country and concerns for the safety of visitors, tourism is not a growth industry. In PNG, more than 90% of the population (mostly rural dwellers) have no electricity (Reegle, 2014b).

4.4 Philippines

The Philippines is the second largest producer of geothermal electricity after the USA, In the Philippines, 90 % of the population has access to electricity (United Nations Development Programme, 2013). While much of the population is highly urbanized, there are some that lead a subsistence lifestyle in remote areas.

The Philippines environmental protection is not delegated to a single government agency but instead environment-related concerns are part of the directives of several agencies dealing with agriculture, natural resources, health, housing and public works. The National Environmental Protection Council (NEPC) was created in 1977 as the policy-making body on matters related to environment. Environmental Management Bureau (EMB) was created in 1987 under the Department of Environment and Natural Resources (DENR) where it assumed the duties of NEPC (Pascual, 2005).The environmental and geothermal laws in Philippines are based on key Presidential decrees (PD) (Cheptum, 2013).

Some of the Acts that govern the implementation of the environmental management in Philippines include the following (Benito et al., 2005; Pascual, 2005; Sander, 2012):

- National Integrated Protected Areas System (RA 7586, 1992),
- Mining Act (RA 7942, 1995),
- Indigenous Peoples Rights Act (RA 8371, 1997),
- Philippine Clean Air Act (RA 8749, 1999),
- Ecological Solid Waste Management Act (RA 9003, 2001)
- Philippine Clean Water Act (RA 9275, 2004).
- Renewable Energy Act of 2008 (R.A. 9513,2008)

The government's push for geothermal electricity developments to fuel the nation's growing industrialization sometimes runs into opposition from local affected parties concerned with environmental impacts such as land subsidence, dehydration of ricefields and springs that provide the area with tourism and the effects of geothermal plants' chemical discharge to the health of host communities (Samson, 2013).

4.5 Malaysia

99% of people are connected to electricity in Malaysia (United Nations Development Programme, 2013). In some areas with small power demand, alternative sources of energy, such as photovoltaic and diesel battery hybrid electricity generation systems, have been implemented under the Rural Electrification Programme (Reegle, 2014c).

The country's first geothermal power plant is being built in Apas Kiri, Tawau. Concerns have been expressed about the amount of native forest felled for the power station site and the fate of the profits from the sale of the logs (Daily Express, 2014)

4.6 Australia

Australia is a developed country with a booming mining industry and a high standard of living. 100% of the population has access to electricity ((United Nations Development Programme, 2013)). Geothermal energy is currently produced at one small binary power station at Birdsville in western Queensland, supplemented by diesel-powered generators. The geothermal fluid is 98°C and derives from the Great Artesian Basin (also referred to as the Eromanga Basin) that overlies the Cooper Basin (Government of South Australia, 2014). The nation's geothermal resources consist mainly of hot sedimentary aquifers and hot dry rock, and it is only in recent years that attempts have been made to develop them, with investigations and exploratory drilling at several sites. Since the geothermal resource has always been hidden underground, no indigenous rights issues surrounding geothermal resources have been expressed to date.

4.7 Kenya

Only about 16% of Kenyans are connected to electricity (United Nations Development Programme, 2013). This situation is rapidly changing as the country invests more resources in power generation, transmission, and distribution, including several geothermal power projects driven by the government. Kenya currently produces about 215 MWe of geothermal electricity (Matek, 2013).

To obtain a license for geothermal development, Ministerial approval is needed and anyone so authorized is entitled to undertake actions in connection with the survey and investigation of such areas. The rights of the licensee also include the right to claim and utilize any water. However, landowner rights with regard to entry, drilling and well testing exist. The license holder is responsible for damages and injury that may result from these activities. Compensation to the landowner or resident is required. The licensee is also subject to conditions relating to safety or any other conditions imposed by the Minister (Baba, 2003).

Kenya has a set of complicated Acts of Parliament and laws that work together to guide and regulate the use of geothermal and natural resources that a developer has to comply with, for sustainable development and conservation of the environment (Cheptum, 2013).

Geothermal power developments, including an expansion of existing plant at Olkaria, are facing opposition from Maasai tribes, who inhabit the land. The World Bank, which is involved in some geothermal developments, denies being involved in any related evictions (World Bank, 2013).

4.8 Iceland

Iceland has installed geothermal electricity generation capacity of 664 MWe (Matek, 2013) and all of the population has access to electricity (World Bank, 2013). The use of geothermal resources has been essential for survival since the country was colonized, for bathing, cooking, and space heating. In more recent times geothermal energy has also been used for crop cultivation, other primary production, direct uses, and electricity production. Icelanders have geothermal bathing firmly embedded in their culture.

Several Acts govern the development of geothermal resources (Andrésdóttir, Sigurdsson, & Gunnarsson, 2003). The Environmental Impact Assessment Act in Iceland was composed in accordance with EU Directives 1985, amendment 1997 (Cheptum 2013).

CONCLUSION

Every country has a unique setting in which geothermal development may or may not occur. This setting is shaped by many factors including the size and nature of the geothermal resource; accessibility issues for its development; the state of knowledge regarding the geothermal resource; the interaction between geothermal development and other parts of the the physical environment; policy and regulatory situation regarding environmental matters and the electricity sector; indigenous people, their socioeconomic situation, their cultural practices and aspirations; attitude of government towards the rights of indigenous peoples, and the development aspirations of the nation.

Whatever the national situation, optimum long-lasting benefit from use of geothermal resources is maximized by careful planning and ensuring that the science, environmental, political and commercial aspects are aligned. Some countries do this better than others and all can learn from the mistakes and successes of other.

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